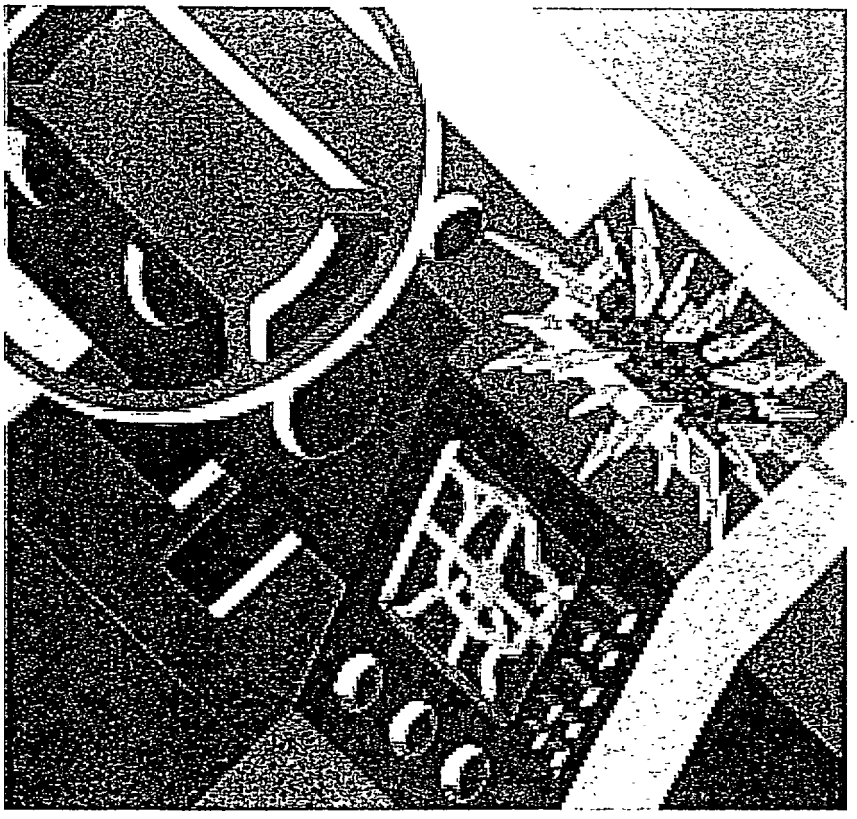
Trilogy

Operational Test

FINAL REPORT

(September 29, 1998)



1998

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TRILOGY FINAL REPORT

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1.a. PROJECT BACKGROUND

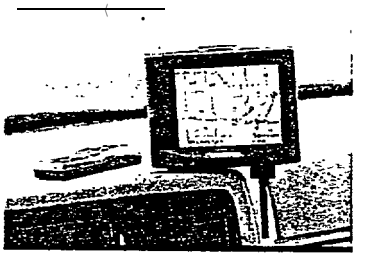

Figure 1-1. Trilogy Display Device

The Trilogy project was an ITS demonstration of the broadcast of freeway system traveler information to both commercial and commuter drivers over a 25-mile (40.3 km) radius of the Twin Cities metropolitan area. In this project, real-time freeway system operating conditions, particularly incidents and traffic congestion, were monitored at the Minnesota Department of Transportation (Mn/DOT) Traffic Management Center (TMC). This information was broadcast to a fleet of test vehicles with dashboard mounted display screens as shown on Figure l-l. Two different systems were used to broadcast traveler information. The first system utilized the Radio Broadcast Data System (RBDS) - Traffic Message Channel; and the second system utilized the High Speed Data System (HSDS) to transmit messages to in-vehicle receivers.

The purpose of the test was to determine if real-time traveler information would influence individual travel decisions, determine the technical feasibility of the system, and access the usefulness of the information. The project was started in August, 1995 and ran through February, 1998.

This project was cosponsored by the Federal Highway Administration (FHWA) and the Mn/DOT as part of the Minnesota Guidestar program. Private partner project contributions were provided by AB Volvo, Inditka Display Systems Ltd., Differential Corrections, Inc. (DCI) and Seiko Communication Systems, Inc. Additional project partners included the involvement of 156 commercial vehicle drivers from the following eight private and public commercial device users: Roadrunner Transportation, Inc., Quicksilver Express Courier, Indianhead Truckline, Northern States Power (NSP), Hennepin County Medical Center (HCMC), Council Transit Operations, and Bureau of Criminal Apprehensions. A total of 78 commuter drivers also participated in the evaluation of the Trilogy System. Figure l-2 illustrates the Trilogy project organization chart.

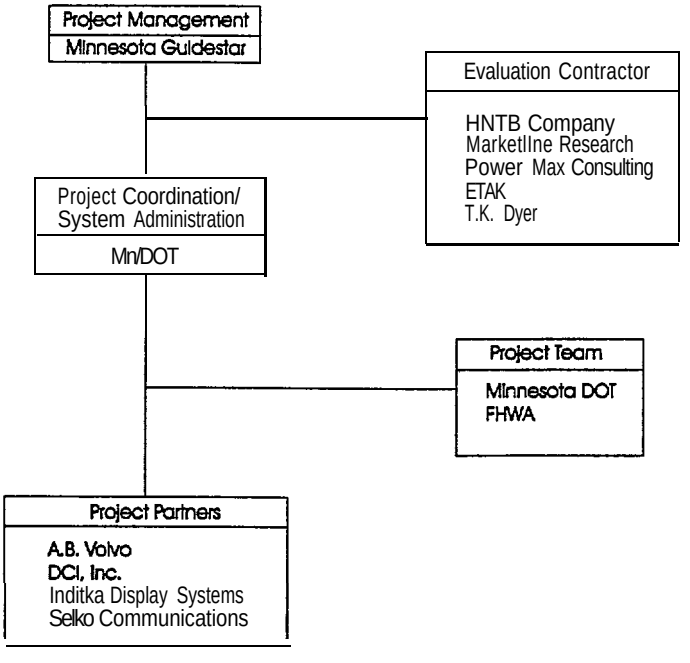

Figure 1-2. Trilogy Project Organization

As also shown on Figure l-2, HNTB Company was selected to evaluate the Trilogy Project. HNTB, assisted by

MarketLine Research, Inc. Power Max Consulting. Inc., ETAK and T.K. Dyer, prepared a total of six Individual Evaluation Test Plans (IETP's). The IETP's focused on commercial and commuter assessments of Trilogy, the impact of Trilogy on traveler behavior, technical performance, liability and project costs.

1.b. PROJECT FINDINGS

The following is a summary of the evaluation findings reported in the "Trilogy Final Report". That report is divided into the following sections: 1) Project **Overview; 2)** Test Descriptions and Findings; 3) Evaluation Issues; 4) Lessons Learned, Benefits, Risks and Future Applications; and 5) Final Conclusions.

l.b.1. Commercial and Commuter Assessment of Trilogy

The usefulness of the Trilogy information service on commercial and commuter driver travel efficiency and appropriateness of the North American Standard ITIS message format protocol was evaluated in this test. Baseline surveys, early surveys, driver logs, past surveys and interviews were the principal source of information for this test.

The following basic conclusions were reached by HTNB:

- Trilogy became the principal source of travel information for 66% of commercial users and 9 1% of commuter users.
- The worth of traffic information on a congested route was defined by users as knowing:

Information	Commercial	Commuter
– Exact Congestion Location	88%	94%
– Backup Length	**75%**	**74%**
– Affected Lane Information	**71%**	**74%**
– Type of Problem	**70%**	**73%**
– Average Speed through Affected Area	**60%**	**71%**

- To the majority (98% of commercial and 95% of commuter) users, the Trilogy protocol and message **delivery** was coherent, comprehensible and user-friendly **in** the presentation formats.

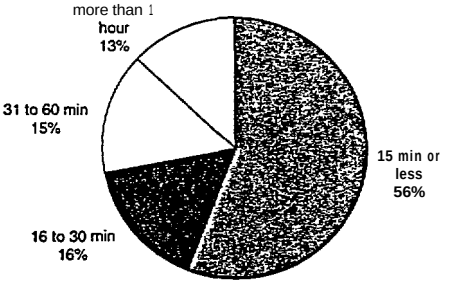

Figure 1-3. Estimated Commercial Weekly Time Savings with Trilogy System

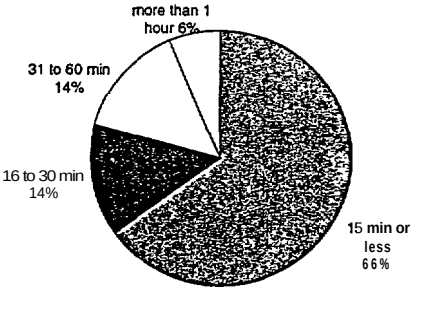

Figure 1-4. Estimated Commuter Weekly Time Savings with Trilogy System

- The majority of users (52% commercial users and 81% commuter users) felt they changed routes more frequently using the Trilogy system. indicating that users were better informed about incidents and congestion on the roadways that they traveled.
- 50% of commercial and 44% of commuter users reported weekly travel time savings of 20 minutes or more with a mean average weekly savings of 39 minutes.
- The majority of device users (commercial 70% and commuter 8 1%) felt they changed routes more frequently using the Trilogy system than with previous sources of traffic information.
- Both commercial and commuter users felt reduced stress and increased feelings of safety were benefits of the device, especially with increased usage.
- The average purchase price of the Trilogy device in the opinion of commercial users was determined to be $420 compared to commuter users which was determined to be $450. Both users estimated the average monthly device service fee to be about $25.

l.b.2. Impact of Trilogy Technology on User Travel Behavior and the Metropolitan Transportation System

With the wide-spread implementation of the Trilogy system, users determined that usage of Trilogy allowed them to:

	Commercial	Commuter
· take alternate routes to avoid congestion	80%	88%
• reduce travel time	72%	69%
• improve knowledge of the freeway system	54%	81%
• reduce stress and increase feelings of safety on the freeways	33%	50%

l.b.3. Technical Performance

The AB Volvo Dynaguide 2.0 (RBDS) and the Dynaguide 3.0 (HSDS) were the two in-vehicle user devices evaluated. For both the RBDS and HSDS devices, the time from incident occurrence identification and roadway link congestion evaluation to information received by the user was adequate for the user **to take** appropriate action. The HSDS system has an advantage over the RBDS system, since it provides faster incident data updates. This was supported by the commuter device users who stated their likelihood to purchase Dynaguide 3.0 was 63% compared to Dynaguide 2.0, which was 40%.

System Reliability: According **to** the operator logs, Trilogy system problems occurring at the Minnesota Department of Transportation's Traffic Management Center were principally a result of workstation software failures. These software failures were relatively minor, and did not significantly impact the Trilogy operational test for any significant amount of time.

Device user problems with the Dynaguide devices were most often the result of component problems with the Trilogy signal receivers, followed by problems with the Global Positioning System (GPS) receiving unit. Since these repairs were typically made locally soon after the problem was reported, the device user was not significantly impacted or inconvenienced by the failed components.

Svstem Components: For both RBDS and high speed (HSDS) systems, the standard equipment necessary is:

1. Traffic Management Center with appropriate operator workstations
2. CCTV network
3. Ethernet of other network connection system (for workstation-system linkages)
4. Radio station transmitter
5. Roadway loop detection system
6. Communications processor for message formatting
7. Communications link from TMC to communications processor and from processor to radio station

System Improvements: Interviews with the TMC operators identified several recommendations for changes in equipment or procedures that could improve the overall efficiency of the Trilogy system. These recommendations include: adding a count-up incident timer, adding ITIS locations to freeway ramps, sectioning off long roadway links, implementing "pop-up" screens to remind the operator to update incidents, refine the incident list and provide training to all operators for consistent data entering practices.

l.b.4. Liability Issues

Liability agreements were signed by project participants, project partners and software providers, which documented information on the liability of each party and the liability concerns of each of the partners. No liability claims were made during the Trilogy operational test. The following indicates some of the concerns raised by test participants regarding the Trilogy system:

- Trilogy users recommended access to text while driving for improved operation of the Trilogy system. This option was rejected due to the potential liability issues surrounding that situation.
- Only a few users expressed any concern regarding personal safety issues from operating the Trilogy device while driving.

It can be concluded that liability or insurance issues were not concerns of potential commercial and commuter users of the Trilogy system, and that liability issues had no impact on the Trilogy operational test.

l.b.5. Cost of Project

The Trilogy Operational Test project costs between the dates of January 1, 1995 and July **1,** 1998 totaled $4.03 million, which includes $756,000 in project partner contributions. Of the project expenditure cost, the majority of the spending went for Phase II devices expenses (22.1 percent), which included Seiko and Volvo devices as well as Ball software expenditures. Other major expenditures were for pre-engineering, evaluation, operations, RBDS, project management and expenses. Figure l-5 highlights these major expenditures for the Trilogy FOT.

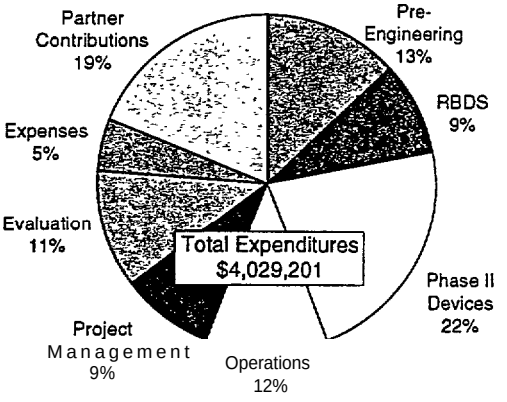

Figure 1-5. Trilogy Project Expenditures

Federal, State and private funds were used for the

Trilogy operational test. Approximately 18 percent ($600,000) of the project funds came from the State of Minnesota and 82 percent ($2.800,000) came from Federal sources. Additional research/development funds of about $756,000 were provided as services by AB Volvo, Indikta. DCI and Seiko.

l.c. **EVALUATION ISSUES**

In summing up the results from the six individual test reports the main issues that merit further examination are related to: 1) system expansion; 2) system deployment capability; 3) impact on the transportation system; and 4) user responses/system technical capabilities.

- System Expansion: Commercial and commuter users were more likely to purchase the Trilogy device for personal use if the service coverage were expanded (full freeway system information, longer hours of reporting and, if possible, arterial street system operating condition information).
- System Deployment: The provision of pre-trip information as a intemet service should be provided, since the ability to change trip departure times based on Trilogy information accessed prior to making a commuter trip could potentially impact traffic demand on the transportation system.
- Impact on Transportation System: Commercial users were able to adjust some of their trip routes, become more productive by either saving travel time or by making additional trips and better utilizing the freeway system. However, commuter users did not change their trip start or departure times because the Trilogy information is not available unless they are in their vehicle.
- User Responses/System Technical Capabilities; In the user survey information there were numerous suggestions regarding increased coverage enhancements for area expansion, 24 hour operation and potential arterial system detection.

1.d. LESSONS LEARNED, BENEFITS AND FUTURE APPLICATIONS

This section summarizes the lessons learned, benefits and future applications of the Trilogy system.

1 .d.l . Lessons Learned

This FOT was well founded technologically with a base of European experience. The principal project lessons learned for future applications of the Trilogy advanced traveler information project are listed as follows:

- Unless an existing software program meets the project needs, it is recommended to develop project specific software from scratch.
- Adequate training should be provided to all **new** TMC operators for consistency in relaying messages.
- Traveler information regarding the exact location of congestion, the length of backup, affected lane information and the type of problem should be provided.

l.d.2. Benefits

Project participants indicated what they perceived as potential benefits of the project. These are as follows:

- Project benefits were realized in the TMC traffic control room where much was learned from user feedback on how to present traffic information. This involved improved consistency and accuracy of incident reporting and refinement of incident description lists.
- Another benefit was related to the ability to refine and field test the development of a traveler information system.
- Benefits to users involved reduced travel time and driver stress as well as increased productivity and feelings of safety.

In addition to the benefits, some of the risks of the project included: 1) opinion of the public acceptance of the system; 2) the risk involved in the development of device receiver technology and 3) liability user issues.

l.d.3. Future Applications of Trilogy Technology

The following are potential future uses of the Trilogy technology evaluated in this project.

- As an ATIS system, Trilogy could be deployed as a fleet dispatch center resource.
- . Trilogy systems could be deployed in Emergency and police vehicles and dispatch centers, where real-time information provides a potential response time savings.
- Use of the high speed travel conditions map has the ability to assist control room operators with problem identification and extent when reporting incidents.
- The advantage of real-time travel information in airport taxi services and rental vehicles would allow a driver who is in their vehicle to make route decisions when utilizing the freeway system as part of their travel route. The device's GPS capability can enhance the Trilogy device value to these users.
- Application of the Trilogy systems to intemet or news media sources would allow pre-trip planning to occur before a traveler is already committed to a trip when they enter their vehicle.

1.e. FINAL CONCLUSIONS

After a thorough review of the history and documents of this test and feedback from the Project Manager and Project Evaluation Committee, HNTB offers the following final conclusions with regard to Trilogy:

- The Trilogy FOT was a successful demonstration of the benefits of real-time travel information that can be realized in travel time savings, improved productivity (more commercial trips can be made per day) and motorist stress reduction. The test shows that people will change travel patterns to avoid congestion based on reliable traffic information. The data show that for a Trilogy type system to become widely accepted by the motoring public, it must be available 24-hours per day and expanded to include travel information on the arterial street system.

- Based on data collected in this test, real-time travel information devices such as Dynaguide. do not create a distraction to normal driving functions. The use of icons and system map operating speed data are easily understood by the motorist for informed travel decision making purposes. Users understood messages at a high rate and experienced little difficulty in comprehending the intent of messages or utilizing the information received. Dynaguide-type in-vehicle devices are reliable and functionally easy to operate by the motorist.
- As designed, the technical capability of the Trilogy system is limited in its ability to provide real-time traveler information for an extensive network of city arterial streets and freeway segments. Expansion of the system would require additional operator reporting resources for incidents and a reduced broadcast message redundancy frequency. Expanded use of device message filtering capability would assist the motorist in sorting pertinent trip travel information.
- In-vehicle real-time traveler information cannot be expected to impact motorist trip start times. In-vehicle traveler information is limited to impacting route choice. Expansion of this information to other services such as intemet, weather and news information sources may have a greater impact on pre-trip planning as well as overall travel behavior and its potential impact on an area's transportation system. There is no reason to not consider this type of ATIS application as part of a larger traffic information package to be made available to the public.
- The Trilogy FOT successfully demonstrated the potential for public/private cooperation in the development of a traffic information system. Both communication and product design services can be provided through a cooperative partnership. Commercial businesses can assist in the evaluation and deployment of traveler information.

2.a. **PROJECT PROPOSAL**

The Trilogy project is a demonstration of area-wide broadcast of digital data to in-vehicle receivers capable of filtering traffic data for the motorist. Trilogy was started as a Mn/DOT pilot project in 1993. Minnesota Guidestar, Mn/DOT's ITS program was selected in 199-l by the U.S. Department of Transportation to develop and manage the Trilogy Field Operational Test (FOT). The Field Operational Test is a demonstration to evaluate the effectiveness of providing real-time traffic and travel information via two different communications media, Radio Broadcast Data System-Traffic Message Channel (RBDS-TMC) and a high speed FM Subsidiary Carrier Authorizations (FM-SCA) to user in-vehicle devices with varying capabilities. Trilogy was approved as a FHWA operational test with an overall cost of $4 million. The federal share of this is $2.8 million. It is anticipated that Trilogy technology could maximize the use of transportation systems through more efficient utilization of the existing transportation roadway infrastructure.

The objectives of the operational test are to:

- Influence individual travel decisions,
- Make the most efficient use of the existing road infrastructure.
- Determine the technical feasibility of an enhanced Trilogy system.
- Undertake a comprehensive system evaluation.
- Compliment the Genesis and Travlink operational tests.
- Assess the usefulness of the Trilogy information service to a variety of types of end users.
- Determine the appropriateness of messages and message formats.

2.b. PROJECT PLANS

The project plans call for the Trilogy project to be divided into three principal phases.

- Phase I involved the installation and testing of basic RBDS capabilities on an FM radio station sideband. Ten Delco prototype receivers were procured and installed into Mn/DOT fleet vehicles. Software to automate message generation from a location code database and sample message list was procured.
- **Phase** II involved local RBDS-TMC pilot testing of various prototype receivers. The message list and location coding database were finalized and tested in the 10 Mn/DOT fleet vehicles.
- **Phase** III was the Trilogy field operational test described and evaluated in this report. Phase III was initiated in July 1994, RBDS deployment started in July of 1995 and High Speed deployment started in July 1997.

The Trilogy evaluation was performed by HNTB Companies in conjunction with MarketLine Research, Inc., Power Max Consulting, Inc., ETAK and T.K. Dyer. The evaluation test plans are discussed in Section 3 of this report.

2.c. PROJECT ORGANIZATION

Figure 2-l provides an overview of the Trilogy project organization during the Phase III field operational test. This organization provides a very strong example of public-private partner cooperation in the development and testing of ITS technology. Private partners involved in this project include: AB Volvo, Differential Corrections, Inc. (DCI), Seiko Communications Systems, Inc., and Indikta Display Systems Ltd. In addition to these system design project partners, the Trilogy evaluation included the following private and public commercial partners as Trilogy device users: Roadrunner Transportation, Inc., Quicksilver Express Courier, Indianhead Truckline, Northern States Power (NSP), Hennepin County Medical Center (HCMC), Minnegasco, Bureau of Criminal Apprehension and the Metropolitan Council Transit Operations. Public partners included the Mn/DOT and FHWA.

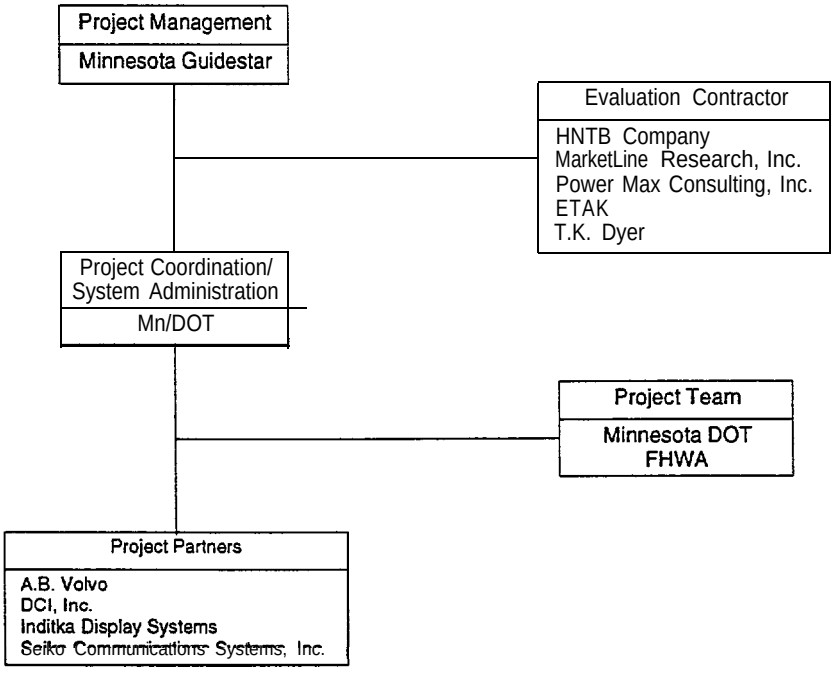

Figure 2-1. Trilogy Project Organization.

2.d. TRILOGY SYSTEM DESIGN

The Trilogy system design requires three basic components: 1) a traffic monitoring system; 2) a message transmission system; and 3) an in-vehicle information receiver. The first component involves a freeway traffic management center with the capability to monitor freeway congestion conditions and detection of incidents. This includes such basic elements as freeway loop detectors, closed circuit TV cameras (CCTV) and system operations staff. The Mn/DOT Traffic Management Center (TMC) infrastructure provides the core data for Trilogy. About 70% of the

freeway system as shown on Figure 2-2, is monitored by the TMC. The Trilogy system is operational during the hours of 6:00 a.m. to 7:00 p.m.

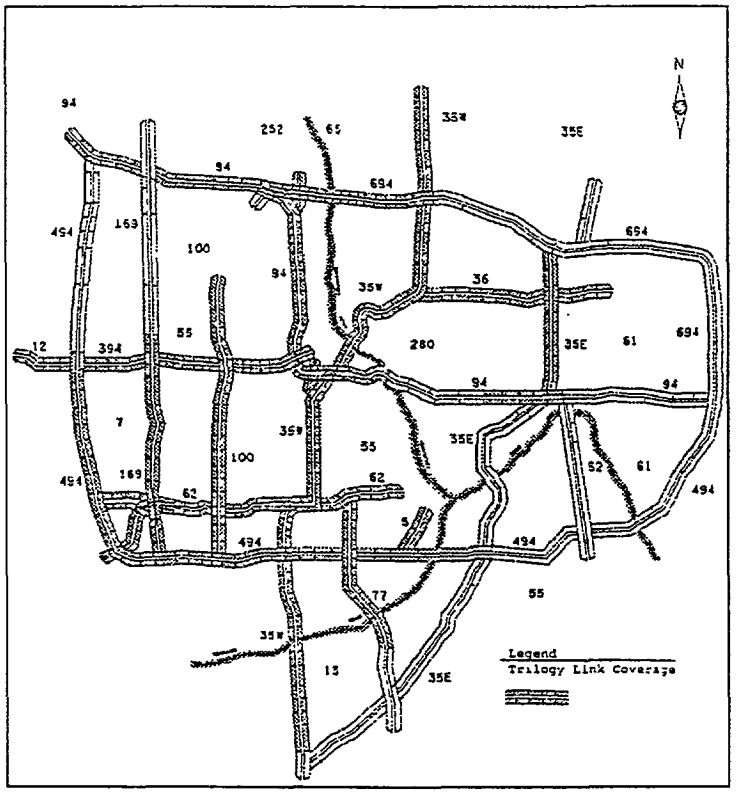

Figure 2-2. Trilogy Roadway Link Test Coverage Area.

The second component involves the ability to transmit traveler information messages to the public. In the Trilogy project design this element involves utilizing a Trilogy workstation to code traffic information for broadcast transmission digitally. Two different broadcast technologies (RBDS-TMC and High Speed SCA) were evaluated in the Trilogy project. Traffic information messages are divided into four basic elements: 1) location of the travel situation; 2) description of the travel event; 3) extent of traffic situation over segment length; and 4) duration of event condition over time. Messages on traffic conditions are digitally coded and transmitted in the North American Standard, International Traveler Information Interchange Standard (ITIS) RBDS-BAP protocol. This format provides the user the capability to filter information with regard to incident type and/or route. The High Speed transmission system includes an additional element of real-time freeway link travel speed and ramp meter conditions that is automatically displayed on the Trilogy in-vehicle device.

The third system component involves the Trilogy in-vehicle traveler information device. The device shown in Figure 2-3 consists of a small TV screen that can be mounted on a vehicle's dashboard. The device uses a map of the Twin Cities metropolitan area with icons and text to present traffic information. Icons, shown on Figure 2-4 are geographically located to show an incident location and type. An additional icon is shown to display the vehicle location and

direction of travel from a Global Positioning System (GPS). The device has the ability, with a remote controller, to pan or zoom 50 different map frames.

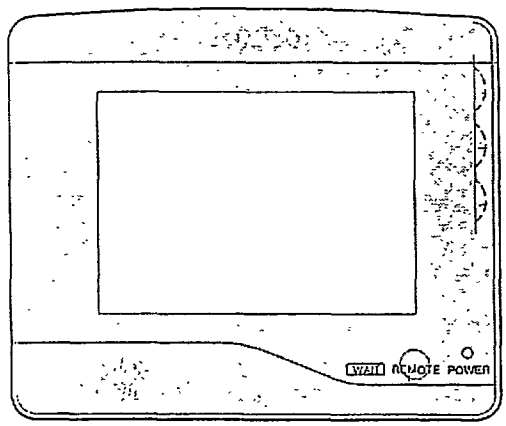

Figure 2-3. Volvo In-Vehicle Traveler Information Device.

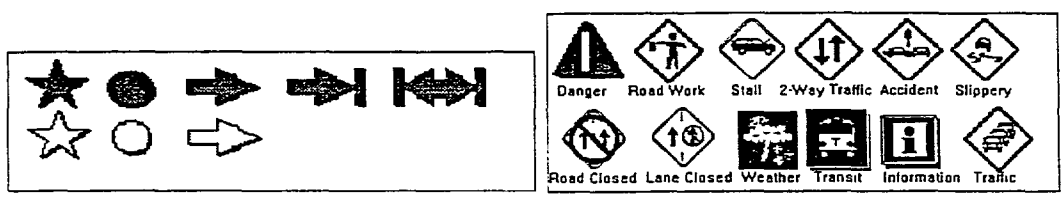

Figure 2-4. Traffic Information Icon Examples.

2.e. EVALUATION MANAGEMENT

HNTB Companies was selected to perform the duties of the Independent Evaluator for the Trilogy FOT. HNTB performed all the evaluation tasks which included design of the final individual test plans, collection of data, data evaluation and reporting.

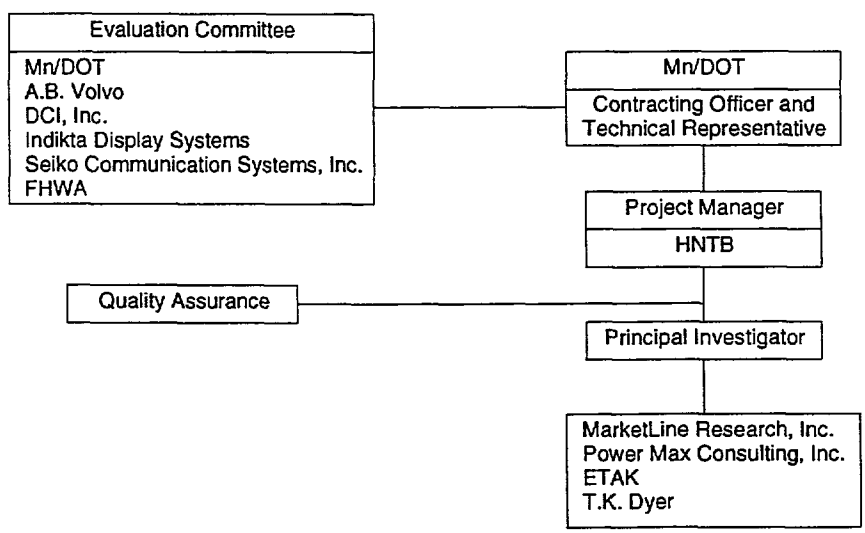

Figure 2-5. Trilogy Evaluation Management Structure.

MarketLine Research, Inc. and Power Max Consulting. Inc. assisted with the user surveys and interviews. T.K. Dyer, a subsidiary of HNTB, assisted with the technical assessment of the Trilogy system and ETAK assisted with development of the technical assessment test plan. The evaluation management structure is illustrated in Figure 2-5.

2.f. **EVALUATION PLAN DEVELOPMENT**

The Independent Evaluator prepared a total of three final evaluation planning documents beginning in May of 1995. All of these documents were in support of the Trilogy evaluation.

- Trilogy Operational Test-Evaluation Plan (May, 1995)
- Trilogy Data Management Plan (February, 1995)
- Trilogy Detailed Evaluation Plan (January, 1996)
- Trilogy Interim Report (March, 1997)
- Trilogy Final Evaluation Report (September, 1998)

Within the Trilogy Detailed Evaluation Plan there were a total of six Individual Evaluation Test Plans (IETP's) which addressed the following five Evaluation Goals. The goals are listed in order of priority.

Goal **1:** Evaluate the Trilogy technologies' potential to provide useful information on travel decisions made by commercial, government and private citizen users.

Goal 2: Evaluate the ability of Trilogy technologies to induce travel behavior changes in the end users, and evaluate the potential effect of these changes on the metropolitan transportation system.

Goal 3: Perform a comprehensive technical evaluation of the performance of the Trilogy systems.

Goal 4: Document the liability issues and effects on the Trilogy operational test.

Goal 5: Document the costs of the Trilogy operational test.

Each goal was supported by a set of objectives and measures of effectiveness or documentation.

TRILOGY INDIVIDUAL OPERATIONAL TESTS

3.a. INTRODUCTION

The Trilogy project objective is to test and evaluate innovative means of providing real-time traffic and travel information to travelers en-route. A range of user devices with varying capabilities will provide the end users with route specific advisories on the highway operating conditions of the Twin Cities Metropolitan Area. It is anticipated that Trilogy will help maximize the use of transportation systems through more efficient utilization of existing infrastructure by providing information to travelers that will allow them to re-route. Users assessments will be conducted to ascertain the relevance and usability of the information service provided.

This section describes each of the six individual operation tests that were conducted for the Trilogy system. Each description will contain:

- The purpose of the individual test including the stated objectives;
- A description of the test;
- Findings by the independent evaluator: and
- Conclusions from the independent evaluator.

The six individual operational tests described in this evaluation are:

1. Commercial User Assessment of Trilogy Technology Test Plan
2. Commuter User Assessment of Trilogy Technology Test Plan
3. Impact of Trilogy Technology on User Travel Behavior and the Metropolitan Transportation System Test Plan
4. Technical Performance Test Plan
5. Liability Issues Test Plan
6. Cost of Operations Test Plan

3.b. COMMERCIAL USER ASSESSMENT OF TRILOGY TECHNOLOGY TEST PLAN

3.b.l. Purpose

The purpose of the Commercial User Assessment Test Plan is to evaluate and determine the potential benefits and operating characteristics of in-vehicle real-time travel information devices. In this test, a sample of commercial fleet vehicle operators and dispatch managers were provided with up to two different communication devices that have a varying range of capabilities to provide route specific traffic advisories on freeway operating conditions in the Twin Cities metropolitan area. This test, in general, evaluates the usefulness of the Trilogy information service on commercial travel efficiency and the appropriateness of the ITIS North American Standard message format protocol.

This test was designed to specifically address the following Trilogy evaluation goal: **"To Evaluate the Trilogy Technologies' potential to provide useful information on travel decisions made by commercial, governmental, and private users."**

The objectives of this test were to:

- Assess the users' estimate of worth before, during and after the test.
- Assess the effectiveness of, and user preference for, different information output formats. with repeated use of the system.
- Assess usefulness of functions and features offered by different user devices, and suggested improvements.
- Assess what information was useful. and what information would be helpful.
- Assess the ability of the RBDS-BAP Protocol and ITIS messages and locational databases to communicate the intended messages to the users.
- Assess user perception of product operability.
- Assess how much commercial users are willing to pay for a device and/or service.
- Assess product and service market potential.
- Assess the reliability, accuracy, and timeliness of information received, based on user requirements.
- Assess effects on economic productivity of commercial users.

This test also **addresses** the following National ITS Goal:
Create an environment in which development and deployment of ITS can flourish

3.b.2. Test Description

Device users (100 Dynapuide 2.0 users and 56 Dynaguide 3.0 users) represented in this report are commercial drivers from eight Twin Cities metropolitan companies. Companies and organizations included:

- Hennepin County Medical Center
- Indianhead
- Quicksilver
- Minnegasco
- Metro Transit
- NSP
- Road Runner
- Bureau of Criminal Apprehensions

The first group of commercial drivers tested the Dynaguide 2.0 in-vehicle device during the period from August 1995 through January 1997. The second group tested the Dynaguide 3.0 devices from May 1997 to February 1998. This group consisted of a mixture of new users and previous users of the Dynaguide 2.0 device. At various stages during these periods, individual companies were trained, devices were installed and data collection was initiated.

Data for this test plan was compiled from survey instruments including: 1) Baseline Survey: 2) Focus Groups; 3) User Logs; 4) One-on-One Interviews; 5) Early Survey; and 6) Post Survey. Al findings outlined in this report are based on this data.

3.b.3. Evaluator Findings

The following findings were made concerning the **users' estimate of worth before, during and after the test:**

- Worth of traffic information on a congested route was defined by users as knowing the exact location of congestion, the length of backup on the congested road, affected lane information and the type of problem.
- A simple majority [67%] of device users perceived some reduction in travel time attributable to the Trilogy system. Half [50%] of all users estimated a weekly travel time savings of 20 minutes or more.

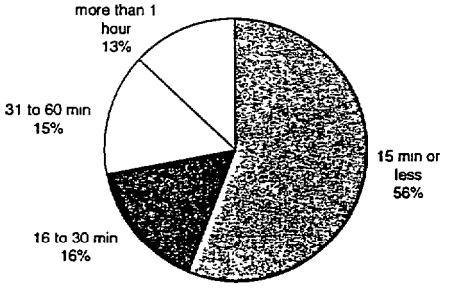

Figure 3-1. Estimated Weekly Time-Savings with Trilogy System.

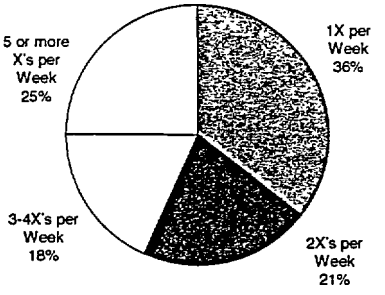

Figure 3-2. Number of Route Changes per Week.

- The majority [52%] of device users felt that they changed routes more frequently using the Trilogy system, indicating that users were better informed about incidents and congestion on the roadways that they travel.
- 70% of users found value in **having** their companies purchase the device, but indicated that they were not very likely to purchase it for personal use [58%]. Increased exposure over time and familiarity with the device, however, increased the drivers likelihood of purchasing the **device for** personal use. [2 1% **after** initial use to 30% after prolonged use.]
- Users were able to define at a very high rate how frequently they availed themselves of the information in terms of days [76%] receiving actionable messages. Those using the device infrequently, cited reasons related to limitations of the system and the device, not of the quality of information received.

- Users felt reduced stress and increased feelings of safety were benefits of the device. especially with increased usage.
- Sixty-six percent of commuter users rated Trilogy as their number one source of traffic information. More commuter users rated Dynaguide 3.0 as their number one source of traffic information than Dynaguide 2.0.

The following findings were made concerning the **effectiveness of, and users' preference for, different information output formats with repeated use of the system:**

- To the majority of users [98%]. the Trilogy protocol and message delivery was coherent, comprehensible and user friendly in its multiple presentation formats.
- Users [72%] preferred the output device as a total presentation package with information provided through icons, symbols and text.
- Users felt that they received useful information a majority of the time. To make the Trilogy system more useful, commercial users recommended expanded coverage area. increased relevant messages and complete information.

The following findings were made concerning **the usefulness of functions and features offered by different user devices, and suggested improvements:**

- The features that were perceived to be useful by the majority [75%] of users were: 1) Night palette for driving after dark; 2) the Zooming and Panning control of the display; 3) "Home Map" features; and 4) device specific filtering capabilities.
- For most users, improved usefulness of their tested device was not linked to any single or limited set of additional new functions or features. but rather expansion of existing device capabilities (more coverage area).

The following findings were made concerning **what information was useful, and what information would be helpful:**

- Users were able to utilize Trilogy messages to make informed decisions, and stated that the information **received** was accurate [94%] and reliable [92%].
- For improved ability to make informed travel decisions, users recommended expanded coverage area [20%] and access to text messages while driving [22%].

The following findings were made concerning **the ability of the RBDS-BAP Protocol and ITIS messages and locational databases to communicate the intended messages to the users:**

- Users received adequate information from the message format, although they had numerous minor suggestions for improvements or refinements that would make the information more valuable to them.
- TMC operators were able to assemble accurate messages with the Type 1A single group message formats. Operators noted areas of improvement, but felt that they were adequately providing users with all of the available information provided in a descriptive manner.

The following findings were made concerning user perception of product operability:

- Few drivers reported that the Trilogy device limited or distracted their attention away from the task of driving [20%]. Those that did felt that this feeling decreased over time.
- Users uniformly agreed that they wanted device text capability while their vehicle was moving and that this was a major limitation of the system.
- . The Home Map, Pan and Zoom features were rated very easy to use [72 to 87%] and the icons, symbols and text messages were rated very easy to understand [60 to 8 1 %] by most commercial users.

The following findings were made concerning **how much commercial users are willing to pay for a device and/or service:**

- With user-recommended improvements, the majority [57%] of the commercial users would be likely to purchase a Trilogy device for personal use. These improvements included: increased coverage area, more maps, weather information, and access to text.
- Dynaguide 3.0 users had many installation problems and mounting issues with the device screens. One of the top recommendations for system improvements that Dynaguide 3.0 users made were regarding better system installation.

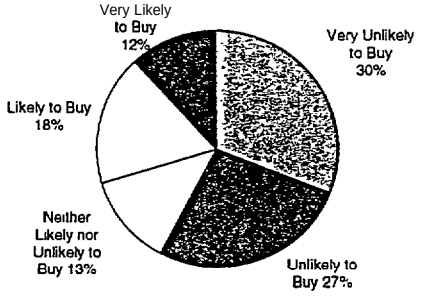

Figure 3-3. Likelihood of User to Purchase Trilogy System in its Current Form.

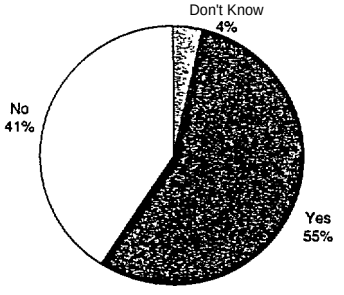

Figure 3-4. Likelihood of User to Purchase Trilogy System with User Recommended Improvements.

The following findings were made concerning **product and service market potential:**

- Users were able to define a price range for purchases and service costs, but stated that they were not very likely to purchase the device for personal use. The estimated purchase price of the Trilogy device was from $100 to over $500, with a mean price of $420 and an average monthly fee of $25. Commercial drivers who spend more time on the freeways show a greater likelihood to purchase the device for personal use.
- Users [70%] were more likely to recommend that an employer purchase the device for work-related use, rather than purchase it themselves for personal use [30%].

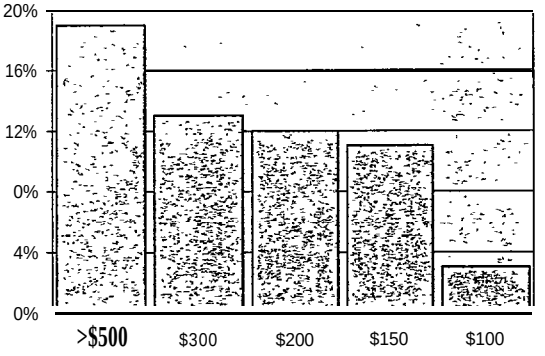

Figure 3-5. Percent of Users **Estimating Price Ranges from $100 to >$500.**

The following findings were made concerning **the reliability, accuracy, and timeliness of information received, based on user requirements:**

- Users [52%] rated Trilogy information much higher than alternative sources of information in terms of accuracy and reliability. Dynaguide 3.0 users were more likely to give higher ratings for accuracy. reliability, timeliness and quality than Dynaguide 2.0 users.

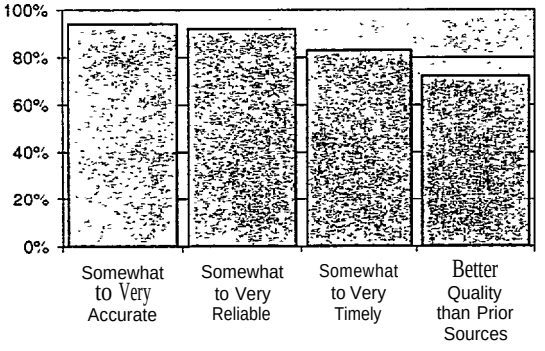

Figure 3-6. Percent of Users Who Feel that the Trilogy System is More Accurate, Reliable and of Better Quality than Previous Sources of Information.

- Users defined the main errors of system messages in terms of informational shortcomings, such as lane and directional information, text information or icon representation.
- The overall device failure rate was very low [10%], and the level of error or frequency of omissions did not affect credibility or trust in the **tested** Trilogy devices.
- Many commercial users expressed a desire to receive unconfirmed information (information from State Patrol or cellular phones) to reduce the number of times users encountered a problem **not** reported on their Trilogy device. Users [8 1%] stated that **receiving these** unconfirmed **reports** would not **reduce** their feelings that **Trilogy provides reliable** information.

The following findings were made concerning the effects on economic productivity of commercial users:

- The managers felt there were perceivable differences in travel times and the number of trips made per day.
- Dispatchers felt that the task of planning and scheduling drivers was positively impacted by having current real-time information available.
- Companies were more likely to recommend purchasing the Trilogy system for dispatching areas. and were more likely to purchase based upon freeway travel patterns or types of vehicles used.
- Managers were more likely to purchase the Dynaguide 3.0 device, rather than the Dynaguide 2.0 device.

3.b.4. Conclusions

Based on the perceptions of drivers, dispatchers and managers of eight different commercial businesses in the Twin Cities area, it can be concluded that commercial users found the Trilogy device in-vehicle real-time traveler information technology to be useful for making travel decisions that increased productivity, reduced travel times (about 20 minutes per week) and increased the number of trips made per day. Drivers using the Trilogy device also reported to have changed routes more frequently. indicating they were better informed about traffic incidents and congestion conditions. After using the devices. Trilogy information became the drivers principal source of travel information with a high reliability rating. Of the two Trilogy devices tested, users preferred the Dynaguide 3.0 device over the 2.0 device due to its real-time display of freeway system traffic operating conditions.

Commercial drivers found the Trilogy message format to be coherent, comprehensible and user friendly as well as accurate and reliable. They reported that the Trilogy devices were easy to use and did not distract them from normal driving functions. In addition, relatively few maintenance problems were experienced by commercial drivers during the test period. Recommended improvements to the Trilogy system, however, were stated by commercial drivers to increase the information coverage area followed **by** increased relevant messages, weather information and direct access to **text** messages while driving.

Commercial drivers were not likely to purchase the Trilogy device for personal use, but would recommend that their employers purchase it. Companies were more likely to recommend purchasing the Trilogy system for dispatching to improve driver planning and scheduling. The purchase value of the Trilogy device for the majority of commercial users was determined to be between $100 to over $500, with an average price of $420 and an average monthly service fee of $25.

3.c. COMMUTER USER ASSESSMENT OF TRILOGY TECHNOLOGY TEST PLAN

3.c.l. Purpose

The purpose of the Commuter User Assessment Test Plan is to evaluate and determine the potential benefits and operating characteristics of in-vehicle real-time travel information devices. In this test, a sample of commuter drivers were provided with up to two different communication devices that have a varying range of capabilities to provide route specific traffic advisories on freeway operating conditions in the Twin Cities metropolitan area. This test, in general, evaluated the usefulness of the Trilogy information service on private citizen travel efficiency and the appropriateness of the ITIS North American Standard message format protocol.

This test was designed to specifically address the following Trilogy evaluation goal: **"To Evaluate the Trilogy Technologies' potential to provide useful information on travel decisions made by commercial, governmental, and private users."**

As with the Commercial User Assessment test plan, the objectives of the Commuter User Assessment test plan were to:

- Assess the users' estimate of worth before, during and after the test.
- Assess the effectiveness of, and user preference for, different information output formats. with repeated use of the system.
- Assess usefulness of functions and features offered by different user devices, and suggested improvements.
- Assess what information was useful, and what information would be helpful.
- Assess the ability of the RBDS-BAP Protocol and . messages and locational databases to communicate the intended messages to the users.
- Assess user perception of product operability.
- Assess how much commercial users are willing to pay for a device and/or service.
- Assess product and service market potential.
- Assess the reliability, accuracy, and timeliness of information received, based on user requirements.

This test also addresses the following National ITS Goal:
Create an environment in which development and deployment of ITS canjlourish.

3.c.2. Test Description

Device users (46 Dynaguide 2.0 users and 32 Dynaguide 3.0 users) represented in this report were commuter drivers who volunteered to have the devices installed in their personal vehicle and to participate in the evaluation. Users were recruited through newspaper ads placed in the Minneapolis Star-Tribune, St. Paul Pioneer Press and the City Pages (Metropolitan Area distribution). Users then were screened by telephone interview and qualified after providing information on typical routes driven per week, proof of insurance and **a DMV record.**

The first group of commuter drivers tested the Dynaguide 2.0 in-vehicle device during the period from June 1996 through January 1997. The second group tested the Dynaguide 2.0 devices from May 1997 to September 1997. The final group tested the Dynaguide 3.0 device from July 1997 to February 1998. This group consisted of a mixture of **new** users and previous users of the

Dynaguide 2.0 device. At various stages during these periods, individuals were trained, devices were installed and data collection was initiated.

Data for this test plan was compiled from survey instruments including: 1) Baseline Sun ey: 2) Focus Groups; 3) User Logs; 4) One-on-One Interviews; 5) Early Survey: and 6) Post Survey. Findings outlined in this report are based on this data.

3.c.3. Evaluator Findings

The following findings were made concerning the **users' estimate of worth before, during and** after **the test:**

- Worth of traffic information on a congested route was defined by commuter users as **knowing** the exact location of congestion [94%], the length of backup on the congested road [74%], affected lane information [74%], the type of problem [73%] and alternate route information [67%].
- Most [74%] of the device users found information received on their Trilogy devices to be useful, and rated the information as above average. Users [69%] specified that the Trilogy system quality was better than previous sources of traffic information.

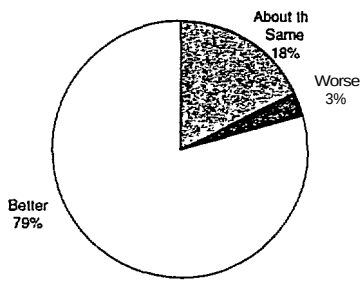

Figure 3-7. Overall Quality Comparison to Previous Sources of Information.

- Commuter users [81%] felt that they changed routes more frequently with the Trilogy system, indicating that they were better informed and were making more quality decisions when it came to changing (or not changing) **routes.**
- A majority [67%] of device users agreed that the use of Trilogy generally reduced travel time to their destinations.

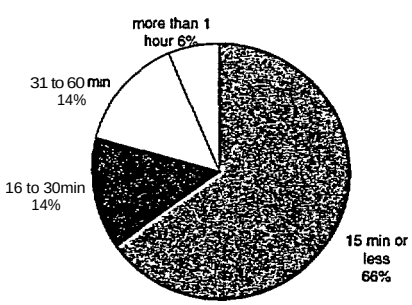

Figure 3-8. Estimated Weekly Time-Likelihood Saving Using Trilogy.

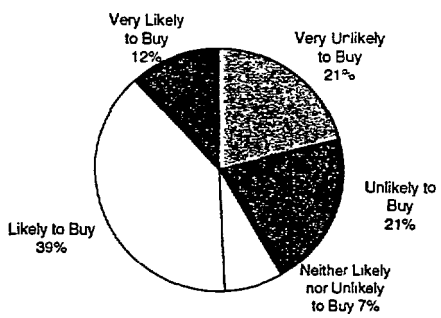

Figure 3-9. Commuter User to Buy Trilogy Device.

- About half [51%] of the commuter users stated that they were likely to buy the device for personal use, but the majority [88%] reported that they would recommend it to a friend or an employer.
- Users felt reduced stress and increased feelings of safety were benefits of the device, especially with increased usage. Only a few users [13%] felt that device usage in vehicles did impact personal safety issues, namely increased distraction from driving tasks.
- Commuter users [91%] rated Trilogy as their number one source of traffic information.

The following findings were made concerning the **effectiveness of, and users' preference for, different information output formats with** repeated use of the system:

- To the majority of users [95%], the Trilogy protocol and message delivery was coherent, comprehensible and user friendly in its multiple presentation formats.
- Commuter users [66%] preferred the device as a total presentation package, with information provided through icons, symbols and text.
- Users [74%] reported that they were receiving useful information a majority of the time. No changes to the format were suggested, except access to the device text capability while driving their vehicles as well as reducing screen glare and improving the visibility.

The following findings were made concerning the **usefulness of functions and features offered by different user devices, and suggested improvements:**

- The features that allowed users better navigational control (GPS [90%]. Zooming, Panning, Home Map [70%]) of presented information or extended viewing opportunity (Night palette [70%]) were judged to be the most useful by commuter users.
- Dynaguide 3.0 features such as favorite scale. GPS directional icons and system messages were also viewed as useful.
- For most users, improved usefulness of the tested device was not linked to any single or limited set of additional new functions or features, but rather expansion of existing device capabilities. Reduction in glare and greater access to currently provided information were the main improvements that would enhance user perception of device usefulness.

The following findings were made concerning what **information was useful, and what information would be helpful:**

- Users were able to utilize the Trilogy messages **to** make informed decisions, and stated that the information received was accurate [94%] and reliable [95%].
- Users [97%] understood the messages at a very high rate and had little difficulty **in** comprehending the intent of the message or utilizing the information received.
- Commuter users main suggestions for additional information needed to make travel decisions were related to test limitations: 1) limited coverage area; 2) limitations in

the ability to provide detailed information; and 3) ramp meter information (available with Dynaguide 3.0 device only).

The following findings were made concerning the **ability of the RBDS-BAP Protocol and ITIS messages and locational databases to communicate the intended messages to the users:**

- Users received adequate information from the message format although they had numerous minor suggestions for improvements or refinements that would make the information more valuable to them.

The following findings were made concerning **user perception of product operability:**

- 3 1% of the drivers felt the Trilogy device limited or distracted attention from driving.
- Commuters [58%] reported that overall, the devices were working well for their needs. The Home Map was rated as the most easy to use, while the screen saver was **cited** as the least easy to operate (the default is to leave the screen saver inactive). Icons and symbols were rated above text messages **in terms** of ease of understanding.

The following findings were made **concerning how much commercial users are willing to pay for a device and/or service:**

- Less than half of the users [44%] were likely to purchase the device, as is, for use in their personal vehicles. Users stated several improvements, focusing on operational issues (reduced glare [23%]. increased coverage area [14%], access to text while driving [12%]). that would increase their likelihood to purchase the device for personal use.

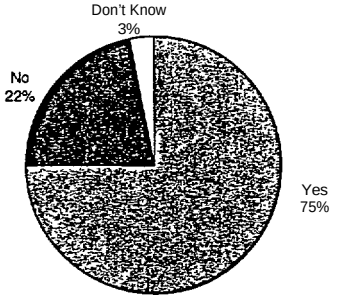

Figure 3-10. Likelihood to Purchase with Recommended Improvements.

- Dynaguide 3.0 users recommended a need for improved device installation workmanship for the Trilogy system.

The following findings were **made** concerning **product and service market potential:**

- **Users** were able to define a price range for purchase and for service costs. These estimates were lowered over time, which is typical of new technology which is felt to be more expensive at first but gradually the price decreases. The estimated purchase price of the Trilogy system was from $100 to over $1000, with an average **price** of $450 and a monthly service fee from $20 to $25.
- Users [88%] would recommend the Trilogy device **to** friends or companies that **would** benefit from the traffic and navigational information.

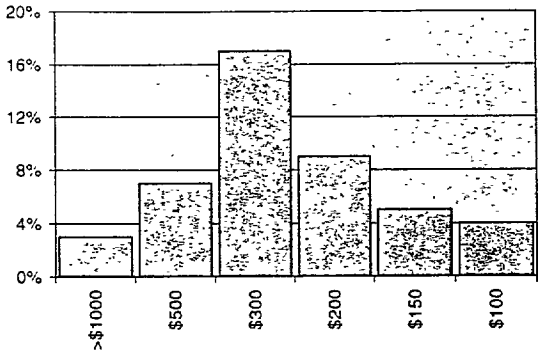

Figure 3-11. Percent of Users Estimating Price Ranges from $100 to >$1000.

The following findings were made concerning the **reliability, accuracy, and timeliness of information received, based on user requirements:**

- Trilogy performed well when compared against alternative sources of information, even official eyewitness reports. Tested devices very dependably provided users with both accurate and reliable traffic information judged to be of better quality than prior available sources [83%]. Dynaguide 3.0 users were more likely to give higher ratings for accuracy, reliability, timeliness and quality than Dynaguide 2.0 users.
- The level of device error or information omissions [16%] did not affect credibility or trust in the tested Trilogy devices. Reliability and trust were reported as very high with device usage. The overall quality rating of the Trilogy system is consistent with this feeling of high reliability of the information received.

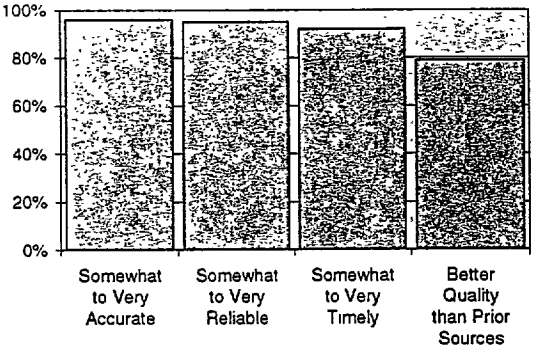

Figure 3-12. Percent of Users Who Feel that the Trilogy System is More Accurate, Reliable, Timely and of Better Quality than Previous Sources of Information.

3.c.4. Conclusions

Based on the perceptions of the commuter drivers, it can be concluded that they found the Trilogy in-vehicle real-time traveler information technology to be useful on making informed travel decisions that reduced travel time and increased feelings of safety when driving in the metropolitan area. Drivers using the Trilogy device also reported to have changed routes more frequently, indicating they were better informed about traffic incidents and congestion conditions. The most useful features of the Trilogy system were reported to be those that allowed better

navigational control (GPS, Zooming, Panning, Home Map) of presented information or extended viewing opportunity (Night palette).

Commuter users specified that the Trilogy system quality was better than previous sources of information, and that the message format was coherent, comprehensible and user friendly as well as accurate and reliable. Users understood the messages at a high rate and had little difficulty in comprehending the intent of the message or utilizing the information received. Commuter users were not concerned with distractions or limitations to attention caused by the Trilogy devices.

Commuter users were likely to purchase the device for personal use, especially with the recommended improvements such as reduced screen glare, increased coverage area and access to text while driving. Users found value in having their friends purchase the device and would recommend it to friends or companies that would benefit from the traffic and navigational information. The purchase value of the Trilogy device was determined by the commuter users to be from $100 to over $1000. with an average price of $4.50 and a monthly service fee of $20 to $25.

3.d. **IMPACT OF TRILOGY TECHNOLOGY ON USER TRAVEL BEHAVIOR AND THE METROPOLITAN TRANSPORTATION SYSTEM TEST PLAN**

3.d.l. Purpose

The purpose of this test plan is to determine as to whether the Trilogy system changes user travel behavior facilitating motor vehicle travel throughout the metro highway/freeway system served by the Trilogy test grid. This test was designed to specifically address the following Trilogy evaluation goal: **'To induce travel behavior changes in end users, and evaluate the potential effect of these changes on the metropolitan transportation system."**

The objectives of the Impact of Trilogy Technology test plan were to:

- Assess effect of system operation on user avoidance of incidents and construction causing major travel delays.
- Assess perceived change in users' travel time.
- Assess change in participants' travel patterns.
- Assess the potential effect of Trilogy on the metropolitan transportation system.

This test also addresses the following National ITS Goal:
Create an environment in which development and deployment ***of*** *ITScan flourish.*

3.d.2. Test Description

Data for this test plan was compiled from survey instruments of the Commercial and Commuter User Assessment Test Plans.

3.d.3. Evaluator Findings

The following findings were made concerning the **effect of system operation on user avoidance of incidents and construction causing major travel delays:**

- The raw data from the User Logs concluded that users perceived to be changing routes more frequently with Trilogy than with previous sources of information. This may be due to the fact that they are receiving more quality information with Trilogy, such as duration and length of backups caused by incidents on the roadway, and can make more informed decisions about whether or not to divert from their original routes.
- Based on the End of Test Survey, 70 percent of commercial and 8 1 percent of commuter users felt that they were taking alternate routes or diverting more often than with previous sources of traffic information.
- Commercial drivers were able to divert or change routes (2.7 times per week) almost twice as much (on average) as commuter drivers (1.3 times per week). This is most likely due to the fact that commercial drivers spend much more time on the freeway system than commuter drivers.
- Both commercial [74%] and commuter [83%] users "strongly" or "somewhat agree" that use of Trilogy generally allows avoidance of congestion.

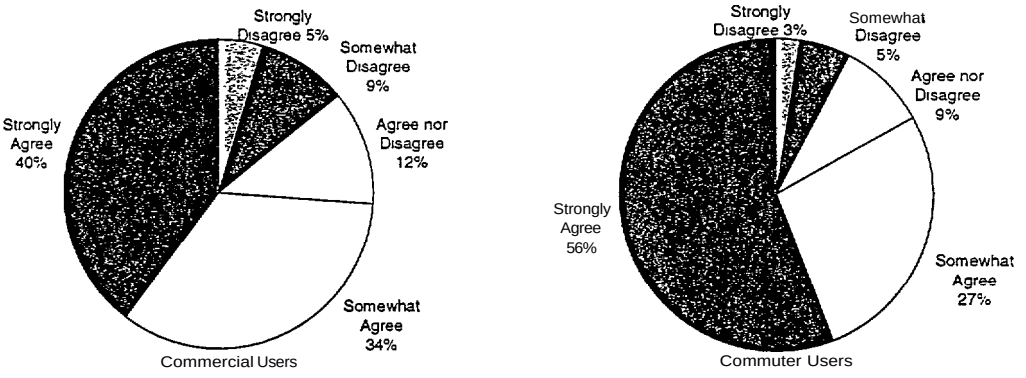

Figure 3-13. Use of Trilogy Generally Allows Avoidance of Congestion

The following findings were made concerning **the perceived change in users' travel time**

- A majority of the commuter users [64%] felt that the Trilogy device information generally reduced their overall travel time.
- Heavy freeway users reported greater weekly time-savings, probably as a result of having more opportunities to change routes than other drivers, who spend less time on the freeway system.
- Over half [53%] of the commercial drivers felt that the travel time-saving from taking alternate routes (a result of the Trilogy system) increased their ability to make more trips per day.
- Commercial users reported a mean weekly time-saving with Trilogy of 39 minutes similar to that reported by commuter users.

Table 3-1. Reported Weekly Time-Savings for Route Changes Before and After Using Trilogy

	Estimated Weekly Time-Savings		
	Before Using Trilogy (Baseline)	**Needed to See Benefit of Trilogy**	**After Using Trilogy**
Commercial Users			
15 minutes or less	43.1%	**47.7%**	**55.8%**
16 to 30 minutes	19.0%	11.1%	16.2%
3 1 to 60 minutes	**17.0%**	**15.7%**	**14.9%**
Longer than one hour	**20.9%**	**25.5%**	**13.0%**
Commuter Users			
15 minutes or **less**	**56.6%**	**39.5%**	**64.9%**
16 to 30 minutes	**21.1%**	**27.6%**	**14.3%**
3 1 to 60 minutes	17.1%	**22.4%**	**14.3%**
Longer than one hour	**5.3%**	**10.5%**	**6.5%**

The following findings were made concerning the change in participants' travel patterns.

- Users were asked to specify if they were able to rearrange their order of stops. start trips earlier or later with device information or use advanced route planning. In every case. less than one out of five commercial and commuter users were able to save time by using any of these techniques.

Table 3-2. Ability To Make More Trips per Day Based On Rearranging Order, Starting Earlier or Trip Planning

	Rearranging Order	**Starting** Earlier	**Route** Planning
Commercial Users			
Yes	18.5%	18.5%	16.7%
No	68.5%	68.5%	71.1%
Don t Know/No	13.0%	13.0%	9.3%
Commuter Users			
Yes	18.5%	18.5%	16.7%
No	68.5%	68.5%	71.1%
Don t Know/No	13.0%	13.0%	9.3%

- Commercial users [74%] were not likely to use advanced route planning or rearrange their stops [68%] due to time schedule constraints and dispatchers who organized their trips for them.
- Commuter users did not indicate that they left earlier [68%] or used advanced route planning [74%] **to** avoid incidents on the roadway system. Commuters have limited choices of which routes to take to/from work, and they aren't able to change their start times because users do not have access to the device unless they are in their vehicles. By the time commuter users turned on their Trilogy device, they were already in their cars and on the roadway system. It is also probable that many users do not have work schedule flexibility on the start or end times of their normal work day.
- Commercial users [52%] continued to use their considerable personal experience as much as information provided by Trilogy to decide whether **to** divert or not. This is probably significant when taking into consideration that most alternative routes **taken** by users would be on side streets or arterials, where they have the greatest experience, and where there is **no** information available from the Trilogy system.
- Commuter users rated Trilogy information [66%] much higher than their own personal experience [28%] in making route choice decisions. This is probably due to commuters limited ability to change routes, or limited knowledge of which routes **to** take. Commuters who utilized Trilogy become more informed as to the extent of congestion or incidents on their routes and the conditions on possible alternative routes.

The following findings were made concerning the **potential effect of Trilogy on the metropolitan transportation system:**

- Users stated that with wide-spread implementation, an overall Trilogy effect on the metropolitan highway system would be for users to:

	Commercial	Commuter
– Take alternate routes to avoid congestion	80%	88%
– Reduce travel time	72%	69%
– Knowledge of the freeway system	54%	81%
– Increase feelings of safety on the freeways	33%	50%

- The metro-wide effect most commonly cited by both commercial and commuter users was reduction in encountering congestion [commercial users 28%, commuter users 6583. Commercial users [21%] also reported that Trilogy would have a metro-wide effect on increasing the overall benefits of using the freeway system. Some commuter users felt that Trilogy would end up increasing congestion on the alternate routes [15%].

. Both commercial and commuter users felt that the Trilogy system improved their concern for accidents and safety (commuter users [50%] felt this improvement more than the commercial users [33%]). These users may have felt that wide-spread use of the Trilogy system would decrease congestion, the number of accidents or reduce the stress of most drivers on the freeways. The presumed overall effect would be better decision making and more alternate route usage.

3.d.4. Conclusions

The data from the surveys conclude that 70 to 81 percent of users perceived to be changing routes more frequently and saving more time [commercial users 39 minutes per week compared to commuter users 22 minutes per week] with the Trilogy system than with previous sources of information obtained before becoming involved with the Trilogy operational test. This could be due to the fact that users received more quality information with Trilogy and could make more informed travel decisions. In comparison, radio broadcasts traffic condition reports every ten minutes, which may not be timely enough for some commuters to make route changes.

Users were not likely to rearrange their order of stops, change their trip start times or use advanced planning **to** save time or avoid incidents on the freeway system. One reason for this is because the Trilogy devices were not available to users unless they were in their vehicle. In addition, commuter users had specific routes they traveled, with few diversion alternatives and commercial users relied on dispatchers to plan and organize their delivery schedules.

With the wide-spread implementation of the Trilogy system, users determined that usage of Trilogy allowed them to: 1) **take** alternate routes to avoid congestion; 2) reduce travel time; 3) gain knowledge of the freeway system; and 4) increase feelings of safety on the freeways. Most of the users felt that the Trilogy system improved their concern for both accidents and safety on the freeway system.

3.e. TECHNICAL PERFORMANCE TEST PLAN

3.e.l. Purpose

The purpose of the Technical Performance of the Trilogy System Test Plan is to perform a comprehensive technical evaluation of the Trilogy motorist information system to determine the performance capabilities of the transmission/communication systems, electronic relay time of data to an FM carrier and reliability of each device in use for the Trilogy operational test.

This test was designed to specifically address the following Trilogy Evaluation Goal: **"Perform a Comprehensive Technical Evaluation of the Performance** of **the Trilogy Systems."**

The objectives of the operational test were to:

- Determine data handling capacities and delays of all components of each system. and provide recommendations for system improvements.
- Identify and comparatively assess transmission coverage areas for each system: identify areas where data transmission coverage is poor and determine reasons for poor transmission.
- Assess suitability of all components of each system.
- Assess the minimum ATIS infrastructure necessary for deployment of the system.

This test also addresses the following National ITS Goal:
Create an environment in which development and deployment ***of*** *ITS can jlourish.*

3.e.2. Test Description

The two devices evaluated **in** this test plan were provided by AB Volvo, a Swedish auto manufacturer. Both devices receive information utilizing FM Subsidiary Communications Authorization (FM SCA) sidebands of local radio stations. These subsidiaries broadcast at frequencies that standard receivers do not detect. The first Volvo device receives information broadcast on an RBDS-TMC frequency with the capability of freeway system in-vehicle graphical display as its primary information delivery source. The second device receives information broadcast on a high speed FM subcarrier frequency at approximately 10 times the data rate of the RBDC-TMC, with an in-vehicle graphical display of segmented freeway system links color coded with real-time traffic operating speeds. The geographical display screen for both devices was approximately four-inches square.

This test plan evaluates data handling capacities and delays of all components of the RBDS and High Speed systems, and provides recommendations for system improvement. The various elements of the current infrastructure and system components were assessed to determine time lapses in the data handling thread of the systems. This data is beneficial to identifying the baseline configuration of this test and is tied closely with several objectives associated with user perspectives. The analysis also focused on the impact to the system when the number of links or roadway segments is expanded to include the entire metropolitan area.

Ranges of time for incident detection, verification, dissemination and user receipt were allocated in this **test** plan. The analysis determines if there are any appreciable differences based on the technology employed. Field observations were made with regard **to** the elapsed time encountered from information being sent to the service providers to the incident and roadway link information being displayed on a Trilogy in-vehicle device.

Data for this test plan was acquired by observing the operation of the system and logging events as they transversed through the system. This included the time an incident occurred. was reported, was verified. was entered into the system. and was received in the vehicle. Data was also derived from user logs. reports to the help desk and field recording measurements by Mn/DOT staff of FM subcarrier signal message reception. Field recording of FM signal message reception identified the number of messages received per second in groupings of 0- 10, 10-20. and 20-73 on a special receiver/software program developed by Mn/DOT.

Records were kept that logged any problems or maintenance actions required on both transmission equipment and in-vehicle receiving and display equipment. For each device, maintenance information was provided on the type of failure and the time to repair. User logs were reviewed to determine how long device users were out of service due to a component failures.

The Minnesota Department of Transportation provided information regarding hardware repairs and service calls made on the Trilogy Dynaguide 2.0 devices. Limited data was available on the Trilogy Dynaguide 3.0 devices. Mn/DOT Trilogy system operators also maintained a set of records to document Trilogy hardware and software failures at the Traffic Management Center.

Table 3-3. Common Operator Problems with Trilogy System

	Oct. 1995 - June 1996		April 1997 - Feb. 1998	
	Number	**Frequency**	**Number**	**Frequency**
System lock-up/unresponsive	27	18%	188	81%
Scroll bars not functioning	27	18%	0	0%
Modem related	7	5%	4	2%
Database errors	7	5%	10	4%

3.e.3. Evaluator Findings

The following findings were made concerning **data handling capacities and delays of all components of each system:**

RBDS System

- **DCI** transmitted 104 bit messages on the sideband at a rate of 1,187 bits-per-second (bps), or roughly 11 messages per second. Of these 11 **messages,** six were contracted by Mn/DOT to send traffic messages.
- The elapsed time from an incident being sent from the Trilogy operator workstation to the incident display on the AB **Volvo** Dynaguide 2.0 took an average of fifteen (15) seconds (based on observations by the TMC operators).

HSDS System

- Seiko transmitted on the FM sideband at 9,600 bps, sending approximately 73 link segments per second.
- The elapsed time from an incident being sent from the Trilogy operator workstation to the incident display on the AB Volvo Dynaguide 3.0 took an average of eight (8) seconds (based on observations by the TMC operators).

- The elapsed time from roadway link information being sent from the Traffic Management Center (TMC) to link segments displayed on the Dynaguide 3.0 took an average of five (5) seconds.
- With an information update cycle of 30 seconds, the average transmission delays for incidents and roadway links were 23 seconds and 20 seconds respectively.
- The observed time for incident and roadway link information transmission and display was consistent with the Trilogy operational parameters established during system design.

Additional Findings

- While system redundancy could be improved through the use of Primary and Hot-Standby links for both the RBDS and HSDS system links to the radio station carrier. as well as utilizing more than one radio station to improve coverage, it was not proven to be a problem for this project.
- Once an incident was detected and visually verified, operator entry of incident information into the Trilogy system was easily completed by an experienced operator within a one minute time duration. Pull-down menus used to create "standard" messages were presented in a user-friendly format.
- The roadway link sensor polling cycle of Twin City freeway loop detectors successfully updated the database in enough time to provide useful "real-time" segment status indications. A faster poll cycle and database update could have been achieved utilizing higher speed front end processors and data transmission equipment, but would not be cost justified as the 30 second update interval was considered sufficient for system users to take appropriate action.
- DCI and Seiko met their service contract requirements with no appreciable system downtime or compromise of data integrity.
- Ball Aerospace and Technologies, Corp., who replaced Lore1 as the software developer for the Trilogy FOT, did not successfully meet the design criteria.
- With each Trilogy message repeated three (3) times and a contracted transmission rate of six (6) messages per second, this equated to a maximum throughput of two (2) incidents per second. Incident throughput could have been improved by repeating the message only twice instead of three times, effectively increasing message throughput by 50 percent, or three (3) incidents per second. If a user did not receive the incident information during the initial two transmissions but in the next broadcast update, there would still have been adequate time for the user to receive the data and take appropriate action. At times when there were a large number of incidents, the higher incident throughput would have provided the user with a complete picture of traffic conditions in less time. The trade-off would have been that users in areas with marginal radio coverage might not have received all data in a timely manner.
- Incident throughput could have further been improved by increasing the service provider contracted message rate from six (6) to eight (8), however this may have resulted in a higher contract cost with the service provider.
- System start-up time could be improved if the tuner had the capability to determine the availability of other radio stations in the area prior to it being powered off. If it detects that there is only one radio station available, then the system could be

equipped to not scan for an additional frequency once powered back on, even if the device reads that it has "lost" the station. This would protect the device from continually scanning to find a different frequency (that doesn't exist) other than the one it is locked on to when the vehicle enters a temporarily "dead" area. such as a parking garage.

- Timing estimates were to be derived for delivery information in systems with 1000, 5000, 10,000 and 50,000 roadway links for both the RBDS and HSDS systems. The RBDS system had unlimited link expansion capabilities, however. Volvo has not disclosed information on the system's capabilities to display messages with an expanded number of links. The expansion of the HSDS system was based on the robustness of the hardware and software capabilities. With updated computer equipment and revised software. you could expect the message delay to increase linearly with the increase in the number of links added to the system. Therefore, the five-second transmission rate (from the TMC to the link segment display on the Dynaguide 3.0) with approximately 750 roadway links. would be increased to about a 7-, 33- and 67-second transmission rates with 1000,5000 and 10,000 roadway links, respectively.

The following findings were made concerning transmission coverage **areas for each system,** which identify and document areas where the Trilogy in-vehicle devices had difficulty in receiving traveler:

- Relatively few users identified actual signal drop out or signal strength problems (no TMC signal) or GPS receiver system failures.
- Field testing of FM signal strength indicated nearly uniform coverage of message reception. The message reception strength was recorded to be 20 to 73 messages per second.
- The areas identified with poor reception were likely to be attributed to geographic terrain conditions with steep hillsides, depressed freeway cross section or close proximity to adjacent buildings.

The following findings were made concerning the **suitability of all components of each system**

- Most of the Trilogy system problems recorded in the operator logs were a result of workstation software failures.
- For the majority of time (where the duration of failure was recorded) the Trilogy system was down for as little as five minutes to as long as four hours. Several cases of service interruption lasted up to several days.
- Based on Mn/DOT Dynaguide device repair records, Dynaguide 2.0 component failures were **most** often a result of problems with the receiver/processor component, GPE **receiver** or the display. For Dynaguide 3.0 device users, component failures were most often a result of problems with the Trilogy display cable connection, the processor unit, the GPS receiver, the FM radio receiver and finally, the display itself.
- Repair **records** indicated that about half of the failed Dynaguide components (42 percent of Dynaguide 2.0 and 61 percent of Dynaguide 3.0 device components) were either exchanged for working components locally at an installation center, or repaired on-site by technicians. These repairs were typically made shortly after the device user requested service.

- While system downtime was incurred by both the Trilogy device user and the TMC operator due to hardware and software malfunctions during the test period, the cumulative time of system failure taken over the entire analysis period equated to less than one percent of total operational time for the TMC operators, one percent for the Dynaguide 2.0 users, and less than three percent for the Dynaguide 3.0 users.

The following findings were made concerning **the minimum ATIS infrastructure necessary for deployment of the system:**

- For both RBDS (Figure 3-14) and HSDS (Figure 3-15) systems, the standard equipment necessary is:
    1. Traffic Management Center with appropriate operator workstations
    2. CCTV network
    3. Ethernet or other network connection system (for workstation-system linkages)
    4. Radio station transmitter
    5. Roadway loop detection system (HSDS only)
    6. Communications processor for formatting messages
    7. Communications link from TMC to communications processor and from processor to radio station
- Based on the TMC operator interviews, the minimum components required to implement a Trilogy-like system elsewhere would be the following:
    - Use a "count-up" timer to relay incident duration times to the user;
    - Further divide long roadway links with additional detectors for reporting more accurate incident locations (some links are too long-delays caused by incidents show up for the entire link length, even if the incident is affecting only a small portion of the link);
    - Implement "pop-up" screens to remind operator to update dynamic incidents/back-ups;
    - Refine incident list for (1) easier selection process, and (2) more descriptive choices; **and**
    - Continue to provide training to all operators for consistent data entering practices.
- Based on the user Post Survey questions, the minimum components required to implement the system elsewhere would be to improve the following:
    - Introduce the accessibility of text while driving (was **not** provided to users due to liability **concerns);**
    - Reduce in-vehicle screen glare from bright sunlight;
    - Increase system coverage area; and
    - Incorporate audio messaging into the system.

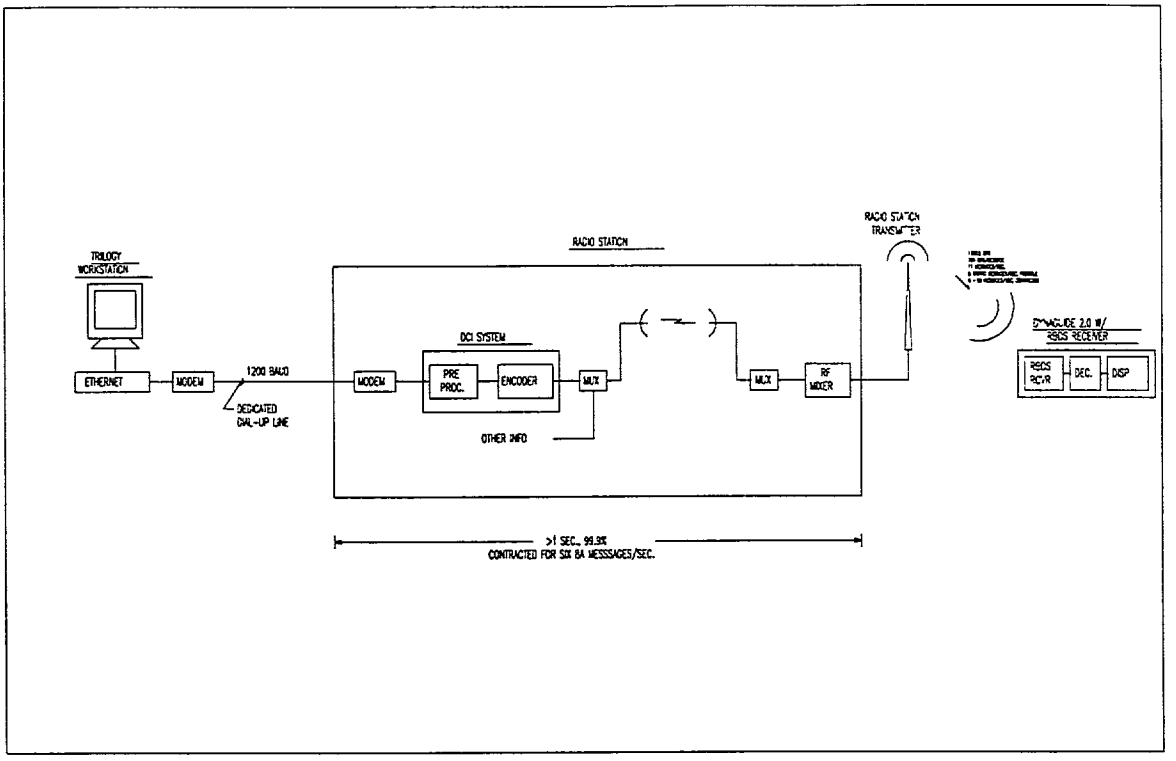

Figure 3-14. Radio Broadcast Data System (RBDS) Data Flow Diagram.

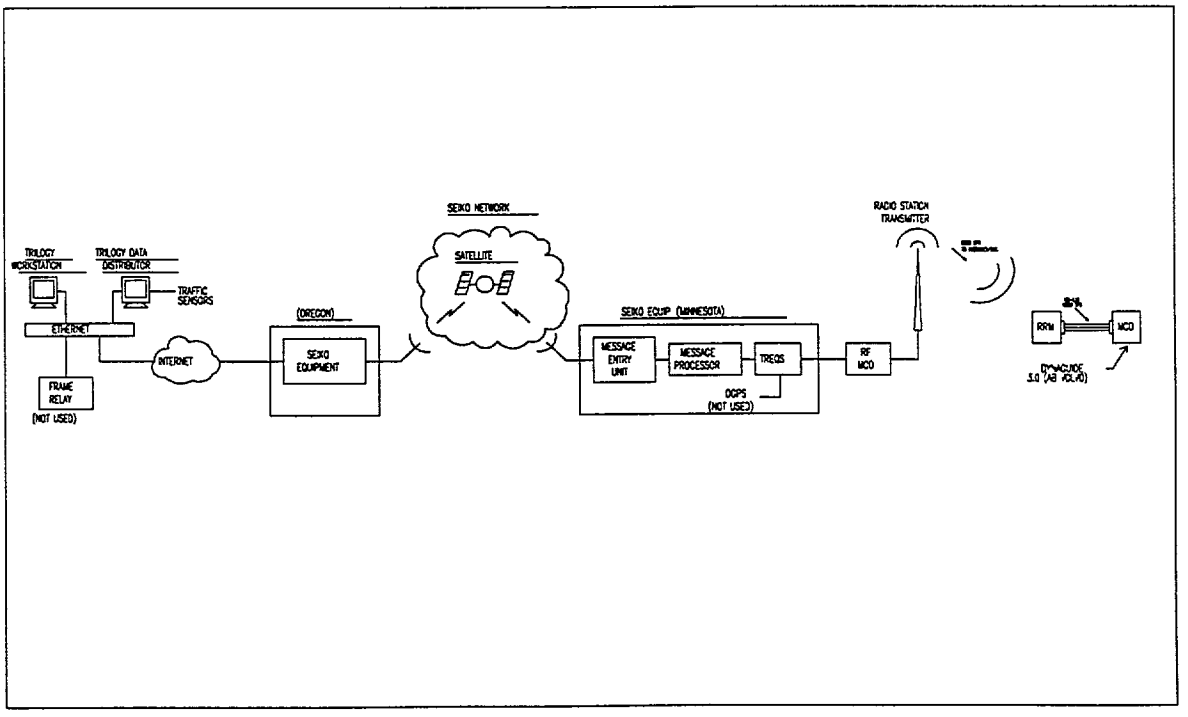

Figure 3-15. High Speed Data System (HSDS) Data Flow Diagram.

3.e.4. Conclusions

The AB Volvo Dynaguide 2.0 (RBDS) and the AB Volvo Dynaguide 3.0 (HSDS) were the two in-vehicle user displays evaluated. User display size (approximately 4" square) was large enough to easily view incident icons and roadway link operating segment status. The under dashboard/trunk mounting of the Dynaguide device receiver and associated equipment did not obstruct the operation of the vehicle when properly installed. Vast improvements in the quality of display with the Dynaguide 3.0 makes it the preferred choice, as well as its capabilities to obtain travel speed and ramp delay information. Secondary roads, as they appeared on the in-vehicle display, were not detailed enough to navigate around a traffic incident or congestion. Detailed secondary road map displays (and their operating conditions) were not part of the Trilogy system design, as the in-vehicle displays were not intended to be a navigation tool.

If a system like Trilogy were applied in a larger metropolitan area, data transmission speed would become more of an issue as there would be more simultaneous incidents and more roadway links to update. The RBDS system has unlimited link expansion capabilities, however, Volvo has not disclosed information on the system's capabilities to display messages with an expanded number of links. With the expansion of the HSDS system, one could expect the message delay to increase linearly with the increase in the number of links added to the system. For both the RBDS and HSDS devices during the Trilogy FOT, the time from incident occurrence identification and roadway link congestion evaluation to information received by the user was considered adequate for the user to take appropriate action. Again, the HSDS system had an advantage as it provided faster incident data updates and real-time system operating speeds.

According to the operator logs, Trilogy system problems occurring at the Minnesota Department of Transportation's Traffic Management Center were a result of workstation software failures. Other failures included those that were related to the International Traveler Information Interchange Standard (ITIS) messages (includes any errors relating to coding messages into the system, or viewing message icons on screen) and locations. Most of these errors consisted of a system lock-up, where rebooting was often necessary. Of the problems reported with durations of failure, these errors usually resulted in a system down-time of five minutes to four hours, and on several occasions, the system was down for a few days. Except for the problems that resulted in several days of system down-time (intemet failures, network and equipment problems, facilities damaged by storms, etc.), these software failures were relatively minor, and did not impact the Trilogy operational test for any significant amount of time. Users were generally understanding of the development nature of the Trilogy technology.

Device user problems with the Dynaguide 2.0 devices were most often the result of component problems with the Trilogy signal receivers/processors (located in the same "box"), GPS receiver and display. For the Dynaguide 3.0 device, component failures were most often a result of display cable connection, processor unit, GPS receiver, FM radio receiver or the display itself. Based on information provided by the technical staff, problems with the Dynaguide 3.0 processor occurred more frequently than the receivers. Since users usually reported that they weren't "receiving" information, these problems were recorded as receiver failures. Therefore, the number of receiver failures recorded may be artificially higher than the processor failures for the Dynaguide 3.0 device.

Most of those units needing repair were either exchanged for working components locally at an installation center, or repaired on-site by technicians. Since these repairs were typically made shortly after the device user requested service, the device user was not significantly impacted or inconvenienced by the failed components.

For both RBDS and high speed (HSDS) systems, the standard equipment necessary is:

1. Traffic Management Center with appropriate operator workstations
2. CCTV network
3. Ethernet or other network connection system (for workstation-system linkages)
4. Radio station transmitter
5. Roadway loop detection system
6. Communications processor for formatting messages
7. Communications link from TMC to communications processor and from processor to radio station

The interviews with the TMC operators identified several recommendations for changes in equipment or procedures that could improve the overall efficiency of the Trilogy system. These recommendations include: adding a count-up incident timer. adding ITIS locations to freeway ramps, sectioning off long roadway links, implementing "pop-up" screens to remind the operator to update incidents, refine the incident list and provide training to all operators for consistent data entering practices. Additional recommendations were made by the TMC operators that are not considered minimum infrastructure requirements, but are expected to enhance the operations of the Trilogy system.

The Trilogy operational test users did not recommend new additional features or functions to the system. However, text while driving, screen glare reduction. increased system coverage area and audio messaging were frequently suggested in the Post Survey for improving the appeal of the Trilogy system to the user. Access to text while driving was not available to users due to liability concerns.

3.f. LIABILITY ISSUES TEST PLAN

3.f.l. Purpose

The purpose of the Liability issues test plan is to document liability and legal issues encountered during the Trilogy operational test and to assess their effects on the test after its completion. To complete this test, Trilogy test participants including device manufacturers, public and private commercial users, private commuter users and public Trilogy partners, were given the opportunity to provide information on liability issues and concerns encountered throughout the test. Any liability and legal issues or questions raised. measures taken by participants to protect themselves from liability and legal issues or legal actions taken were documented.

This test was designed to specifically address the following Trilogy evaluation goal: **"To document the liability issues and effects on the Trilogy operational test."**

The objectives of this test were to:

- Identify liability issues encountered during the test and maintain a library of related documents.
- Document the effects of liability issues on Trilogy operational test.

This test also addresses the following National ITS Goal:
Create an environment in which the development and deployment ***of*** ITS can flourish.

3.f.2. Test Description

The main liability issues addressed by this test plan include liability for device operability and device security, broadcast of incorrect information, economic impacts and transportation impacts. This test documents legal actions and insurance claims as well as all concerns raised by participants.

The evaluation approach used the commuter screening process, discussions with the project manager and partners, interviews with commercial managers and dispatchers, user surveys and user logs. This data was used to document the number and types of issues and concerns raised by users during the test and any legal actions arising during the **test** and to determine the number of persons refusing to participate in the test because of liability issues/concerns.

3.f.3. Evaluator Findings

The following findings were made concerning **the liability issues encountered during the test:**

- Users did not specifically ask any questions **regarding** liability or legal issues of the Trilogy operational test. Users did, however, recommend access to text messages while driving. This option was not implemented because of the liability issues surrounding reading while driving.
- **The majority of users felt increased** feelings of safety were benefits of the Trilogy device. This benefit was a **result of advance notice of congestion on the Dynaguide** screen providing a warning of slow or stopped traffic conditions ahead. Only a few users **felt that device usage in vehicles** impacted personal safety issues, namely increased distraction from driving tasks.

- Each of the project participants, project partners, and software providers signed agreements with the Minnesota Department of Transportation (Mn/DOT). The agreements include language covering the following:
  - Information on the liability of each party.
  - The liability concerns of each of the partners.
  - Each party is responsible for any Workers Compensation claims made by their own employees, or persons affected by their employees.
  - The liability for any third party claims made would be determined according to the applicable laws (Participant and Partner agreements only).
  - The participant would be responsible for repairing or restoring their vehicles or stations after the Trilogy test was completed, and that the participant is not responsible for devices which malfunction, are damaged or are stolen (Participant agreements only).
- No insurance claims or legal actions were initiated due to any aspect of the Trilogy operational test.

The following findings were made concerning **the effects of liability issues on Trilogy operational test:**

- None of the commuters surveyed during the commuter user screening process expressed any comments or concerns which could be construed to be liability-related, and no participants refused to participate based on a liability issue.
- There were no liability issues encountered during the Trilogy test which would affect the conduct of the operational test such as user recruitment, study design and application, device production, and TMC operations.

3.f.4. Conclusions

Trilogy users recommended that access to text while driving for improved operation of the Trilogy system. This option was rejected due to the liability issues surrounding that situation. Only a few users expressed any concern regarding personal safety issues from operating the Trilogy device while driving. Liability issues also encountered during the Trilogy operational test were those documented in each of the agreements with the Trilogy partners, participants and vendors. These issues were primarily concerned with the liability of each party if a claim was submitted by an employee or a third party.

Liability agreements were signed by project participants, project partners and software providers, which documented information on the liability of each party and the liability concerns of each of the partners. No liability claims were made during the Trilogy operational test.

It can be concluded that liability or insurance issues are not concerns of potential commuter users of the Trilogy system and liability issues had no impact on the Trilogy operational test.

3.g.l. Purpose

The purpose of the Cost of Operational Test Plan is to document all costs associated with the Trilogy Operational Test. The execution of this test plan documented capital. insurance. maintenance, leasing, and operating costs of system components and labor/overhead costs of all personnel involved in the project.

This test was designed to specifically address the following Trilogy evaluation goal and objective: "To **Document the Costs of the Trilogy Operational Test."**

This test also addresses the following National ITS Goal:
Create an environment in which development and deployment ***of*** *ITS can flourish.*

3.g.2. Test Description

This test compiled a list of costs associated with the Trilogy Operational Test. Information was obtained for this test plan from the Trilogy Project Manager. including costs identified by agreements between Trilogy partners.

To document costs associated with the Trilogy Operational Test: the following categories were used:

- **Funding Categories:**

Federal Funds - This category consists of project funds received for the Federal Government.

State Funds - This category consists of project funds provided by the State of Minnesota.

Private Funds - Although not documented herein, additional research/development funds for this operational test were provided as services by the project parties, AB Volvo, Indikta. DCI and Seiko.

- **Expenditure Categories:**

Evaluation - The expenditures listed in this category relate to costs associated with evaluation, design, data collection and analysis, report preparation, and meetings. Data collection includes focus groups, interviews, surveys, vehicle logs, correspondence and meeting minutes and technical performance measurements.

Operations -The operations expenditures include the cost of capital equipment for computers, software design, RBDS devices and staff salaries.

Phase II *Devices* - Expenditures related to the Phase II Device category involve the cost of purchasing the high speed receivers from Seiko

Pre Engineering - Pre Engineering expenditures include the cost of pre-engineering for both the RBDS and Hi-speed systems.

Project Management - The expenditures relating **to** the Project Management category include equipment, project management salaries, training salaries, and travel expenses.

Radio Broadcast Data System (RBDS) - The expenditures in this category include the cost of device purchase, customs, fees, and operations.

The main focus of this MOE is to document the costs of the Trilogy project. which includes all maintenance and labor costs of the project partners in addition to all capital, leasing. insurance, maintenance and operation costs of system components. These costs specifically include the following:

- In-vehicle device hardware and operation costs;
- Communication system hardware. software and operating costs:
- TMC operating costs:
- Liability insurance costs;
- Radio station bandwidth leasing costs: and
- Other miscellaneous costs.

3.g.3. Evaluator Findings

Table 3-4 shows that approximately 14 percent of the project funds are from State sources and 67 percent are from Federal sources. Additional project research/development funding was provided by the Trilogy project partners (AB Volvo, Indikta. DCI and Seiko) comprising 18 percent of the project costs.

Table 3-4. Project Funding Sources

Source	Amount	Percent (%)
Federal Funds	$2.800,000	67.3
State Funds	$600.000	14.4
Funding Total	$3,400,00	81.7
Partner Contributions	$756,400	18.3
Total Budget	**$4,159,800**	**100.0**

Table 3-5 summarizes the Trilogy Operational Test project costs between the dates of January 1, 1995 and July 1, 1998. A cost breakdown for each of the expenditure categories is located in Appendix A of this report. As shown on Table 3-5, **the** total project costs was $4.03 million. Of the project cost, about 12.9 percent was devoted to pre-engineering for system design of both the RBDS and Hi Speed device technologies. Approximately 22.1 percent was devoted to Phase II devices, 11.9 percent to operations expenses, 9.0 percent to Radio Broadcast Data System development and 8.7 percent to project management. Only 5.1 percent of the total costs were devoted **to** expenses and about 11.5 percent were devoted to the operational test evaluation. The project partner contributions were 18.8 percent of the total cost.

Table 3-5. Trilogy Expenditures through July 1, 1998

EXPENDITURES	AMOUNT	PERCENT
Pre-Engineering	$522,051	12.9
Radio Broadcast Data Systems	364,038	9.0
Phase II Devices	890,065	22.1
Operations	478,146	11.9
Project Management	350,147	8.7
Evaluation	462,351	11.5
Expenses	206,003	5.1
Project Partner Contributions	756,400	18.8
Total Expenditures	**$4,029,201**	**100.0**

TRILOGY EVALUATION ISSUES

4.a. OVERVIEW

The Trilogy FOT was very complicated, covering many technological factors involving the design of a traveler information message protocol, development of a message transmission system. display receiver and software, location code database, and data handling system. Very dependable partnerships were created with staff resource efforts committed to a successful project. In addition to the technology development element of the project. Mn/DOT staff commitments were very dedicated to the field test evaluation requiring solicitation and negotiations with commercial user firms and private commuters, device installation, completed survey form data collection, user training and system maintenance.

In summing up the results from the six individual test reports the main issues that merit further examination are related to:

- System Expansion
- System Deployment Capability
- Impact on the Transportation System
- User Responses/System Technical Capabilities

4.b. SYSTEM EXPANSION

A principal user response in the evaluation was related to the need to expand the system coverage to increase its value. System users (both commercial and commuters) found the Trilogy system to be of value to improving productivity, saving travel time and reducing driver stress. However, both user groups uniformly agreed that the system's value and their propensity to purchase a Trilogy device would be increased if the service coverage were expanded. Expanded coverage includes full freeway system information, longer hours of reporting and, if possible. arterial street system operating condition information. Increased utilization of Trilogy system technology with system expansion has the potential to increase congestion related diversion thereby balancing system traffic demand between freeway and arterial roadways.

4.c. SYSTEM DEPLOYMENT

The Trilogy device/service market appears to be greatest in the commuter area where unlimited driver numbers are available compared to the commercial fleet/dispatcher area which represents a smaller market. In order to effectively deploy the Trilogy system to these market areas, the provision of pre-trip information as an intemet service should **be** provided. The ability to change trip departure times based on Trilogy information accessed prior to making a home-to-work or work-to-home commuter trip could potentially impact traffic demand balance on the transportation system. This is described further in the following section.

The cost of the Trilogy System and/or monthly service fee will impact its marketability to commuters. Even though the system became the number one source of reliable traveler

information for the study users, free current travel information is readily available through the news media (radio and television). Commercial and commuter users estimated the average purchase price of the Trilogy system to be from $400 to $500 with an average monthly service fee of $20 to $25.

4.d. **IMPACT ON TRANSPORTATION SYSTEM**

It would appear from the information collected in this evaluation that commercial users were able to adjust some of their trip routes based on Trilogy information. Trilogy was also reported to allow commercial users to become more productive by either saving travel time or making additional trips. In reality, the Trilogy system allowed the commercial users to better utilize the freeway system, not reduce their use of it.

Commuter users did not change their trip start or departure times because the Trilogy information is not available unless they are in their vehicle. With more complete coverage of freeway and arterial system operating conditions, Trilogy may have the capability to improve utilization (balancing) of corridor capacity by permitting informed travelers to seek alternative travel routes when an incident or congestion problem occurs on their normal travel route. From a transportation system safety and driver stress reduction perspective, Trilogy device users reported improved conditions with real-time traveler information.

4.e. USER RESPONSES/SYSTEM TECHNICAL CAPABILITIES

In the user survey information there were numerous suggestions regarding increased coverage enhancements for area expansion. 24-hour operation and potential arterial system detection. The area coverage can be expanded with a fixed cost investment of technology deployment. Expansion of detection to the arterial system could become cost prohibitive based on the miles of parallel and cross street system networks needed to provide adequate information. Depending on the signal system detection available with closed loop or adaptive controls, costs could be controlled slightly. But incident and congestion verification. a critical element in the Trilogy information reliability design, would require CCTV system installation to provide comparable information to that reported on the freeway system. Development of such an extensive data link location and reportable incident message system could not be served in the same data transmission frequency as designed for Trilogy.

TRILOGY PERSPECTIVES, LESSONS LEARNED AND FUTURE APPLICATIONS

5.a. INTRODUCTION

The following partner perspectives and lessons learned were provided to HNTB through project management interviews and user responses reported in the Commercial and Commuter Assessment Test Plans.

5.a.l. Project Partner Perspectives

In order to provide an understanding of the lessons learned from this operational test it is important to understand the purpose for the test and the perspective of the partners involved in the test. Mn/DOT is actively involved as a national leader in the deployment and research of ITS technologies. **This** involvement is based on a goal to maximize the efficiency of the existing transportation network to improve mobility and enhance safety. An objective of that overall goal is to provide traffic information to the public in more effective ways. Trilogy was designed to address that objective by providing more condensed information that: 1) did not include interruptions with unrelated information; and 2) could be sent automatically, without user involvement (Dynaguide 3.0). Additionally, Trilogy was designed to filter and display information in a variety of formats.

The Trilogy project allowed private partner firms to develop and refine technology that was being deployed in Europe for potential application in the U.S. market. Other partners that agreed to test the technology were. in some cases. looking for technology advancements to manage their fleets and utilize their involvement as a competitive marketing tool.

5.a.2. Trilogy Participant Benefits and Risks

The Independent Evaluator also asked the project participants to provide their perspective with regard **to** what they perceived as potential benefits and risks of the project. From a Mn/DOT perspective, project benefits were realized in the TMC traffic control room where much was learned from user feedback on how to present traffic information. Much of **the way** that incidents were identified and presented was based on Trilogy user responses. From a public agency perspective, a risk always exists as to the public opinion on the expenditure of funds. With a budget of $4 million. the Trilogy project could have potentially received scrutiny on its impact to improve traveler information to only a very small group of commercial and commuter users.

Risk **is** also involved around the uncertainty of finding commercial partners and commuters who would be willing **to** volunteer as test case users and have equipment installed on their vehicle dashboard as well as complete a series of surveys and weekly activity logs. Overall, this did not become a problem. Risk was also assessed from a liability condition that could occur from **commercial,** or more likely, commuter users. Through discussions with insurance professionals, liability was identified as not being an insurmountable obstacle for Trilogy.

From a private partner perspective, the principle benefits were the ability to refine and field test the development of a traveler information system, an opinion of the public acceptance of the system and the risk involved **in the** development of device receiver technology. This risk was confirmed when the Indikta speech device could not **be** designed to operate reliably, and the

development of the Dynaguide 3.0 device required extra design efforts which delayed the deployment schedule for evaluation.

From a user perspective, the benefits realized with the Trilogy system were reduced travel time. decreased driver stress, increase productivity and greater feelings of safety.

5.b. LESSONS LEARNED

This FOT was well founded technologically with a base of European experience. Lessons learned for future applications of the Trilogy advanced traveler information project relates to problems encountered with speech synthesis, software design, vehicle device installation and information needed by motorists to make route decision changes.

It was not possible to develop a reliable 'speech only' traveler information device. The device design involved a larger effort than was initially anticipated, and numerous reliability problems that were encountered could not be resolved. FM signal strength was stronger in the U.S. than that experienced in Great Britain, where the device was being developed. This problem could not be overcome to provide a reliable device for evaluation.

Software development was designed around an existing program and vendor code. This proved to be difficult to modify to meet the needs of the project design. In the future, unless an existing software program meets the project needs, it is recommended to develop project specific software from scratch.

A major complaint from device commuter users involved problems encountered with the device installation in their private automobiles. In some cases, the complaints were related to dashboard or interior cosmetic workmanship of the installer. In most cases, however, the installation workmanship problems were related to device operability. Installation staff did not appear to take adequate care in the installation, affecting device grounding and/or signal interference. In the future, installation should be undertaken by a firm with a high interest in the project's success. such as an auto dealer or franchised device supplier.

The greatest lesson learned from the Trilogy project involved identification of what information is useful to the motorist and how it should be presented. The motorist information "need" focused on incident location, type and duration. These lessons were applied in the TMC control room to improve the delivery of ATIS. In the future, adequate training of TMC operators should be provided for consistency in relaying messages. Traveler information regarding the exact location of congestion, the length of backup, affected lane information and the type of problem should also be provided.

From an evaluation viewpoint, the greatest lesson learned involved the need to have a flexible schedule that could adjust to changes in device installation and availability. Under a perfect research design, all devices would be installed over a short time period with user **logs** and surveys conducted concurrently for all users. Additionally, an effort should be made to use electronic data collection, entry and reporting to minimize data storage and analysis coding.

5.c. FUTURE APPLICATIONS OF TRILOGY TECHNOLOGY

The following are potential future uses of the Trilogy technology evaluated in this project. Even though the Trilogy users agreed that the information provided on their Trilogy device became their number one source of traffic information, a reluctance appeared to exist on their part to pay for that information. It would appear that for Trilogy to be successfully marketed in the U.S.. it would need to provide additional area coverage to increase its value. Therefore. the application of the Trilogy system evaluated in this project has some limitations.

- As an advanced traveler information system Trilogy could be deployed as a fleet dispatch center resource. Commercial dispatchers and managers found the Trilogy System to provide useful information for the management of delivery services.
- A second future application would involve deployment of Trilogy systems in Emergency and police vehicles and dispatchers centers, where real-time information provides a potential response time savings.
- The application of Trilogy technology and incident reporting procedures is very valuable for traffic management center operations. Use of the high speed travel conditions map has the ability to assist control room operators with problem identification and extent.
- The utilization of Trilogy system information could also be applied in airport taxi services and rental vehicles. The advantage of real-time travel information in both of these situations would allow a driver who was in their vehicle to make route decisions when utilizing the freeway system as an element of their travel route. The device's GPS capability can enhance the Trilogy device value to these users.
- Application of the Trilogy systems to intemet or news media sources would allow pre-trip planning to occur before a traveler is already committed to a trip when they enter their vehicle.

5.d. **CONCLUSIONS**

The Trilogy operational test has proven to be a successful project overall.

- The basic purposes of the test were accomplished: 1) to identify the basic information needed by motorists to make informed travel decisions, such as real-time traveler incident, speed and delay information; and 2) to test the transmission technology, such as data handling capacities and coverage areas, of in-vehicle devices.
- Although the test was extended due to technology considerations of the Dynaguide 3.0 devices, it did not impact the study evaluation findings.
- The study, unlike many operational tests, did remain within budget. This is partially attributed to the fact that the 'speech only' device analysis could not be completed due to product development problems. It is also attributable to the fact that the partnering of Mn/DOT staff with the independent evaluator in the distribution and collection of user surveys and the provision of technical product data helped balance the level of effort by all involved in the test.

- The risks anticipated in the operational test did not materialize with regard to potential liability problems, the ability to find private partners and citizen device users, overall product reliability, or public scrutiny.
- The one risk that did materialize involved the inability to develop a reliable 'speech only' traveler information device for evaluation in this test.
- Traveler information benefits were identified that have already been incorporated into the daily procedures at the Mn/DOT TMC control room.

FINAL CONCLUSIONS

6.a. **OVERVIEW**

HNTB Corporation prepared the Trilogy Evaluation Plans and conducted a thorough review of the survey data, focus group feedback, interview summaries. operational test documentation and all six of the Individual Test Reports. In addition to our own reviews we have received feedback from the Project Manager and the project Evaluation Committee.

6.b. FINAL CONCLUSIONS

Based on the review of the project history and documents of this test we offer the following final conclusions and recommendations:

- **Conclusion:** The Trilogy FOT was a successful demonstration of the benefits of real-time travel information that can be realized in travel time savings, improved productivity (more commercial trips can be made per day) and motorist stress reduction. The test shows that people will change travel patterns to avoid congestion based on reliable traffic information. The data showed that for a Trilogy type system to become widely accepted by the motoring public, it must be available 24 hours per day and be expanded to include travel information on the arterial street system in addition to information on the freeway system.

. **Conclusion:** Based on data collected in this test. real-time travel information devices such as Dynaguide, did not create a distraction to normal driving functions. The use of icons and system map operating speed data were easily understood by the motorist for informed travel decision making purposes. Users understood messages at a high rate and **experienced little** difficulty in comprehending the intent of messages or utilizing the information received. Dynaguide-type in-vehicle devices were reliable and functionally easy to operate by the motorist. The Dynaguide 3.0 device was preferred over Dynaguide 2.0 by test users due to its enhanced graphics and real-time travel information.

- **Conclusion:** As designed, the technical capability of the Trilogy system is limited in its ability to provide real-time traveler information for an extensive network of city arterial streets and freeway segments. Expansion of the system would require additional operator reporting resources for incidents and a reduced broadcast message redundancy frequency. Expanded use of device message filtering capability would assist the motorist in sorting pertinent trip travel information. The use of real-time route travel speed information has the potential to meet basic traveler needs with supplemental route message information.

- **Conclusion:** In-vehicle real-time traveler information cannot be expected to impact motorist trip start times. In-vehicle traveler information is limited to impacting route choice. Expansion of this information to other services such as intemet, weather and news information sources may have a greater impact on pre-trip planning as well as overall travel behavior and its potential impact on an area's transportation system. There is no reason to **not** consider this type of ATIS application as part of a larger traffic information package to be made available **to** the public.

- Conclusion: The Trilogy FOT successfully demonstrated the potential for public/private cooperation in the development of a traffic information system. Both communication and product design services can be provided through a cooperative partnership. Commercial businesses and commuters can assist in the evaluation and deployment of traveler information.