PHASE 2 EVALUATION REPORT

Smart DARTS

Advanced Paratransit Technologies Study

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**TABLE OF CONTENTS**

1.0 EXECUTIVE SUMMARY .......................................................... 1

2.0 PROJECT OVERVIEW .................................................................. 4

   2.1 The Smart DARTS Vision .................................................. 4
   2.2 The Smart DARTS Project Team .......................................... 5
   2.3 Implementation Phasing .................................................. 5
   2.4 Project Objectives ....................................................... 5
   2.5 Computer-Aided Paratransit Software ............................... 6

3.0 THE DARTS SYSTEM ............................................................ 9

   3.1 Service Area .................................................................. 9
   3.2 Service Description ..................................................... 11
   3.3 Service Characteristics ................................................ 11
   3.4 The DARTS Pre-Implementation Scheduling and Dispatch Process ... 12

4.0 PHASE 2 IMPLEMENTATION PROCESS .................................... 19

   4.1 Funding .................................................................... 19
   4.2 System Specifications .................................................. 20
   4.3 Vendor Selection ........................................................ 20
   4.4 Deployment ............................................................... 21
   4.5 The DARTS Post-Implementation Scheduling and Dispatch Process ... 21

5.0 EVALUATION: METHODOLOGY AND RESULTS ....................... 27

   5.1 Measures of Effectiveness ............................................. 27
   5.2 General Methodology .................................................. 30
   5.3 Evaluation Results ..................................................... 30

      5.3.1 Improve Responsiveness ..................................... 32
      5.3.2 Enhance Customer-Focused Service ........................ 35
      5.3.3 Increase System Capacity ..................................... 47
      5.3.4 Increase Cost Effectiveness .................................. 48
      5.3.5 Enhance DARTS’ Ability to Meet ADA Requirements ........ 48
      5.3.6 Ease of Deployment .......................................... 60
### TABLE OF CONTENTS (CONTINUED)

6.0 CONCLUSIONS ............................................................ 65

6.1 Key Considerations .......................................................... 65
6.2 Summary of Measures of Effectiveness Findings .......................... 65
6.3 Understanding the Benefit Realization Process ........................... 67
6.4 Interpreting Phase 2 MOE Findings ....................................... 71
6.5 “Unmeasured” Benefits .................................................... 72
6.6 The Foundation and Need for Phase 3 ................................... 73
6.7 Summary of Findings and Conclusions .................................. 74
6.8 Implications for Transferability .......................................... 76
LIST OF FIGURES

2-1 DARTS Service Area ............................................................ 10
3-1 Pre-Implementation - DARTS Demand Trip Scheduling Process ............... 13
4-1 Post-Implementation - DARTS Demand Trip Scheduling Process .................. 23
6-1 Phase 2 Benefit Realization Process ........................................... 66

LIST OF TABLES

4.1 Implementation Process ....................................................... 19
5.1 Smart DARTS Evaluation Phase 2 Measures of Effectiveness .................... 29
5.2 Pre- and Post-Implementation Total DARTS Ridership .......................... 31
5.3 Percentage of Early, On-Time and Late Trip Pickups (On-Time = +/- 15 Min. of Schedule) ......................................................... 33
5.4 On-Time Pickup Performance .................................................. 33
5.5 Same Day Trip Requests (1995) .............................................. 34
5.6 Trip Request Telephone Calls ............................................... 37
5.7 Trip Request Denials (Including Same Day) .................................... 38
5.8 Pre-Implementation Rider Survey Same Day Trip Reservations .................. 40
5.9 Pre-Implementation Rider Perceptions (Same Day Trips) ........................ 40
5.10 Pre-Implementation Rider Preferences (Same Day Trips) ........................ 41
5.11 Pre- Vs. Post-Implementation Rider Perceptions: Service Quality ............... 41
5.12 Pre- Vs. Post-Implementation Rider Perceptions: Trip Reservation Lead Time ...... 42
5.13 Pre- Vs. Post-Implementation Rider Perceptions: Same Day Trip Requests ...... 42
5.14 Pre- Vs. Post-Implementation Rider Perceptions: Trip Request Call Duration ...... 44
5.15 Post-Implementation Rider Survey Results Perceived Changes in Service .... 45
5.16 Passenger Trip Duration ...................................................... 46
5.17 Percentage of Demand and Standing Order Trips (1995) ......................... 47
5.18 Passengers Per Vehicle Mile ................................................ 48
5.19 Passengers Per Vehicle Revenue Hour .................................... 49
5.20 Staff Labor Hours Data Collection ........................................ 52
5.21 Pre-Implementation (May 1995) DARTS Transit Office Staff Labor Hours by Task ................................................................. 53
5.22 Post-Implementation (November 1995) DARTS Transit Office Staff Labor Hours by Task ................................................................. 54
5.23 Comparison of Pre- and Post-Implementation Averages Transit Office Staff Labor Hours by Task ................................................................. 55
5.24 Average Cost Per Trip ......................................................... 57
5.25 Metropolitan Council Subsidy Per Trip ........................................ 58
5.26 Demand/Standing Order Trip Percentages By Time of Day ..................... 59
1.0 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 benefits, 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 70s, 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 trips 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. Pre-schedules 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
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 preschedule 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 4.1**
**IMPLEMENTATION PROCESS**

<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 break down. 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
Figure 4.1
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-scheduled 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.

If 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-scheduling 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.

**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.
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 MOE.

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>1.0 Improve Responsiveness</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>1.0</td>
<td>1.2 Increase the percentage of same-day trip requests that are satisfied.</td>
</tr>
<tr>
<td>2.0 Enhance Customer-Focused Service</td>
<td>2.1 Reduce the length of time required to make a trip reservation.</td>
</tr>
<tr>
<td>2.0</td>
<td>2.2 Reduce the number of trip request denials.</td>
</tr>
<tr>
<td>2.0</td>
<td>2.3 Improve rider perceptions of service.</td>
</tr>
<tr>
<td>2.0</td>
<td>2.4 Reduce average trip duration (minutes).</td>
</tr>
<tr>
<td>3.0 Increase System Capacity</td>
<td>3.1 Increase the percentage of demand trips served.</td>
</tr>
<tr>
<td>4.0 Increase Cost Effectiveness</td>
<td>4.1 Increase the average number of passengers per revenue mile.</td>
</tr>
<tr>
<td>4.0</td>
<td>4.2 Increase the average number of passengers per revenue hour.</td>
</tr>
<tr>
<td>4.0</td>
<td>4.3 Reduce the scheduling/dispatch labor hours per trip.</td>
</tr>
<tr>
<td>4.0</td>
<td>4.4 Reduce the average total cost per trip.</td>
</tr>
<tr>
<td>4.0</td>
<td>4.5 Reduce the average subsidy per trip.</td>
</tr>
<tr>
<td>5.0 Enhance DARTS' Ability to Meet ADA Requirements</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 dated 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.
<table>
<thead>
<tr>
<th>Condition</th>
<th>Average Arrival (Minutes)</th>
<th>Percentage of Trip Pickups by Arrival Time (minutes)</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>60+</td>
<td>31-60</td>
<td>16-30</td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td>&lt;1%</td>
<td>1%</td>
<td>6%</td>
</tr>
<tr>
<td>Post-Implementation</td>
<td>&lt;1%</td>
<td>1%</td>
<td>5%</td>
</tr>
<tr>
<td>Change</td>
<td>0</td>
<td>0</td>
<td>-1</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996
Results and Conclusions

Table 5.5 indicates that no increase in same day trip request satisfaction occurred. In fact, for unknown reasons, the percentage of same day trip requests satisfied decreased.

Absence of an increase in this MOE is not surprising for two reasons. First, as a result of their 24-hour advance policy, DARTS received few same day trip requests before or after implementation. Furthermore, they accommodated almost all of these few requests. Since DARTS made no effort to stimulate same day trip requests following implementation, the volume of same day trips did not increase significantly. Given how well they served the requests they did receive, there was little room for improvement.

Second, lacking mobile data terminals, a planned component of Smart DARTS Phase 3, the communication and data entry demands associated with maintenance of the required up-to-the-minute schedule essentially preclude an increase in same day trips.

**TABLE 5.5**
**SAME DAY TRIP REQUESTS**
(1995)

<table>
<thead>
<tr>
<th>Trip Requests</th>
<th>Pre-Implementation</th>
<th>Post-Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>May</td>
<td>August</td>
</tr>
<tr>
<td>Requested</td>
<td>140</td>
<td>204</td>
</tr>
<tr>
<td>Denied</td>
<td>3</td>
<td>11</td>
</tr>
<tr>
<td>% Approved</td>
<td>97.9%</td>
<td>94.6%</td>
</tr>
</tbody>
</table>

### 5.3.2 ENHANCE CUSTOMER-FOCUSED SERVICE

**MOE 2.1 Reduce the length of time required to make a trip reservation**

DARTS clients request trips and have trip reservations confirmed over the phone. It was assumed that trip requests could be made and trips scheduled faster using Quo Vadis than when done manually. Specifically, the software was believed to be able to more quickly perform the task of checking the preschedule and determining whether the trip could be served.
Methodology

DARTS office staff recorded the duration of all request calls in logs before and after implementation. Each call was categorized by length, e.g., less than 30 seconds and the percentage of calls in each category before and after implementation was compared.

With Quo Vadis, it was believed DARTS had the capability of attempting to book and schedule calls while a caller made a trip request. DARTS was able to differentiate between “booking only” request calls and “booking and scheduling” request calls. It is assumed that most pre-implementation request calls were only booked and rarely scheduled. To provide another, perhaps more accurate, angle of comparison, Table 5.5 compares post-implementation “booking only” calls to pre-implementation calls. Call duration percentages for “booking only” calls were calculated in the same manner as in Table 5.5.

Results and Conclusions

Table 5.6 indicates that trip request calls are taking longer following implementation of Quo Vadis. Before implementation, 40 percent of all trip request calls lasted less than 1 minute. This number dropped to 17 percent after implementation. The percentage of calls lasting over three minutes increased from 12 to 24 percent.

One possible reason why request calls took longer is that request takers spent more time evaluating and presenting alternative trip times to the callers in the cases where the desired trip time was unavailable. Another possible reason is that completing a trip request using the Quo Vadis scheduling screen actually took longer than the short-hand approach used previously to complete the hand-written forms. DARTS management input supports this second interpretation.

MOE 2.2 Reduce the number of trip request denials

Based on the assumption that trips are denied primarily due to full schedules, it was assumed that by producing more efficient schedules which would accommodate more trips, Quo Vadis would reduce the number of trip requests denied.

Methodology

Trip denials are recorded as part of DARTS regular record keeping practices. Trip denials are reported on a quarterly basis and pre-implementation data is presented in that fashion. Because the post-implementation time period straddled two quarters, data for the four month period of August through November was utilized. Pre-implementation data from two quarters, July through December, for the years of 1993 and 1994 was compared to post-implementation data.

Results and Conclusions

It appears that Quo Vadis did not significantly impact trip denials. Because very few trips were denied before or after implementation there was little room for improvement.
In order to reduce the number of denials, two conditions must exist. First, there must be a sufficient
volume of denials of the type which can be eliminated through scheduling improvements. Second,
scheduling improvements must be realized: more efficient schedules allowing more trips must be
available.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Average Duration (minutes)</th>
<th>Percentage of Calls by Duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Implementation</td>
<td></td>
<td>18% 22% 33% 15% 12%</td>
</tr>
<tr>
<td>Post-Implementation</td>
<td>2.3</td>
<td>5% 12% 38% 21% 24%</td>
</tr>
<tr>
<td>Change</td>
<td>-13 -10 +5 +6 +12</td>
<td></td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996
TABLE 5.7
TRIP REQUEST DENIALS
(INCLUDING SAME DAY)

<table>
<thead>
<tr>
<th></th>
<th>Pre-Implementation</th>
<th>Post-Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trips</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Requested</td>
<td>19,431</td>
<td>19,887</td>
</tr>
<tr>
<td>Denied</td>
<td>270</td>
<td>147</td>
</tr>
<tr>
<td>% Denied</td>
<td>1.40%</td>
<td>0.74%</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

In DARTS' case the first condition did not exist before or after implementation. Prior to Quo Vadis, DARTS turned down very few trips. Following implementation, DARTS made no effort to stimulate latent trip demand and the volume of requests did not increase significantly. With few denials and no additional demand it is essentially impossible to reduce the percentage of trip denials.

This is especially true given that few of the already small number of denials made were made due to insufficient capacity. DARTS management indicated that some denials were made because the requested trip could be served much more efficiently on a different day, a day when, given the “runs” established around standing order trips, a vehicle would be in the vicinity of the rider’s origin and destination. Given the manner in which DARTS has utilized Quo Vadis, it is unlikely the software produced scheduling process eliminated the basis for such denials.

M O E 2.3 Improve (Maintain) Rider Perceptions of Service

Implementation of computer-aided scheduling affected DARTS customer relations in ways which can affect rider perceptions of service quality. This measure of effectiveness was developed in recognition of the potential for this new approach to affect customer satisfaction.

Methodology

Rider perceptions before and after implementation were measured with written surveys. The pre-implementation survey was done in May 1995. Several questions relating to areas potentially affected by Smart DARTS were added to DARTS' regularly scheduled spring rider survey. The post-implementation survey was done in November specifically for this evaluation. DARTS administered both surveys. Both surveys were handed out to DARTS riders “on board”. Surveys were returned to DARTS by mail.
Approximately 170 pre-implementation surveys were returned. Approximately 125 post-implementation surveys were returned. The exact number of surveys handed out is unknown. These figures represent likely response rates of between 30 and 60 percent.

Results

Pre-Implementation Rider Perceptions & Expectations

The implementation of Quo Vadis was expected to improve DARTS capability to satisfy same day trip requests. The information in this section serves to establish rider perceptions and expectations relative to same day trips.

Table 5.8 indicates that nearly half of all DARTS riders surveyed have requested a same day trip. Table 5.9 shows how far in advance riders feel they usually must call to get a trip. Table 5.10 shows how far in advance riders prefer to call. Over two-thirds of riders surveyed feel that they usually have to call at least two days prior to their trip. Over 60 percent of respondents would prefer to call in later than that. Approximately 20 percent would prefer to call in on the day of the trip. This supports the assumption that same day trip serving capabilities are important.

Pre- and Post-Implementation Rider Perceptions

Tables 5.11 through 5.14 compares rider responses to questions that appeared verbatim on both the pre- and post-implementation surveys. These questions address overall service quality as well as the quality of specific services potentially affected by computer-aided scheduling.

DARTS service was rated quite highly both before and after implementation of Quo Vadis. Approximately 80 percent of respondents rated DARTS overall service quality “very good” or “excellent” on both surveys. The convenience in arranging rides and the service received from ride request takers was also rated extremely quite highly both before and after implementation. On these measures, between 70 and 85 percent of respondents rated service “very good” or “excellent”. “Write-in” data collected through the surveys also clearly and strongly supports the finding that DARTS overall service quality is perceived to be excellent. Many, many comments reflected the sentiment that DARTS is doing an excellent job of performing a much valued service.

The results in Table 5.12 suggest that, at least thus far, Quo Vadis has not affected rider perceptions of the required trip reservation lead time. Most riders continue to believe that reservations must be made at least two days prior to the desired travel day.

The results in Table 5.13 indicate that riders feel that their same day trip requests are being satisfied much more regularly now. As presented under MOE 1.2, this perception is not supported by observed data.
### TABLE 5.8
PRE-IMPLEMENTATION RIDER SURVEY
SAME DAY TRIP RESERVATIONS

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you called DARTS for a same day trip?</td>
<td>47%</td>
<td>53%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

### TABLE 5.9
PRE-IMPLEMENTATION RIDER PERCEPTIONS
(SAME DAY TRIPS)

<table>
<thead>
<tr>
<th>Questions/Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>How far in advance of your trip do you usually have to call to make sure you get your ride?</td>
<td></td>
</tr>
<tr>
<td>1 Day</td>
<td>24%</td>
</tr>
<tr>
<td>2 Days</td>
<td>32%</td>
</tr>
<tr>
<td>3-5 Days</td>
<td>17%</td>
</tr>
<tr>
<td>7 Days</td>
<td>17%</td>
</tr>
<tr>
<td>14 Days</td>
<td>9%</td>
</tr>
<tr>
<td>15 Days</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996
### TABLE 5.10
**PRE-IMPLEMENTATION RIDER PREFERENCES**  
(SAME DAY TRIPS)

<table>
<thead>
<tr>
<th>Questions/Response</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ideally, how far in advance of your trip would you like to call DARTS for your ride?</td>
<td></td>
</tr>
<tr>
<td>Same Day</td>
<td>17%</td>
</tr>
<tr>
<td>1 Day</td>
<td>46%</td>
</tr>
<tr>
<td>2 Days</td>
<td>20%</td>
</tr>
<tr>
<td>3-5 Days</td>
<td>9%</td>
</tr>
<tr>
<td>7 Days</td>
<td>5%</td>
</tr>
<tr>
<td>14 Days</td>
<td>2%</td>
</tr>
<tr>
<td>15 Days +</td>
<td>1%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

### TABLE 5.11
**PRE- VS. POST-IMPLEMENTATION RIDER PERCEPTIONS: SERVICE QUALITY**

<table>
<thead>
<tr>
<th>Question</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>The service from the people who take your ride requests...</td>
<td></td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td></td>
</tr>
<tr>
<td>Post-Implementation</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>54%</td>
</tr>
<tr>
<td>Very Good</td>
<td>26%</td>
</tr>
<tr>
<td>Good</td>
<td>16%</td>
</tr>
<tr>
<td>Fair</td>
<td>2%</td>
</tr>
<tr>
<td>Poor</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Very Poor</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>No Opinion</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Change</td>
<td>-8</td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td></td>
</tr>
<tr>
<td>Post-Implementation</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>46%</td>
</tr>
<tr>
<td>Very Good</td>
<td>39%</td>
</tr>
<tr>
<td>Good</td>
<td>11%</td>
</tr>
<tr>
<td>Fair</td>
<td>2%</td>
</tr>
<tr>
<td>Poor</td>
<td>0%</td>
</tr>
<tr>
<td>Very Poor</td>
<td>0%</td>
</tr>
<tr>
<td>No Opinion</td>
<td>2%</td>
</tr>
<tr>
<td>Change</td>
<td>+13</td>
</tr>
<tr>
<td>The convenience of arranging rides...</td>
<td></td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td></td>
</tr>
<tr>
<td>Post-Implementation</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>49%</td>
</tr>
<tr>
<td>Very Good</td>
<td>26%</td>
</tr>
<tr>
<td>Good</td>
<td>19%</td>
</tr>
<tr>
<td>Fair</td>
<td>3%</td>
</tr>
<tr>
<td>Poor</td>
<td>1%</td>
</tr>
<tr>
<td>Very Poor</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>No Opinion</td>
<td>2%</td>
</tr>
<tr>
<td>Change</td>
<td>-6</td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td></td>
</tr>
<tr>
<td>Post-Implementation</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>43%</td>
</tr>
<tr>
<td>Very Good</td>
<td>28%</td>
</tr>
<tr>
<td>Good</td>
<td>20%</td>
</tr>
<tr>
<td>Fair</td>
<td>8%</td>
</tr>
<tr>
<td>Poor</td>
<td>0%</td>
</tr>
<tr>
<td>Very Poor</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>No Opinion</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Change</td>
<td>+2</td>
</tr>
<tr>
<td>The overall quality of service...</td>
<td></td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td></td>
</tr>
<tr>
<td>Post-Implementation</td>
<td></td>
</tr>
<tr>
<td>Excellent</td>
<td>56%</td>
</tr>
<tr>
<td>Very Good</td>
<td>23%</td>
</tr>
<tr>
<td>Good</td>
<td>20%</td>
</tr>
<tr>
<td>Fair</td>
<td>&lt;1%</td>
</tr>
<tr>
<td>Poor</td>
<td>0%</td>
</tr>
<tr>
<td>Very Poor</td>
<td>0%</td>
</tr>
<tr>
<td>No Opinion</td>
<td>0%</td>
</tr>
<tr>
<td>Change</td>
<td>-4</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

### TABLE 5.12
**PRE- VS. POST-IMPLEMENTATION**
### RIDER PERCEPTIONS: TRIP RESERVATION LEAD TIME

<table>
<thead>
<tr>
<th>Question/Condition</th>
<th>1 Day</th>
<th>2 Days</th>
<th>3-5 Days</th>
<th>7 Days</th>
<th>14 Days</th>
<th>15 Days +</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>How far in advance of your trip do you usually have to call to make sure you get your ride?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td>24%</td>
<td>32%</td>
<td>17%</td>
<td>17%</td>
<td>9%</td>
<td>1%</td>
<td>100%</td>
</tr>
<tr>
<td>Post-Implementation</td>
<td>25%</td>
<td>34%</td>
<td>21%</td>
<td>12%</td>
<td>8%</td>
<td>0%</td>
<td>100%</td>
</tr>
<tr>
<td>Change</td>
<td>+1</td>
<td>+2</td>
<td>+4</td>
<td>-5</td>
<td>-1</td>
<td>-1</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

### TABLE 5.13
PRE- VS. POST-IMPLEMENTATION
RIDER PERCEPTIONS: SAME DAY TRIP REQUESTS

<table>
<thead>
<tr>
<th>Question/Condition</th>
<th>Always</th>
<th>Sometimes</th>
<th>Seldom</th>
<th>Never</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>If you have called DARTS for a same day trip, how often have you been able to get your ride?</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td>18%</td>
<td>31%</td>
<td>14%</td>
<td>37%</td>
<td>100%</td>
</tr>
<tr>
<td>Post-Implementation</td>
<td>49%</td>
<td>24%</td>
<td>6%</td>
<td>21%</td>
<td>100%</td>
</tr>
<tr>
<td>Change</td>
<td>+31</td>
<td>-7</td>
<td>-8</td>
<td>-16</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996
The results in Table 5.14 indicate that riders generally believe they are spending more time on the phone during trip reservation calls. As discussed under MOE 2.1, this perception is supported by observed data.

Table 5.15 presents the results of post-implementation survey questions that targeted riders' perceptions of changes since implementation of Quo Vadis. Not surprisingly, most respondents indicated that conditions have stayed “about the same” since implementation, a finding which is generally supported by observed data.

Note that for questions 7, 8, 13 and 17 responses indicating an “increase” represent a reduction in service quality. For these questions, between 15 and 25 percent of respondents indicated that conditions have worsened “slightly” or “greatly”. In some cases these perceptions are consistent with observed changes and in some cases they are not. As discussed under MOE 2.1, the average duration of trip request calls has increased. On the other hand, average trip duration (MOE 2.5) has not.

For questions 9 through 12, responses indicating that something occurs “more often” represent improvements in service quality. For these questions, between 20 and 30 percent of respondents noted improvements in service (responses of “a lot more often” or “slightly more often”). Again, support for these perceptions is mixed. As discussed under MOE 1.1, on-time pickup performance has essentially not changed. However, the finding that 20 percent of respondents believe they receive more ride confirmations during their initial request call is supported by data presented under MOE 4.3.

Conclusions

The following conclusions are based on the preceding findings:

- The vast majority of riders surveyed believe that DARTS provides extremely high quality service. This has not changed since implementation of Quo Vadis.
- Many riders desire same day trip service. Approximately half have requested a same day trip. Riders perceive that more of their same day trip requests are being satisfied. Data does not support this.
- Over half of surveyed riders would prefer to call in no earlier than two days prior to the day of the trip. Less than one-quarter currently feel they are able to call in within just a day or two of their desired travel day. The implementation of Quo Vadis has not changed riders’ perceptions of the service they are receiving in this area.
- When asked about specific changes in services over the months since implementation, most riders surveyed think things have “stayed about the same”. A minority of riders, ranging from 15 to 30 percent, believe the quality of some services has changed.
- Perceptions that more same day trip requests are satisfied, that trips last longer and that on-time pickup performance have improved are not supported by the actual operating data collected in this evaluation. The perception that more trip requests are confirmed immediately is supported by observed data.
### TABLE 5.14
**PRE- VS. POST-IMPLEMENTATION RIDER PERCEPTIONS: TRIP REQUEST CALL DURATION**

<table>
<thead>
<tr>
<th>Question/Condition</th>
<th>Percentage</th>
<th>Don’t Know</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>&lt; .5</td>
<td>.5-1</td>
<td>1-2</td>
</tr>
<tr>
<td>When you call DARTS to request a ride, about how many minutes does it take to make the request?</td>
<td>13%</td>
<td>31%</td>
<td>17%</td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td>5%</td>
<td>24%</td>
<td>32%</td>
</tr>
<tr>
<td>Change</td>
<td>-8</td>
<td>-7</td>
<td>+15</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996
## TABLE 5.15
POST-IMPLEMENTATION RIDER SURVEY RESULTS
PERCEIVED CHANGES IN SERVICE

<table>
<thead>
<tr>
<th>Question</th>
<th>Percentage Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Increased Greatly</td>
</tr>
<tr>
<td>7. In the last three (3) months, the amount of time on the phone needed to make my ride request has</td>
<td>7%</td>
</tr>
<tr>
<td>8. In the last three (3) months, the number of days in advance that I have to call to make a request has</td>
<td>7%</td>
</tr>
<tr>
<td>13. In the last three (3) months, the amount of time that I am usually riding on the bus has</td>
<td>14%</td>
</tr>
<tr>
<td>15. In the last three (3) months, the number of other passengers riding at the same time as I do has</td>
<td>2%</td>
</tr>
<tr>
<td>17. Has this amount of call-ahead time</td>
<td>5%</td>
</tr>
<tr>
<td>A Lot More Often</td>
<td>Slightly More Often</td>
</tr>
<tr>
<td>9. In the last three (3) months, I am able to get the rides I usually request</td>
<td>14%</td>
</tr>
<tr>
<td>10. In the last three (3) months, when I make my request the ride is confirmed or guaranteed when I call</td>
<td>10%</td>
</tr>
<tr>
<td>11. In the last three (3) months, the bus has arrived at my home to pick me up on time</td>
<td>18%</td>
</tr>
<tr>
<td>12. In the last three (3) months, the bus has arrived at the destination for my trip on time</td>
<td>14%</td>
</tr>
</tbody>
</table>
M O E 2.4 Reduce average trip duration

Trip duration is the total time each rider spends in the vehicle, from pickup to drop off. By producing schedules with more optimal routing, it was assumed that Quo Vadis could potentially reduce average trip duration.

Methodology

Pre-implementation data was collected in May 1995 by DARTS drivers and recorded in driver logs. Post-implementation data was collected in the same fashion in November 1995. The before and after percentage of trips falling into various time ranges, and the before and after average trip duration were compared.

Results and Conclusions

Trip duration did not change significantly after implementation of Quo Vadis. It is possible that the schedules produced by Quo Vadis were more efficient than those produced manually but that the efficiency improvements were not reflected in passenger trip length. Trip duration is only one potential indicator of a more “efficient” schedule. Passengers per revenue vehicle hour/mile, also considered in this analysis, provides another important measure of schedule efficiency.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Average Duration (minutes)</th>
<th>Percentage of Trips by Trip Duration (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0-30</td>
</tr>
<tr>
<td>Pre-Implementation</td>
<td>24.9</td>
<td>74%</td>
</tr>
<tr>
<td>Post-Implementation</td>
<td>25.9</td>
<td>71%</td>
</tr>
<tr>
<td>Change</td>
<td></td>
<td>-3</td>
</tr>
</tbody>
</table>

Source: DARTS, BRW, Inc., January 1996
5.3.3 INCREASE SYSTEM CAPACITY

MOE 3.1 Increase the percentage of demand trips served

This MOE is a very indirect measure of the impact of Quo Vadis in that it depended upon a number of more direct impacts of the software. First, it was assumed that Quo Vadis could produce schedules that could accommodate more trips. Second, it assumed that the labor saving capabilities of the software could allow DARTS office staff to schedule more trips in the same period of time. Third, it was assumed this resulting capacity could be utilized and that ridership would increase. Finally, it was assumed that the bulk of the initial increase in ridership would be in demand rather than subscription trips, causing the relative percentage of demand trips served to increase.

Methodology

DARTS office staff recorded the percentage of demand and standing order trips before and after implementation. Pre-implementation data was collected in May 1995. Post-implementation data was collected over a three month period from September 1995 to November 1995. The three month post-implementation average was compared to pre-implementation data.

<table>
<thead>
<tr>
<th>TABLE 5.17</th>
<th>PERCENTAGE OF DEMAND AND STANDING ORDER TRIPS (1995)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip Type</td>
<td>Pre-Implementation</td>
</tr>
<tr>
<td>Demand</td>
<td>48%</td>
</tr>
<tr>
<td>Standing Order</td>
<td>52%</td>
</tr>
</tbody>
</table>

Source: DARTS, BRW, Inc., January 1996

Results and Conclusions

Table 5.17 shows that the percentage of demand trips did not increase after implementation. Although the post-implementation months saw steady decreases in percentages of standing order trips, the three month average is identical to pre-implementation trip characteristics. As discussed in the beginning of Section 5.3, DARTS ridership did not increase following implementation of Quo Vadis. The possible reasons for this are discussed in Section 6.0, “Conclusions”. Regardless of why ridership did not increase, the absence of an increase eliminated the potential for the percentage of demand trips to increase.
5.3.4 INCREASE COST EFFECTIVENESS

All of the MOEs under this objective are indirect measures of the impact of Quo Vadis; they all depend on one of two possible conditions:

1. Increased ridership; and/or
2. Reduced vehicle hours and miles.

MOE 4.1 Increase the average number of passengers per mile

It was assumed that due primarily to its triangulation scheduling algorithm, Quo Vadis could produce more efficient schedules; schedules capable of serving more trips in the same number of vehicle miles.

Methodology

Passengers per mile is a standard statistic recorded monthly by DARTS. Passengers per mile is calculated by comparing the total number of passengers served to the total number of miles traveled by the entire DARTS fleet during a month. For this evaluation pre-implementation and post-implementation data was analyzed for the months of August through November. Pre-implementation statistics from 1993 and 1994 was compared to 1995 post-implementation statistics.

<table>
<thead>
<tr>
<th>Month</th>
<th>1993</th>
<th>1994</th>
<th>1995</th>
</tr>
</thead>
<tbody>
<tr>
<td>August</td>
<td>0.16</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>September</td>
<td>0.17</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>October</td>
<td>0.17</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>November</td>
<td>0.18</td>
<td>0.16</td>
<td>0.17</td>
</tr>
<tr>
<td>Average</td>
<td>0.17</td>
<td>0.16</td>
<td>0.17</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

Results and Conclusions

As shown in Table 5.18, this MOE was unaffected by Quo Vadis. This finding is understandable given that ridership did not increase and total vehicle miles did not decrease. The potential reasons why these conditions did not materialize are discussed in Section 6.0, “Conclusions”.

MOE 4.2 Increase the average number of passengers per revenue hour

The logic for improvement in this MOE is the same as for MOE 4.1: Quo Vadis was expected to produce more efficient schedules.
Methodology

DARTS routinely maintains passengers per revenue hour statistics. On a monthly basis the total number of trips served is compared to the total net driver hours. Net hours include time drivers spent providing service and exclude paid non-service hours including vacation and sick time. Pre-implementation data from 1993 and 1994 was compared to 1995 post-implementation data for the months of August through November.

Some “dead head” time, time not actually spent providing service, is included in revenue hours. Dead head time includes paid driver breaks and time spent to traveling and from the DARTS garage. Because elimination of this time was not possible given the pre-implementation data that was available, dead head time was included in both the pre- and post-implementation calculations.

Results and Conclusions

This MOE was not significantly impacted by Quo Vadis. This finding is understandable given that ridership did not increase and total driver hours did not decrease. The potential reasons why these conditions did not materialize are discussed in Section 6.0, “Conclusions”.

<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>2.60</td>
<td>2.54</td>
</tr>
<tr>
<td>September</td>
<td>2.55</td>
<td>2.91</td>
</tr>
<tr>
<td>October</td>
<td>2.78</td>
<td>2.54</td>
</tr>
<tr>
<td>November</td>
<td>2.34</td>
<td>2.16</td>
</tr>
<tr>
<td>Average</td>
<td>2.57</td>
<td>2.54</td>
</tr>
</tbody>
</table>

Source: DARTS, BRW, Inc., January 1996

MOE 4.3 Reduce the scheduling/dispatch labor hours

As explained in Section 2.0, an increase in scheduling and dispatch staff efficiency, made possible by the labor saving capabilities offered by the software, was identified as one potential benefit of computer-aided scheduling software.
DARTS scheduling and dispatch office staff were asked to maintain daily logs indicating the number of hours spent each day performing various scheduling and dispatch functions. Employees were asked to assign their time to one of the following categories:

- Scheduling
- Dispatching
- Requests/Call Taking
- Confirmation Calls
- Report Generation/Record Keeping
- Data Entry
- Cancellations
- Other

Employees were provided with explanations of each of these categories in order to help them accurately and consistently categorize their time. As discussed in greater detail in Section 4.0, implementation of computer-aided scheduling software significantly changed office staff functions. As a result, the definitions of the above categories were modified slightly in order to encourage categorization of work in a manner which would allow subsequent “apples-to-apples” comparisons.

Despite measures to establish consistency and promote direct comparisons when collecting staff time utilization data, it is likely that the categorization of any given work task varied considerably from day-to-day and from employee to employee. This, combined with the inherent dissimilarity of some of the pre- and post-implementation scheduling and dispatch functions, made it advisable to avoid drawing strong conclusions based on this data. Data suggests that apparent shifts in the time spent on various tasks should be interpreted cautiously.

Initially, this data was planned to be collected over an entire month under both the pre- and post-implementation conditions. However, DARTS management, who coordinated the collection of this data, reported considerable difficulty in persuading all employees to consistently maintain accurate logs of their time over such an extended period. As a result, 15 days of pre-implementation data and 6 days of post-implementation data were collected over the periods shown in Table 5.20.

Results and Conclusions

Tables 5.21 through 5.23 present the DARTS scheduling and dispatch staff daily labor hour logs for the pre- and post-implementation periods that were obtained and used to assess the impact of the new software on scheduling and dispatch staff hours. The following observations pertain to the data in Tables 5.21 through 5.23.

- The daily time required to complete many functions appears to vary considerably from day to day. This variability suggests that more days worth of data is required in order to develop strong conclusions.

Based on this data, the average time required for daily scheduling and dispatch tasks has thus far not been significantly effected by the implementation of computer-aided scheduling. Using manual techniques, an average of approximately 38 hours were devoted to these tasks each day. Using Quo Vadis, an average of approximately 36 hours are required. Given the reliability of the data and the potential for non-meaningful variation, this difference is probably too small to be significant.
## TABLE 5.20
**STAFF LABOR HOURS DATA COLLECTION**

<table>
<thead>
<tr>
<th>Day</th>
<th>Pre-Implementation Date</th>
<th>Post-Implementation Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday</td>
<td>May 10, 1995</td>
<td>Wednesday November 15, 1995</td>
</tr>
<tr>
<td>Thursday</td>
<td>May 11, 1995</td>
<td>Thursday November 16, 1995</td>
</tr>
<tr>
<td>Friday</td>
<td>May 12, 1995</td>
<td>Friday November 17, 1995</td>
</tr>
<tr>
<td>Tuesday</td>
<td>May 16, 1995</td>
<td>Tuesday November 21, 1995</td>
</tr>
<tr>
<td>Wednesday</td>
<td>May 17, 1995</td>
<td>Wednesday November 22, 1995</td>
</tr>
<tr>
<td>Thursday</td>
<td>May 18, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Friday</td>
<td>May 19, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Monday</td>
<td>May 22, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Tuesday</td>
<td>May 23, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Wednesday</td>
<td>May 24, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Thursday</td>
<td>May 25, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Friday</td>
<td>May 26, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Tuesday</td>
<td>May 30, 1995</td>
<td>NA</td>
</tr>
<tr>
<td>Wednesday</td>
<td>May 31, 1995</td>
<td>NA</td>
</tr>
</tbody>
</table>
Table 5.21
Pre-Implementation (May 1995)
DARTS Transit Office Staff
Labor Hours by Task

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Scheduling</th>
<th>Dispatch</th>
<th>Trip Requests</th>
<th>Data Entry</th>
<th>Reports</th>
<th>Call In/Out</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday</td>
<td>5/10</td>
<td>11.5</td>
<td>0.8</td>
<td>10.8</td>
<td>5.0</td>
<td>6.3</td>
<td>3.0</td>
<td>2.8</td>
<td>40.2</td>
</tr>
<tr>
<td>Thursday</td>
<td>5/11</td>
<td>14.3</td>
<td>2.8</td>
<td>8.8</td>
<td>4.5</td>
<td>8.0</td>
<td>2.0</td>
<td>1.0</td>
<td>41.4</td>
</tr>
<tr>
<td>Friday</td>
<td>5/12</td>
<td>21.0</td>
<td>3.0</td>
<td>9.0</td>
<td>6.8</td>
<td>0.5</td>
<td>2.0</td>
<td>0.3</td>
<td>42.6</td>
</tr>
<tr>
<td>Monday</td>
<td>5/15</td>
<td>9.5</td>
<td>2.0</td>
<td>12.3</td>
<td>7.0</td>
<td>0.3</td>
<td>1.5</td>
<td>8.3</td>
<td>40.9</td>
</tr>
<tr>
<td>Tuesday</td>
<td>5/16</td>
<td>8.5</td>
<td>3.0</td>
<td>11.0</td>
<td>6.5</td>
<td>1.3</td>
<td>0.5</td>
<td>19.0</td>
<td>49.8</td>
</tr>
<tr>
<td>Wednesday</td>
<td>5/17</td>
<td>7.3</td>
<td>8.0</td>
<td>4.0</td>
<td>1.0</td>
<td>3.5</td>
<td>1.0</td>
<td>9.5</td>
<td>34.3</td>
</tr>
<tr>
<td>Thursday</td>
<td>5/18</td>
<td>1.8</td>
<td>5.3</td>
<td>9.8</td>
<td>9.3</td>
<td>5.0</td>
<td>1.0</td>
<td>1.5</td>
<td>33.7</td>
</tr>
<tr>
<td>Friday</td>
<td>5/19</td>
<td>2.0</td>
<td>4.5</td>
<td>4.5</td>
<td>1.0</td>
<td>0.3</td>
<td>0.5</td>
<td>3.0</td>
<td>15.8</td>
</tr>
<tr>
<td>Monday</td>
<td>5/22</td>
<td>1.3</td>
<td>8.5</td>
<td>13.0</td>
<td>3.8</td>
<td>3.8</td>
<td>1.0</td>
<td>21.0</td>
<td>52.4</td>
</tr>
<tr>
<td>Tuesday</td>
<td>5/23</td>
<td>7.0</td>
<td>7.3</td>
<td>7.8</td>
<td>3.3</td>
<td>5.0</td>
<td>1.8</td>
<td>7.5</td>
<td>39.7</td>
</tr>
<tr>
<td>Wednesday</td>
<td>5/24</td>
<td>1.0</td>
<td>6.5</td>
<td>7.8</td>
<td>8.5</td>
<td>0.8</td>
<td>0.8</td>
<td>13.0</td>
<td>38.4</td>
</tr>
<tr>
<td>Thursday</td>
<td>5/25</td>
<td>1.8</td>
<td>5.8</td>
<td>5.8</td>
<td>0.5</td>
<td>0.0</td>
<td>1.3</td>
<td>13.3</td>
<td>28.5</td>
</tr>
<tr>
<td>Friday</td>
<td>5/26</td>
<td>0.3</td>
<td>6.8</td>
<td>4.0</td>
<td>0.8</td>
<td>0.5</td>
<td>0.5</td>
<td>6.3</td>
<td>19.2</td>
</tr>
<tr>
<td>Tuesday</td>
<td>5/30</td>
<td>6.0</td>
<td>9.0</td>
<td>11.8</td>
<td>3.0</td>
<td>5.5</td>
<td>1.0</td>
<td>12.3</td>
<td>48.6</td>
</tr>
<tr>
<td>Wednesday</td>
<td>5/31</td>
<td>3.3</td>
<td>8.5</td>
<td>7.0</td>
<td>5.3</td>
<td>0.3</td>
<td>1.0</td>
<td>15.3</td>
<td>40.7</td>
</tr>
</tbody>
</table>

| Total Hours | 96.6 | 81.8 | 127.4 | 66.3 | 41.1 | 18.9 | 134.1 | 566.2 |
| Average Hours (% of Avg. Daily Total) | 6.4 (17.1%) | 5.4 (14.4%) | 8.5 (22.5%) | 4.4 (11.7%) | 2.7 (7.3%) | 1.3 (3.3%) | 8.9 (23.7%) | 37.6 (100.0%) |
### Table 5.22
Post-Implementation (November 1995)
DARTS Transit Office Staff
Labor Hours by Task

<table>
<thead>
<tr>
<th>Day</th>
<th>Date</th>
<th>Scheduling</th>
<th>Dispatch</th>
<th>Schedule</th>
<th>Book</th>
<th>Total</th>
<th>Data Entry</th>
<th>Reports</th>
<th>Trip Cancels</th>
<th>Call In/Out</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wednesday</td>
<td>11/15</td>
<td>6.0</td>
<td>9.8</td>
<td>4.3</td>
<td>6.0</td>
<td>10.3</td>
<td>0.3</td>
<td>0.0</td>
<td>0.0</td>
<td>2.5</td>
<td>4.3</td>
<td>33.2</td>
</tr>
<tr>
<td>Thursday</td>
<td>11/16</td>
<td>12.8</td>
<td>10.5</td>
<td>3.8</td>
<td>11.3</td>
<td>15.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.8</td>
<td>4.8</td>
<td>44.0</td>
</tr>
<tr>
<td>Friday</td>
<td>11/17</td>
<td>6.3</td>
<td>9.0</td>
<td>2.8</td>
<td>11.3</td>
<td>14.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.3</td>
<td>1.5</td>
<td>0.3</td>
<td>31.5</td>
</tr>
<tr>
<td>Monday</td>
<td>11/20</td>
<td>12.0</td>
<td>11.5</td>
<td>0.3</td>
<td>11.8</td>
<td>12.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.8</td>
<td>1.8</td>
<td>3.3</td>
<td>41.5</td>
</tr>
<tr>
<td>Tuesday</td>
<td>11/21</td>
<td>17.3</td>
<td>4.8</td>
<td>1.8</td>
<td>12.3</td>
<td>14.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.5</td>
<td>0.8</td>
<td>2.8</td>
<td>40.3</td>
</tr>
<tr>
<td>Wednesday</td>
<td>11/22</td>
<td>14.0</td>
<td>3.5</td>
<td>0.0</td>
<td>9.0</td>
<td>9.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.5</td>
<td>1.0</td>
<td>28.0</td>
</tr>
<tr>
<td><strong>Total Hours</strong></td>
<td></td>
<td>68.4</td>
<td>49.1</td>
<td>13.0</td>
<td>61.7</td>
<td>74.3</td>
<td>0.3</td>
<td>0.0</td>
<td>1.6</td>
<td>7.9</td>
<td>16.5</td>
<td>218.5</td>
</tr>
<tr>
<td><strong>Average Hours</strong></td>
<td></td>
<td>11.4</td>
<td>8.2</td>
<td>2.2</td>
<td>10.3</td>
<td>12.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.3</td>
<td>1.3</td>
<td>2.8</td>
<td>36.4</td>
</tr>
<tr>
<td>(% of Avg. Daily Total)</td>
<td></td>
<td>(31.4%)</td>
<td>(22.6%)</td>
<td>(5.9%)</td>
<td>(28.3%)</td>
<td>(34.2%)</td>
<td>(0.0%)</td>
<td>(0.0%)</td>
<td>(0.7%)</td>
<td>(3.6%)</td>
<td>(7.5%)</td>
<td>(100.0%)</td>
</tr>
</tbody>
</table>
Table 5.23
Comparison of Pre- and Post- Implementation Averages
Transit Office Staff Labor Hours by Task

<table>
<thead>
<tr>
<th>Requests</th>
<th>Scheduling</th>
<th>Dispatch</th>
<th>Schedule</th>
<th>Book</th>
<th>Total</th>
<th>Data Entry</th>
<th>Reports</th>
<th>Trip Cancels</th>
<th>Call In/Out</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Daily Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Imp.</td>
<td>6.4</td>
<td>5.4</td>
<td>NA</td>
<td>NA</td>
<td>8.5</td>
<td>4.4</td>
<td>2.7</td>
<td>NA</td>
<td>1.3</td>
<td>8.9</td>
<td>37.6</td>
</tr>
<tr>
<td>Post-Imp.</td>
<td>11.4</td>
<td>8.2</td>
<td>2.2</td>
<td>10.3</td>
<td>12.4</td>
<td>0.1</td>
<td>0.0</td>
<td>0.3</td>
<td>1.3</td>
<td>2.8</td>
<td>36.4</td>
</tr>
<tr>
<td>% Change</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NA</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of Total Hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Imp.</td>
<td>17.1</td>
<td>14.4</td>
<td>NA</td>
<td>NA</td>
<td>14.4</td>
<td>22.5</td>
<td>11.7</td>
<td>NA</td>
<td>3.3</td>
<td>23.7</td>
<td>100.0</td>
</tr>
<tr>
<td>Post-Imp.</td>
<td>31.4</td>
<td>22.6</td>
<td>5.9</td>
<td>28.3</td>
<td>34.2</td>
<td>0.0</td>
<td>0.0</td>
<td>0.7</td>
<td>3.6</td>
<td>7.5</td>
<td>100.0</td>
</tr>
<tr>
<td>Change</td>
<td>+14.3</td>
<td>+8.2</td>
<td>NA</td>
<td>NA</td>
<td>+19.8</td>
<td>-22.5</td>
<td>-11.7</td>
<td>NA</td>
<td>+0.3</td>
<td>-16.2</td>
<td>0.0</td>
</tr>
</tbody>
</table>
Although the reliability of the data precludes meaningful direct comparisons of the time associated with specific functions, the data does suggest that more time is spent on the scheduling/dispatch functions themselves and less time on data entry and reporting.

This data suggests that the majority of demand trip requests are not being scheduled during the initial trip request call; on average only about 20 percent (2.13 hours/day) of the time devoted to trip requests was classified as "scheduling" and about 80 percent (10.25 hours/day) was classified as "book" only (recording the request and making a preliminary schedule assignment). The data on confirmation calls ("call in/out") support this finding. Booked trips require a confirmation call to supply a precise, confirmed trip time. This data indicates that the time spent on calls has not decreased.

Without a clearly defined product against which to compare the reported labor hours, the possibility that more work is actually being done in the same amount of time cannot be ruled out. For example, anecdotal data suggests that DARTS is working farther ahead in terms of the preparation and revision of future pre-schedules. Since employees had no ability to distinguish next day and future day scheduling tasks, it is possible that such work could explain the apparent increase, or at least the apparent absence of a decrease, in scheduling hours.

M O E 4.4  Reduce the average cost per trip

Average cost per trip is the total amount of DARTS’ expenditures divided by the total number of passengers served. Expenditures include overhead costs, labor, vehicles, vehicle maintenance, fuel, etc. Passengers per mile directly affects cost per trip as does fuel price, wages, and maintenance costs.

This MOE could be impacted only indirectly by Quo Vadis. The cost per trip could have been reduced if more trips were served with the same or fewer resources or if the same number of trips were served with less resources. As discussed previously, both ridership increases and resource efficiencies depend upon a number of other conditions being met, including that Quo Vadis actually delivered expected benefits and that these benefits were exploited.

Methodology

DARTS maintains cost per trip on a monthly basis as part of their standard record keeping practices. Annual cost per trip data for 1993 and 1994 and January-July of 1995 was compared to post-implementation for August-November 1995.

Results and Conclusions

DARTS average cost per trip decreased following the introduction of Quo Vadis. However, since none of the necessary precursor benefits, including labor and schedule efficiencies, were adequately demonstrated and attributed to software impacts, this reduction cannot be attributed to Quo Vadis.
In the absence of these pre-cursor benefits, it is assumed that the observed change in average cost resulted from fluctuations in other variables, such as fuel prices, wages or maintenance costs.

### TABLE 5.24
AVERAGE COST PER TRIP

<table>
<thead>
<tr>
<th></th>
<th>Pre-Implementation</th>
<th>Post-Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>$11.71</td>
<td>$11.36</td>
</tr>
</tbody>
</table>

Source: DARTS, BRW, Inc., January 1996

**MOE 4.5 Reduce the average subsidy per trip**

The Metropolitan Council provides a variable subsidy to DARTS to help cover ridership costs. The amount of subsidy is determined by the gap in costs compared to revenues generated by fares, donations, and the Dakota County subsidy. In the absence of fare increases and changes in the relative number of the various types of trips DARTS serves, changes in this MOE would therefore depend entirely changes in the average cost per trip (MOE 4.4).

**Methodology**

The Metropolitan Council provides its subsidy to DARTS monthly. DARTS maintains monthly subsidy records to track its overall costs of providing service. Monthly records are compiled into yearly averages. Pre-implementation data includes average subsidies provided to DARTS between 1993 and 1995. Data from 1993 and 1994 reflects the yearly averages. Pre-implementation 1995 data reflects the average subsidy up to the time of Quo Vadis implementation (approximately the first six months of 1995).

**Results and Conclusions**

The average subsidy per trip is entirely dependent upon the average cost per trip, unless fares or other revenues increase. Because the average cost per trip decreased after implementation of Quo Vadis, the average subsidy per trip also declined. As noted in MOE 4.5, however, reduced trip costs cannot be attributed to Quo Vadis in the absence of other pre-cursor benefits, including labor and schedule related efficiencies. The potential reasons why these pre-cursor benefits were not identified are discussed in Section 6.0, “Conclusions”.
### TABLE 5.25
**METROPOLITAN COUNCIL SUBSIDY PER TRIP**

<table>
<thead>
<tr>
<th></th>
<th>Pre-Implementation</th>
<th>Post-Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subsidy</td>
<td>$7.94</td>
<td>$8.08</td>
</tr>
</tbody>
</table>

Source: DARTS, BRW, Inc., January 1996

### 5.3.5 ENHANCE DARTS’ ABILITY TO MEET ADA REQUIREMENTS

#### MOE 5.1 Increase Peak Hour Demand Trip Availability

As discussed under MOE 3.1, it was presumed by the DARTS project team that if an increase in ridership was possible through the implementation of computer-aided scheduling, this increase would be seen primarily in demand trips, with the number of standing order trips remaining essentially unchanged in the short term. Such an increase would naturally raise the relative percentage of demand trips. Changes in the overall percentage of demand trips as an indicator of demand trip ridership increases is evaluated under MOE 3.1.

This MOE utilizes demand/standing order trip percentages as a measure of compliance with the American with Disabilities Act (ADA), which stipulates that no more than 50 percent of paratransit trips during any given period may be standing order trips. In order to measure compliance under “worst case” conditions this MOE considers the demand/standing order proportion only during DARTS peak service hours, identified by DARTS as 6:00-9:00 AM and 3:00-6:00 PM.

#### Methodology

Although the required information was and is available, the proportion of demand and standing order trips during peak periods was not a statistic routinely maintained by DARTS. As a result, this information was assembled by DARTS for this application.

Pre-implementation data was collected for the entire month of May 1995. Post-implementation data, collected using the Quo Vadis management information system and reporting capabilities, was collected for the entire month of November 1995. Based on DARTS experience, seasonal variations in this MOE are not significant enough to require seasonal adjustments. As a result, the May data has been compared directly with the November data.
Results and Conclusions

Table 5.26 presents pre- and post-implementation demand/standing order trip percentages. The following observations relate to the data shown in Table 5.20.

- Both before and after the introduction of computer-aided scheduling, the proportion of demand and standing order trips varied considerably by time of day.

- Standing order trips comprise the majority of trips during the AM and PM peak periods both pre- and post-implementation although they represent a higher proportion during the morning than in the afternoon.

- After implementation of Quo Vadis, the proportion of demand-to-standing order trips in the AM peak period is unchanged and far below the ADA required level. During the PM peak, the relative proportion of demand trips increased significantly, nearly to the 50 percent level required by ADA. During off peak hours, the relative proportion of demand trips decreased considerably but remained well in excess of the level required by ADA.

<table>
<thead>
<tr>
<th>TABLE 5.26</th>
<th>DEMAND/STANDING ORDER</th>
<th>TRIP PERCENTAGES BY TIME OF DAY</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time of Day</td>
<td>Pre-Implementation</td>
<td>Post-Implementation</td>
</tr>
<tr>
<td></td>
<td>Demand</td>
<td>Standing Order</td>
</tr>
<tr>
<td>AM Peak</td>
<td>28%</td>
<td>72%</td>
</tr>
<tr>
<td>(6:00 - 9:00 AM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM Peak</td>
<td>14%</td>
<td>86%</td>
</tr>
<tr>
<td>(3:00 - 6:00 PM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Off-Peak</td>
<td>86%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Source: DARTS; BRW, Inc., January 1996

It is important to point out that, considered on a daily basis, DARTS does satisfy ADA requirements concerning the proportion of demand and standing order trips. The preponderance of standing order trips in the AM is a direct reflection of the nature of paratransit demand. Many of the reoccurring trips made by paratransit riders are those which many people prefer to do in the morning, such as medical appointments or other social service trips as well as shopping or other errands. Although DARTS could easily achieve the required ADA proportion by denying standing order trip requests beyond a certain level, they understandably see the provision of needed trips as more important than the satisfaction of any single statistical requirement.
Given the presumed mechanism by which the percentage of standing order trips would be produced, i.e., by disproportionate increases in demand trips, and given the hurdles to overcome (the overwhelming preponderance of standing order trips during the peak periods) a fairly large increase in total ridership would be required to shift the peak period proportion of demand trips to a level close to the level required by ADA. The fact that the PM peak trip proportion shifted significantly toward ADA compliance therefore suggests that either some other aspect of the new DARTS scheduling approach is responsible for the improvement.

5.3.6 EASE OF DEPLOYMENT

Ease of deployment includes issues related to implementation time frame, DARTS resource commitment, vendor performance, and employee reaction. Overall, the negative aspects of the deployment effort relate to the considerable delays that were encountered, frustrations and inefficiencies associated with vendor dealings and the effort required on the part of DARTS to insure a successful implementation. Positive aspects of the deployment include the fact that the system was successfully installed and utilized and that the transition to the new system was made without any disruption to service or degradation of service quality. Specific deployment issues are discussed below.

Implementation Time Frame

Implementation took longer than planned. Unexpected delays were encountered at almost every juncture. Originally scheduled for four months, implementation required approximately 10 months. Major delays were encountered in negotiating the vendor contract. A contract was not signed until approximately six months after vendor selection. This was much longer than anticipated.

Significant delays were also encountered in completing the GIS map and in obtaining necessary supporting software from the vendor. The Dakota County GIS map did not originally cover the entire DARTS service area and was expanded for the project by Dakota County. Creation of the DARTS client file, an activity conducted by the vendor with DARTS assistance, also took longer than expected.

DARTS Resource Commitment

DARTS staff were intimately involved throughout the implementation process and devoted a great deal of time to the project that would not normally have been spent on scheduling-related issues. DARTS played an especially important role in refining the initial hardware specification identified in the Smart DARTS Feasibility Study and in assisting in the procurement, installation and testing of the equipment. DARTS management staff spent a considerable amount of time performing in-house orientation and staff training to support the formal training provided by the vendor.

To some extent, project delays were useful in providing the time necessary for DARTS staff to thoroughly familiarize themselves with the new system and to work closely with the vendor to work out any difficulties. Some of the effort expended by DARTS in preparation for the transition to the new scheduling system was probably non-critical to deployment. Although the extra effort undoubtedly contributed to the essentially flawless transition, it is likely that transition acceptable to agencies with different priorities and requirements could be achieved without this degree of involvement.

Vendor Performance
Overall, the software vendor performed acceptably. Ultimately, the vendor demonstrated the commitment required to successfully implement the vast majority of intended Phase 2 capabilities. However, numerous difficulties were encountered throughout the implementation process which contributed to delays and frustrations.

Several elements of the Quo Vadis package were not available on time. Much of the frustration and delay encountered during implementation related to these non-delivered items. Some of these elements were identified by the vendor as available at the vendor interview. Others were identified as under development. Several of the delayed software features were items which the vendor had to customize in order to meet DARTS specifications.

Non-delivered software elements include the Trapeze portion of the software, which provides on-line fixed-route transit schedules and route maps to facilitate transfers with fixed-route providers, maintenance-related functions, rider complaint recording capabilities, reporting capabilities and ARC/INFO map translation. The ARC/INFO translator proved to be the most difficult non-delivered item to resolve.

The translator converts the ARC/INFO format Dakota County GIS maps into the format required by Quo Vadis. DARTS required a two-way conversion capability so that Dakota County’s map could be converted, used and updated by DARTS, and they reconverted back to the Dakota County format for the County’s use. The vendor agreed to provide only the front half of this conversion capability. Significant time and effort was expended in negotiating the resolution of this issue. This issue was not successfully resolved at the end of the four month evaluation period.

Throughout roughly the first five months of the deployment effort, vendor responsiveness was a problem. Unusually long delays were encountered in returning phone calls and responding to requests. It became apparent that some of the delays were related to the vendor’s work load and staff inavailability. It is likely that difficulties experienced by the vendor in completing “customization” jobs for previous clients which were planned for use at DARTS, and in performing the customization requested by DARTS, were also responsible for vendor unresponsiveness.

After a change of vendor project supervision in early spring 1995, approximately four months prior to “going live”, vendor responsiveness improved. Under the closer attention of the vendor’s new project manager most of the undelivered items were resolved and training was successfully completed.
Since the “go live” date in late July 1995 DARTS and MnDOT have continued to work closely with the vendor to resolve the remaining few outstanding issues. Although slow, these efforts have been relatively successful. The four month evaluation time frame was insufficient to generate any significant conclusions regarding longer term vendor support.

**DARTS Employee Reaction/Organizational Impacts**

The technologies included in the Smart DARTS vision significantly change the way scheduling, dispatch and certain management functions are performed. The ability of a transit agency to adapt to these changes and to reorganize their work processes in ways that take advantage of the capabilities inherent in these technologies is critical.

**Pre-Implementation Expectations**

The relatively drawn-out implementation of Smart DARTS Phase 2 meant that staff and employees had a lot of time to consider and prepare for the changes associated with the new technology and procedures. Initially, and to some extent throughout the implementation process, some scheduling staff expressed concern that the technology would eliminate the need to “think” and that the software was “replacing” them. For some employees the prospect of change was quite threatening and employee concerns about the new technology may have been related to employee departures experienced by DARTS prior to implementation.

**Post-Implementation Reactions**

Overall, employee reactions to Quo Vadis implementation were positive. Scheduling, dispatch and driving staff all reported that the new system represented a major departure and required a significant adjustment but most employees have responded positively to the new system.

DARTS management staff reported that the new technology and associated procedures have had important office democratization and team-building impacts. The implementation of Quo Vadis has tended to diminish the segregation of skills and specialization that was practiced previously in the transit office. Now the responsibilities of scheduling staff are much more consistent and employees have been cross-trained such that one person can usually easily fill in for another. This provides new flexibility to management in staff utilization and makes covering for sick or vacationing staff easier.

DARTS management staff have also reported that the elimination of “specialist” roles, especially in the actual preparation of daily schedules, has instilled greater feelings of capability and responsibility among all scheduling staff and made each employee feel that they are an important member of “the team”.

Overall, Quo Vadis has helped democratize the scheduling process by spreading responsibility among the various staff members and eliminating specialization. As a result, DARTS scheduling management staff report that the overall work environment and employee satisfaction improved following implementation, noting that “this is the first time that everyone seems happy!”.
Finally, it is important to note that DARTS management reported that they have not yet had the opportunity to thoroughly consider how the scheduling and dispatch work process may be further refined to take advantage of Quo Vadis capabilities. DARTS management indicated that they believe further refinements are possible. As discussed in Section 6.0, Conclusions, such responses to the capabilities of the technology are critical for realizing full benefits.

DARTS Employee Focus Groups

As part of their own effort to insure a smooth transition to the new system, DARTS management organized employee focus groups to discuss the implementation of Quo Vadis. DARTS management’s notes from these sessions are presented below, organized by type of employee.

1. Driver Reactions

Positive Impacts:

- Easier to reassign trips appropriately
- More efficient daily changes
- Less map work
- Increased southern ridership
- Some riders served more frequently
- Some riders experience a shorter trip duration
- Quick rescheduling of rides
- Helps avoid big breakdowns
- Increased ridership
- Rider information provided—know what to expect at pickup
- Riders arrive at destination closer to appointment time
- Schedule breaks and lunches

Unmet Expectations/Negative Impacts:

- Pick up times did not become more consistent
- Not enough load time for wheelchairs and walkers
- Schedules did not become more logical
- More paper to look through
- Increased pressure by using “minutes” in pickup time arrival
- Difficult to make additions to complex itinerary
- More difficult to understand itinerary
- Inconsistent start times for riders and drivers
- Riders and drivers blame any problem on the computer
- Quality of service may have suffered
- Standing order trips time change

2. Operator Reactions

Positive Impacts:

- Paperwork and resulting errors reduced
- Job duties equalized
• Can provide real time information to riders
• Requests are taken more quickly
• Increased ridership
• More “will-calls”; Staff is better able to match a “will call” to a bus than before -- riders worry less about whether a bus will be available
• More professional, quieter office

Unmet Expectations/Negative Impacts:

• Scheduling did not become more automatic
• Tied to the phone
• Overloaded during dispatching
• Conflicting information from drivers/office; drivers still change schedules
• Rider first time registration takes longer, more information needed from rider
• Some riders not able to get rides like they “used” to; normally open slots are now full -- some regularly or habitually late callers who know “their” ride slot would be available now find that these slots are filled sooner or by others on a first call basis.
• Riders now call in earlier for trips to guarantee a seat
• No blocks of time to complete specific tasks; difficult to concentrate when doing phones, booking, and scheduling
6.0 CONCLUSIONS

6.1 KEY CONSIDERATIONS FOR INTERPRETATION OF FINDINGS

Before presenting the specific conclusions of this evaluation, it is important to reemphasize several considerations critical to the proper interpretation of the results presented in Section 5.0:

1. The objective of this evaluation is not to determine “success” or “failure”; the objective is to identify what works, when and why.

2. The reliability of some pre-implementation data, and the discrepancies in calculation methods between pre-implementation and Quo Vadis data, made fair comparisons of some MOEs difficult.

3. Phase 2 was not expected to and could not impact all of the measures of effectiveness.

4. Phase 2 provided critical capabilities which, although incapable in and of themselves of affecting some important MOEs, provide the foundation required for the Phase 3 technologies which do affect these MOEs.

5. DARTS was and is an efficient operation with extremely high levels of customer satisfaction; there was little room for improvement in many MOEs given the specific benefits associated with Phase 2.

6. The MOEs do not fully measure all of the Phase 2 benefits experienced by DARTS.

7. Other agency experience suggests that the full benefits of advanced technologies do not occur until up to 12 months after deployment.

6.2 SUMMARY OF MEASURES OF EFFECTIVENESS FINDINGS

Of the 13 MOEs evaluated in Phase 2, the following were found to improve:

- Reduce the average total cost per trip;
- Reduce the average subsidy per trip; and
- Increase peak period demand trip availability.

In all three cases the improvement cannot, given the data available, be attributed to Quo Vadis related changes in the DARTS operation.
6.3 UNDERSTANDING THE BENEFIT REALIZATION PROCESS

In order to understand these results and to form appropriate conclusions, it is necessary to identify the specific linkages between Phase 2 capabilities and the benefits associated with the measures of effectiveness. Figure 6-1 graphically depicts these linkages in a flow chart. The process depicted in the flow chart includes two primary components: Phase 2 capabilities and organizational responses. The relationships among these components and their impact on benefit realization are discussed in detail below.

Step 1: Capability Acquisition

The process shown on Figure 6-1 begins with the inherent capabilities of the scheduling software and the acquisition of those capabilities by the transit agency. At this stage in the process, deployment consists of purchase and installation of required hardware and software and staff training.

Once deployed, the inherent capabilities of the software become available to the transit agency. These capabilities are discussed in detail in Section 2.5 of this report. Generally, these capabilities are related to:

- the introduction of a management information system (MIS) which eliminates considerable paper work and associated opportunities for error, provides a host of computerized data which facilitates reporting and provides new more accurate tools for system management;
- the software’s ability to “optimize” schedules, i.e., create schedules which serve an equivalent number of trips in fewer vehicle hours and/or which serve more trips in an equivalent number of vehicle hours than can be done manually; and
- labor savings associated with the elimination of several data entry steps (input of the hand-written trip request forms) and fuller automation of the final scheduling process.

Step 2: Increased Capacity

This step in the process increases system capacity and creates MIS-related efficiency benefits through the realization of the potential capabilities of the advanced software. These capabilities are realized through several specific responses on the part of the transit agency related to:

- changes in management practices based on the new and improved management tools and more plentiful and accurate system performance data made available through the MIS;
- changes in the utilization of drivers and vehicles to operationalize the improved schedules produced by the software; and
- changes in the staff assignments and work processes within the scheduling and dispatch area to capitalize on the labor savings capabilities of the software.
In the case of MIS related capabilities, no additional specific organizational responses are identified. It is assumed that over time, the MIS will improve an agencies overall management of their staff and vehicle fleet through a variety of management decisions based on the new and improved performance data. The cumulative effect of such changes is presumed to contribute, although probably to a lesser extent than the scheduling-related software capabilities, to overall system performance improvements.

In the case of the other two major capabilities of the software, those related to the schedules themselves and the labor required to produce them, successful implementation increases system capacity. With less time spent on data entry and production of final schedules, staff are available to do other things, including taking additional trip requests.

It is important to note that capacity increases realized at this stage of the deployment process may or may not be apparent depending on whether significant excess demand is present. Capacity is a capability, an ability to do more. If there is not more that needs to be done (excess demand) it can be difficult to know if more can be done.

**Step 3: Increased Ridership**

This step in the process converts capacity increases realized in Step 2 into ridership increases. This occurs when previously unserved trips (excess demand) are accommodated. As shown in Figure 6-1, at least two sources of excess demand are possible:

- denied trips; and
- latent trip demand.

**Denied Trips**

Previously denied trips are reflected by the transit agency’s system denial percentage. When a significant number of trips are denied due to capacity constraints, trip denials represent the most important, and most quickly tapped, source of increased ridership. With drivers and vehicles capable of serving more trips and scheduling staff able to take and schedule more requests, it is logical that trips previously denied due to inadequate capacity would be the first “new” trips served.

**Latent Trip Demand**

Latent trip demand refers to the trips people would like to take but do not (or no longer) request. There are many reasons that patrons qualifying for paratransit service and who could significantly benefit from that service may not request it, the most important of which is a history of repeated denials. Repeated denials can “educate” patrons such that they no longer request a particular type of trip. The determination of if, and exactly how much latent demand exists for any given transit service can be very difficult.

Latent trip demand should not be confused with stimulated demand. In applications of advanced paratransit software in public or non-profit agencies, especially those receiving subsidy, stimulation of demand is generally not desirable.

In the case of paratransit, such as DARTS, same-day trips may account for the majority of any latent demand which exists. Lacking the scheduling and dispatch capabilities to effectively dispatch a significant volume of same day trips, many agencies discourage these trip requests directly through
stated policies and indirectly through their pattern of trip denials.

When latent trip demand is tapped, which typically requires some sort of outreach effort, the number of trips requested will increase. This increase in demand, coupled with the trip denials, accounts for the increase in total ridership that can occur following implementation of advanced paratransit scheduling software.

**Step 4: Improved Cost-Effectiveness**

This step represents the culmination of the successful deployment of advanced paratransit software. With more trips served utilizing the same or fewer resources, important indicators of system effectiveness such as cost per trip and passengers per vehicle revenue hour will increase.

**Time**

Time is a final variable that must be considered in the realization of the benefits of advanced paratransit software, and that is important in each of the four preceding steps. Time is depicted along the vertical axis on Figure 6-1.

Prior to Smart DARTS, insufficient experience existed to identify for certain when specific benefits occur or to generalize how the timing of these benefits may be related to particular applications. Clearly, benefits cannot occur immediately and will not increase indefinitely. The data available prior to Smart DARTS implementation suggested that it may take up to 12 months before significant benefits materialize. When these benefits plateau is unknown.

**Necessary Conditions**

As the final step in the process, it is clear that many important intervening conditions must be satisfied in order to realize improvements in system cost-effectiveness. Four conditions are especially critical:

1. **Software Performance** - the software must be capable of doing what it is supposed to do.

2. **Hardware, Software and Training** - the software must be deployed adequately; all the necessary hardware and software and staff training must be in place to allow the software to function optimally.

3. **Organizational Responses** - the implementing transit agency must change its practices and procedures in order to take advantage of software capabilities.

4. **Excess Demand** - in order to do more work there must be work to be done; significant excess demand, in the form of trip denials and/or latent demand, must exist.
5. **Time and Experience** - it takes time and experience to get the most out of software and to institute required organizational responses.

Now that the specific relationships and preconditions relative to successful deployment have been identified, the reasons why Quo Vadis does not appear to have impacted Phase 2 MOEs can be identified.

**Necessary Organizational Responses May Have Been Lacking**

Given the relationships shown in Figure 6-1, it is possible that some MOEs were not impacted in Phase 2 of the Smart DARTS project because required organizational responses did not occur. In the preceding sections, these responses are identified as one of the four critical conditions necessary for success.

**Schedule Parameter Optimization**

The results of this evaluation do not demonstrate that more efficient schedules are being produced with Quo Vadis. DARTS scheduling staff report that they have not yet had the opportunity or acquired the necessary expertise to evaluate and select the combination of software scheduling parameters needed to produce the most efficient schedules. Staff has indicated that additional training in this area would be useful, especially after having several months of operating experience with the software.

**Labor Efficiencies**

The data presented under MOE 4.3 indicate that approximately the same amount of time is being spent on trip scheduling as before implementation of Quo Vadis. As with schedule optimization it is unclear whether DARTS has made the staff utilization changes required to manifest any labor savings in this area. Regardless of why such labor savings have not occurred, their absence eliminates one of the critical mechanisms by which cost-effectiveness benefits may be realized.

**Absence of Significant Trip Denials Due to Insufficient Capacity**

As shown on Figure 6-1 and explained in Section 6.3 trip denials represent one of the two important sources of the excess demand that underlies ridership increases. DARTS had very, very few denials before Quo Vadis. As a result, despite whatever capacity may or may not have been provided by the software, there was very limited potential to gain ridership through a reduction in trip denials.

**No Effort to Tap Latent Demand**

DARTS did not attempt to encourage same-day trips after implementing Quo Vadis. As explained below, this decision was well grounded given that Phase 2 technology did not supply all of the capabilities necessary to effectively serve increased volumes of same day trips. Regardless of the reasons, the fact that no attempt was made to tap latent demand, especially same day trips, significantly limited the potential to increase ridership and realize cost-effectiveness benefits.

**6.4 INTERPRETING PHASE 2 MOE FINDINGS**

In light of the process and conditions identified in Section 6.3 and other lessons learned in the course
of this evaluation, several likely reasons can be identified for why Quo Vadis did not significantly affect Smart DARTS Phase 2 measures of effectiveness. Many of these reasons relate directly to linkages shown in Figure 6-1 which did not (or have not to this point) been made at DARTS. Other reasons transcend the issues identified in Figure 6-1.

**Questionable Reliability of Some Pre-Implementation Data**

Comparison of some pre- and post-implementation MOEs was made more difficult due to the inconsistent and in some cases poor validity and/or quantity of pre-implementation data. Comparisons were also hampered by the discrepancies between the way Quo Vadis calculates certain measures and how these measures were calculated in the past. In all cases, DARTS staff report a much higher degree of confidence in the Quo Vadis calculated measures. The availability of accurate, plentiful and consistent data is a major benefit of the new software, a capability which will provide a reliable basis for all future evaluations.

**Phase 2 Technology Did Not Have the Potential to Change Some Important MOES**

As discussed in detail in Sections 2.3, 2.4 and 5.1, the Smart DARTS project objectives and measures of effectiveness applied in this evaluation were developed to help measure and understand the benefits of the completed Smart DARTS Vision, which includes several key components not included in Phase 2. It is therefore incorrect to assume Phase 2 to significantly influence MOEs which are relatively insensitive to Phase 2 capabilities.

This is not to imply that Phase 2 technologies do not possess the potential for important “stand alone” benefits or that these benefits have not been realized to some extent. Phase 2 provides key capabilities related to system management, schedule optimization and scheduling efficiency.

System management capabilities include record keeping, reporting and most importantly, data and analysis tools. The data and the analysis tools in turn hold the potential to improve the efficiency of many aspects of the DARTS system, including fleet management, staff utilization, maintenance and contracting.

Schedule optimization refers to the software’s capability, when properly calibrated, to produce schedules that can serve more passengers per vehicle hour/mile. This capability derives primarily from the triangulation algorithm employed by the software in assigning trips. This algorithm essentially selects the most efficient of three scheduling scenarios.

Scheduling efficiency refers to the labor savings associated with preparing schedules. With Quo Vadis, trip information is entered only once, several times less than was the case with DARTS prior approach. Once entered, the software is capable of generating schedules automatically. This time-consuming task was previously performed manually at DARTS.

Although important, the preceding capabilities are only part of what is required to effectively tap the latent demand for same day trip making. Same day trip serving potential is an extremely important source of ridership increases, which in turn profoundly impact MOEs related to system cost-effectiveness. This makes same day trip capabilities a critical component of the DARTS Vision. Since Phase 2 capabilities did not include same day trip service, Phase 2 clearly could not affect many of the important MOEs.
DARTS Had Little Room to Improve on Many Important MOEs

As indicated in the evaluations of specific MOEs in Section 5.0, DARTS had very little room to improve in many important areas including:

- on-time pickup performance
- same day trip request satisfaction
- trip denials
- trip request phone call service (call duration)
- rider perceptions of service quality.

It May Be Too Early to Gauge the Impact to Some MOEs

The four month evaluation period may not have allowed DARTS the required time to implement Quo Vadis in a way that produces increases in ridership and cost-effectiveness. As shown in Figure 6-1, organizational responses are required at several junctures in the successful implementation process. These responses can not happen immediately.

For example, it appears logical that the benefits related to improved system management tools could take more than four months to manifest themselves. Anecdotal reports from DARTS management support the assumption that DARTS has not had enough time to “fine tune” the scheduling process, which consists of testing alternative combinations of software options and parameters. DARTS also reports that they have yet to reorganize staffing assignments in the scheduling and dispatch to fully take advantage in some of the labor saving benefits of the software that have been realized.

6.5 “UNMEASURED” BENEFITS

DARTS management and senior scheduling/dispatch staff, those most familiar with the nuances of the DARTS operation and most sensitive to changes, believe that Quo Vadis has improved the performance of the DARTS operation and they have cited a number of benefits not reflected in the MOEs. These benefits include the following:

- Improved Data Quality. As noted earlier in this section, the comparisons of some pre- and post-implementation measures of effectiveness were compromised by the questionable reliability of the pre-implementation data and by the technical discrepancies between pre-implementation and Quo Vadis methods of calculation. The establishment of a foundation of reliable, consistent and accurate data will make all future analysis of system performance easier and more meaningful. The establishment of a reliable benchmark of DARTS system performance is a very important benefit of the project.
• **Reduced Error Potential.** Prior to implementation of the software, trip requests were handwritten on forms, transcribed to preschedules, then typed into a database. Each step represented an opportunity for error. Now trips are entered only once, eliminating two opportunities for error.

• **Improved Working Conditions and Employee Satisfaction.** By eliminating shuffling of paperwork and the need for schedulers to walk around the office to access various preschedules and other resources, DARTS management reports that Quo Vadis has made the transit office a quieter, “more professional” environment. Implementation of Quo Vadis has also had an important democratization and team-building impact on the scheduling and dispatch office. By eliminating certain “specialist” roles, cross-training employees, and spreading the responsibility for scheduling to more employees, Quo Vadis has made each employee feel more a part of “the team” and has generally improved employee satisfaction.

• **Staffing Flexibility.** Implementation of Quo Vadis and associated staff training has had a leveling effect on staff skill levels and capabilities. Previously, certain staff performed only certain elements of the scheduling function and only certain people knew how to do certain things. When these people were unavailable, management staff usually had to fill-in. Now, most of the staff is capable of performing most of the required scheduling activities and can more easily fill-in for one another.

• **Improved Reporting Capabilities.** Although DARTS management reported that it took a lot of time and effort to learn how to utilize some reporting functions, once understood these functions greatly simplified the generation of some types of reports and allowed many new and useful reports to be generated. This learning process was far from complete at the end of four month evaluation period. It is expected that as DARTS becomes more familiar with software capabilities report-related benefits will increase.

• **Improved Management Tools.** By establishing a management information system, the software provided a source of new and more accurate data for system performance assessment. The benefits of this information only just began to appear at the end of the four month evaluation period. It is expected that in time, these tools will contribute to management decisions which improve cost-effectiveness.

### 6.6 THE FOUNDATION AND NEED FOR PHASE 3

Phase 2 implements capabilities that are critical to the success of the next project phase, which introduces automatic vehicle location technology and mobile data terminals. These components provide the remaining capabilities required to deliver improved same day trip service. The capability to provide same day trip service is a cornerstone of the Smart DARTS Vision and represents the most important missing link to significant system operational improvements.

Achieving the Smart DARTS Vision requires implementation of Phase 2 and Phase 3 technologies. The phasing of these technologies reflects the necessities imposed by resource constraints and the capacity of a transit agency to respond to major technological change. Phasing does not imply interchangability or independence of the technologies. Implemented alone, neither is capable of providing the benefits underlying the Smart DARTS Vision.

Phase 2 provides a critical part of what is required for same day trip dispatching: the management
information system (computerized schedules). What is missing, and what will be provided in Phase 3, is:

- the communications technology (mobile data terminals) necessary to maintain an “up-to-the-minute” schedules; and
- the automatic vehicle location technology necessary for the software to accurately determine what vehicle is in the best position to serve a same day trip request.

Given the capabilities provided in Phase 2 and Phase 3, the interrelationship between these capabilities and the importance of the combined capabilities of both phases for realizing benefits, it was understood from the beginning that both phases are justified and necessary. This evaluation focused on improving the understanding of the relationship between advanced paratransit technology benefits, transit organizational characteristics and the specifics of deployment, including the hardware and software selected and the phasing of their implementation.

6.7 SUMMARY OF FINDINGS AND CONCLUSIONS

The following are the key findings and conclusions of this evaluation relative to the performance of advanced paratransit scheduling software at DARTS:

Implementation Issues

- Maintenance of Service. Implementation can occur without disruptions to service, significant inconveniences to patrons or reductions in perceived service quality. This finding is especially significant in that it comes after a recent well-publicized failure on the part of another Minneapolis-St. Paul area transit operator to implement advanced technologies, an experience which for many people cast serious doubt on the fundamental feasibility of such technologies.

- Implementation Delays. Implementation took a lot longer than planned. Originally scheduled for four months, implementation required approximately 10 months. Unexpected delays were encountered at almost every juncture.

- Vendor Responsiveness. Lack of responsiveness on the part of the software vendor contributed to much of the delay. This includes delay in providing “missing pieces” of the system, including delays in completing pieces which were described as “in-production” during vendor interviews. Other delays were related to failure to promptly return telephone calls and to respond to requests. In some cases these delays were justified and in others it appears that they were not.

- Vendor Support and Commitment. Despite delays and difficulties, the software vendor eventually responded to almost all requests and contributed significantly to a successful implementation.
Training and Familiarization. Implementation delays probably contributed to the successful implementation of the software. Although no more formal training by the vendor was supplied, DARTS management had plenty of time to become familiar with the software and to orient and prepare their staff for the transition.

DARTS' Commitment and Competency. The majority of the credit for successful implementation should be attributed to DARTS. They demonstrated an extraordinarily high level of commitment and competency throughout the implementation process. Management staff devoted hundreds, if not thousands of hours to the project. The competency of the DARTS staff, especially management’s computer skills, were a key component of the successful implementation.

Hardware and Software Performance. The hardware specified and purchased for the project performed as intended and as required. Generally, the software functioned as intended. Software performance was comprised in some areas where required elements were not delivered on time. In some respects, such as the ability to generate “better” schedules, it is unclear whether the absence of demonstrated benefits is related to the software or to the manner in which DARTS has utilized it thus far.

Costs. Phase 2 implementation was accomplished within the available budget. However, this budget does not include the value of the many hours spent by DARTS staff before, during and after implementation.

Benefits

Insufficient Time and Experience. Prior experience, as well as the DARTS experience suggests that four months is probably too early to identify many benefits. Full utilization of the software requires significant reorganization of the scheduling process and much experimentation with the software. These responses can occur only over time.

MIS Benefits Demonstrated. The management information system-related capabilities of Quo Vadis have provided immediate benefits and represent a significant step forward for DARTS. Even more benefits will be realized over time.

"Unmeasured Benefits". As noted in Section 6.5, implementation of Quo Vadis has generated a number of important benefits not specifically addressed through the measures of effectiveness. These benefits include:

- reduced error potential
- improved operating data reliability/establishment of a performance benchmark
- improved employee satisfaction and sense of teamwork
- improved staff flexibility
- improved data reporting capabilities
- improved management tools
• **Improved Data Quality.** As previously noted, Quo Vadis data has established a valid benchmark of DARTS system performance which will allow reliable and meaningful analysis of future changes related to Smart DARTS Phase 3 implementation and to all future changes in DARTS operations.

• **Unimproved Schedules.** The new schedules are no more efficient than those previously produced by DARTS. This may be because of the way DARTS is using the software. It may also be due to the fact that DARTS has yet to find the right combination of software parameter settings and options to produce the best schedules. It is also possible that DARTS has retained certain aspects of their scheduling approach which may be essentially insuring that more schedules are not produced, such as failing to test the ability to serve the same number of trips with fewer vehicles and/or reduced service hours. It may also be that DARTS’ desire to maintain an extraordinarily high level of rider satisfaction has prevented them from producing “better” schedules but which could otherwise result in reduced customer satisfaction.

• **Probable Labor Efficiencies.** It appears that some labor efficiencies have been realized on some scheduling tasks. However, the same amount of time is still spent on scheduling as a whole. Failure to capitalize on labor efficiencies may be related to the fact that DARTS has yet to optimize scheduling staff utilization.

• **Lacking Some Required Organizational Responses.** Successful implementation relies upon a series of organizational changes in response to improved capabilities. It appears that DARTS has not yet made some of these responses. These responses include optimization of scheduling staff utilization and optimization of the scheduling technique. The possible reasons for this are varied and include a lack of time, a resistance to fundamental changes and concerns about potential service quality ramifications.

• **Lacking Same Day Trip Capabilities.** Same day trips are the most important source of new ridership. Phase 2 technology provides only part of what is required to effectively serve more same-day trips. Phase 3 provides the remaining capabilities.

• **No Significant Ridership or Cost-Effectiveness Improvements.** The software has yet to produce significant improvement in ridership or cost-effectiveness. There are three likely reasons for this:
  1. It’s too early;
  2. DARTS needs to do more to take advantage of the software; and
  3. Phase 3 same-day trip capabilities are missing.

### 6.8 IMPLICATIONS FOR TRANSFERABILITY

The following constitute the key lessons learned in the implementation of Smart DARTS Phase 2 which are important to the transferability of the technology to other transit agencies. These lessons represent the basis for a checklist which can be applied as a screening tool for determining which transit organizations may best benefit from Smart DARTS Phase 2 technology.

• **Implementation Time Frame.** Assume that delays will occur. The original Smart DARTS Phase 2 four month implementation schedule was too short. It is reasonable to expect that hardware and software can be purchased, installed and tested within this time. However, the DARTS
experience suggests that at a minimum, an additional two or three months may be productively used learning the software and preparing for the “go live” date. The required implementation time frame should be even longer if the software vendor is unable to confirm delivery of all required elements by the desired time.

- **Timing of Benefits.** How fast benefits occur is directly related to how fast an agency is ready and willing to adapt its processes to take advantage of the new capabilities. Benefits are the result of a long chain of events. Many of the linkages in the chain take time to establish, especially those related to significant changes in processes and staff responsibilities. Four months after “going live” is probably too early to expect to see some benefits.

- **Agency Commitment and Resources.** Successful implementation demands strong and enduring commitment on the part of the implementing agency. Presence of a “champion” is important. Presence of a champion who is familiar with the scheduling process and possesses the required skills and willingness to experiment with the software is even better. Depending upon the priorities and requirements of implementing agencies, “successful” implementation may not require the effort expended by DARTS. However, the essentially flawless transition that occurred in this project may demand similar resources.

- **System “Health”.** An agency struggling with fundamental management and service delivery issues will probably not be in a position to devote the resources necessary for successful implementation nor to take full advantage of the software’s capabilities. This technology is not a “fix” for a “broken” system. The system must be fundamentally healthy to afford the resource commitment required for successful and timely implementation.

- **Room for Improvement.** Benefits can only occur where there is realistic room for improvement. For example, a very low trip denial rate cannot be significantly lowered by implementing the software, especially if denials are not directly related to capacity constraints.

- **Necessary Agency Responses.** The software provides opportunities to make changes that can create benefits. If the proper changes are not made benefits will not occur. Numerous impediments to these changes may exist, including insufficient time or staff resources, reticence to deviate from “proven” or “comfortable” processes and hesitancy to jeopardize rider satisfaction.