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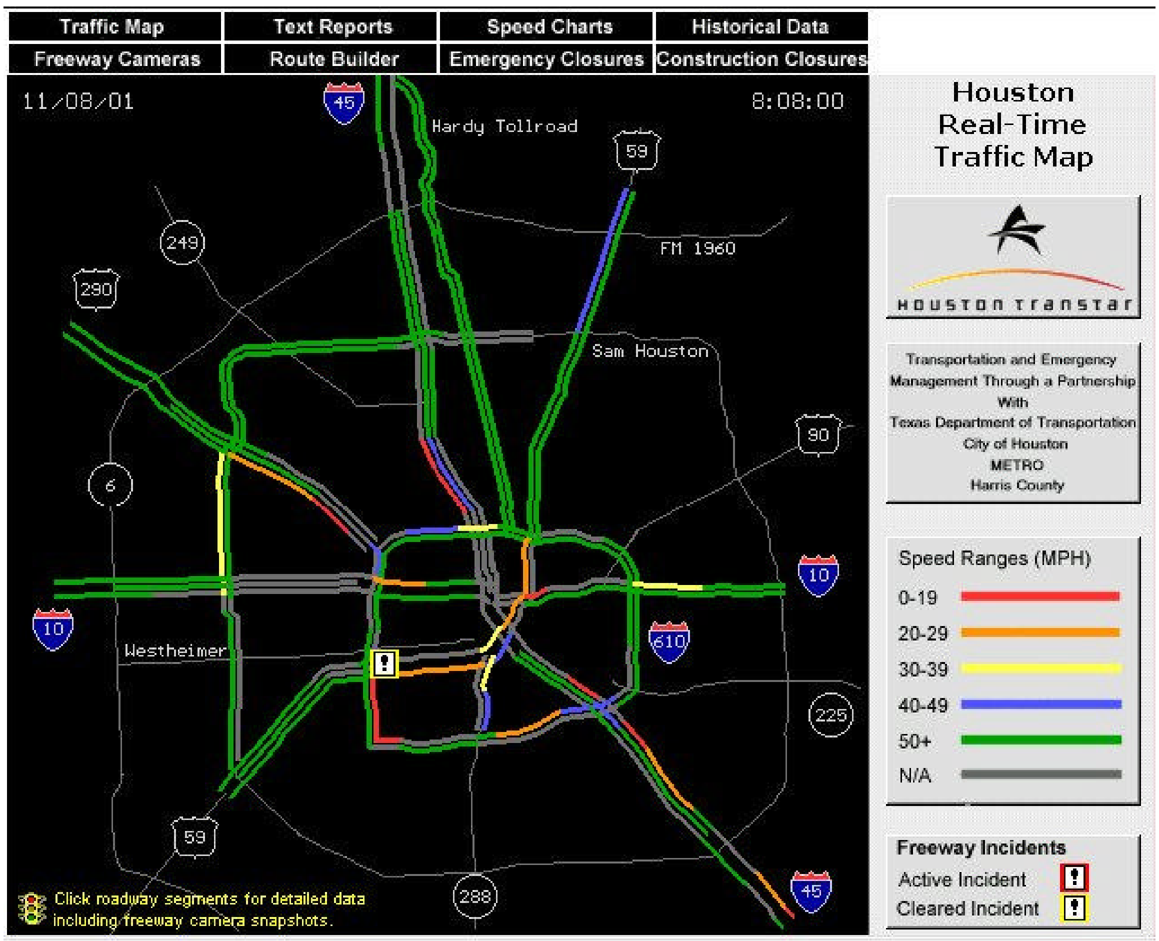
Of Transportation

Federal Transit Administration

Final Report
April 2002

Houston Smart Commuter



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13. ABSTRACT (Maximum 200 words)

This final report documents the background, history, operations and findings of the Houston Smart Commuter operational test. This operational test was designed to evaluate the potential for achieving more efficient use of travel alternatives through the provision of travel conditions via portable computer devices and an automated telephone system. Ongoing technical problems, participant and control group attrition, external influences, and problems with evaluation data quality made it impossible to prove or disprove the effectiveness of the Advanced Traveler Information System design concept. Nevertheless, some changes in travel patterns were made by project participants and several design, procurement, deployment, operations and project management lessons were learned that will be useful in future deployments.

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METRIC/ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)		
1 inch (in)	=	2.5 centimeters (cm)
1 foot (ft)	=	30 centimeters (cm)
1 yard (yd)	=	0.9 meter (m)
1 mile (mi)	=	1.6 kilometers (km)
AREA (APPROXIMATE)		
1 square inch (sq in, in^2)	=	6.5 square centimeters (cm^2)
1 square foot (sq ft, ft^2)	=	0.09 square meter (m^2)
1 square yard (sq yd, yd^2)	=	0.8 square meter (m^2)
1 square mile (sq mi, mi^2)	=	2.6 square kilometers (km^2)
1 acre = 0.4 hectare (he)	=	4,000 square meters (m^2)
MASS - WEIGHT (APPROXIMATE)		
1 ounce (oz)	=	28 grams (gm)
1 pound (lb)	=	0.45 kilogram (kg)
1 short ton = 2,000 pounds (lb)	=	0.9 tonne (t)
VOLUME (APPROXIMATE)		
1 teaspoon (tsp)	=	5 milliliters (ml)
1 tablespoon (tbsp)	=	15 milliliters (ml)
1 fluid ounce (fl oz)	=	30 milliliters (ml)
1 cup (c)	=	0.24 liter (l)
1 pint (pt)	=	0.47 liter (l)
1 quart (qt)	=	0.96 liter (l)
1 gallon (gal)	=	3.8 liters (l)
1 cubic foot (cu ft, ft^3)	=	0.03 cubic meter (m^3)
1 cubic yard (cu yd, yd^3)	=	0.76 cubic meter (m^3)
TEMPERATURE (EXACT)		
[(x-32)(5/9)] °F	=	y °C

METRIC TO ENGLISH

LENGTH (APPROXIMATE)		
1 millimeter (mm)	=	0.04 inch (in)
1 centimeter (cm)	=	0.4 inch (in)
1 meter (m)	=	3.3 feet (ft)
1 meter (m)	=	1.1 yards (yd)
1 kilometer (km)	=	0.6 mile (mi)
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1 square centimeter (cm^2)	=	0.16 square inch (sq in, in^2)
1 square meter (m^2)	=	1.2 square yards (sq yd, yd^2)
1 square kilometer (km^2)	=	0.4 square mile (sq mi, mi^2)
10,000 square meters (m^2)	=	1 hectare (ha) = 2.5 acres
MASS - WEIGHT (APPROXIMATE)		
1 gram (gm)	=	0.036 ounce (oz)
1 kilogram (kg)	=	2.2 pounds (lb)
1 tonne (t)	=	1,000 kilograms (kg)
	=	1.1 short tons
VOLUME (APPROXIMATE)		
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1 liter (l)	=	2.1 pints (pt)
1 liter (l)	=	1.06 quarts (qt)
1 liter (l)	=	0.26 gallon (gal)
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1 cubic meter (m^3)	=	1.3 cubic yards (cu yd, yd^3)
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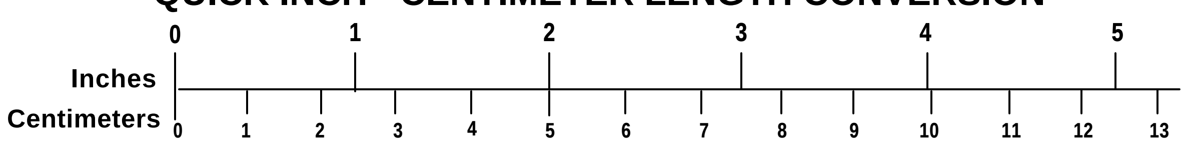
QUICK INCH - CENTIMETER LENGTH CONVERSION



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LIST OF ACRONYMNS

APTS	Advanced Public Transportation Systems
ATIS	Advanced Traveler Information System
AVI	Automatic Vehicle Identification
COTS	Commercial Off the Shelf
FHWA	Federal Highway Administration
FTA	Federal Transit Administration
Houston TranStar	Greater Houston Transportation and Emergency Management Center
HOT	High Occupancy Toll
HOV	High Occupancy Vehicle
IDS	Houston Smart Commuter Information Delivery System (Server)
I/O	Input/Output
IVHS	Intelligent Vehicle Highway System
IVR	Interactive Voice Response
LCD	Liquid Crystal Display
METRO	Metropolitan Transportation Authority of Harris County
NTP	Notice to Proceed
RFTP	Request for Technical Proposals
RID	Remote Information Device
SCA	Subsidiary Communications Authority
SOV	Single Occupancy Vehicle
TDM	Transportation Demand Management
TTI	Texas Transportation Institute
TxDOT	Texas Department of Transportation
VMS	Variable Message Sign
Volpe Center	John A. Volpe National Transportation Systems Center

EXECUTIVE SUMMARY

Introduction

The Houston *Smart Commuter* Intelligent Transportation Systems operational test spanned almost ten years from the original feasibility study beginning in 1990 to the conclusion of the test period in 1999. The operational test was funded, implemented and evaluated through the joint efforts of the Metropolitan Transit Authority of Harris County (METRO), the Texas Department of Transportation (TxDOT), the Federal Highway Administration and the Federal Transit Administration. The Texas Transportation Institute (TTI) conducted a local evaluation for TxDOT. Multisystems, Inc. conducted this national evaluation for the Volpe National Transportation Systems Center.

Operational Test Objectives

The Houston *Smart Commuter* operational test was designed to evaluate the potential for gaining more efficient use of major travel corridors through greater utilization of high-occupancy commute modes, shifts in travel routes, and changes in travel time through the application of innovative approaches using advanced technologies. The test was based on the hypothesis that commuters who have quick and easy access to relevant, accurate, and up-to-date travel information (e.g., existing traffic conditions, bus routes, bus schedules, how to use the bus, and instant ride-matching services) in their home and workplace will be more likely to use public transportation and other high-occupancy commute modes.

Project Description

The *Smart Commuter* operational test was to include bus and carpool components intended to make better use of Houston's high-occupancy vehicle (HOV) facilities in the I-10 and I-45/Hardy Toll Road corridors. Both components also were designed to take advantage of the Greater Houston Transportation and Emergency Management Center (Houston TranStar) which opened in 1995.

The bus component involved providing a selected group of travelers with real-time information on traffic conditions and transit options utilizing portable computer devices. The carpool component, which was to involve instant rideshare-matching for employees at several companies in a non-downtown employment center, was never implemented due to external developments that undermined the test.

The bus component focused on commuters residing in the vicinity of the Kuykendahl park-and-ride lot near I-45 North and traveling to work in downtown Houston. The primary commuter information delivery system for the operational test was a handheld personal information device, the commercially available battery-operated Sony Magic Link™ Personal Intelligent Communicator (PIC)-100.

Houston TranStar processed real-time traffic conditions and formatted it for distribution to the *Smart Commuter* test groups' Magic Link™ units via a wireless FM subcarrier broadcast channel. Information on bus routes, schedules, fares, and current status, as well as directions to the nearest park-and-ride lots were also made available.

Individuals using the Magic Link™ first received a report on the general traffic conditions in the I-45 North corridor. The user could then opt to see more detailed information on specific segments of the corridor, including real-time speed maps of I-45 North, its HOV lane, and the Hardy Toll Road.

The secondary information delivery system was an interactive telephone system which provided the same information as the Magic Link™ device except for the map displays.

The traveler information delivery system was designed to collect detailed information about when and how the Magic Link™ was being used and to collect information on participants' travel via an electronic travel diary that could be uploaded to the system server.

Project History

After several years of conceptual design research led by TTI, a proposal for Federal funding for the *Smart Commuter* project was submitted. Funding was approved in late 1992. A contract to carry out the operational test was awarded to a team led by TRW.

The first functional test occurred in September 1996, and the second occurred between November and December 1996. By December 1996, the participant and control groups had been trained, and 273 Magic Link™ units were deployed. In December 1996, TRW began system acceptance testing. Because the system did not pass the entire set of requirements, the acceptance test was repeated four more times before finally being accepted in August 1997.

Because the project team determined that the first participant group had experienced too many problems with the *Smart Commuter* system, a second participant group was recruited in the fall of 1997. The I-45 portion of the operational test was completed in December 1998, although the system continued to operate until February 1999.

The Houston *Smart Commuter* bus component was projected to cost $6.96 million over its originally scheduled four-year implementation period. The actual cost of the project over the extended period of operation is not available.

Evaluation

Multisystems assumed the role of national evaluator in August 1994. Since the first year test was subject to significant technical problems, the national evaluation team concentrated its analysis on the second year test data. A comparison of the December 1998 post-test surveys and travel diaries with the baseline information became the focus of the national evaluation along with analysis of second-year log data uploaded from the Magic Link™ units. The information became available to the national evaluation team in the summer of 1999, following a TxDOT review process.

Several factors challenged the national evaluation, including:

- Delays in the project schedule and operation;
- Ongoing changes in project design and operation;
- Attrition in the test groups;

- Timeliness in receipt of data; and
- Quality of the data received.

As a result, the national evaluation approach evolved during the project to focus on lessons that can be learned from the *Smart Commuter* project rather than a detailed quantitative evaluation of impacts. It was believed that this type of evaluation would provide greater benefit to those planning other ITS field tests. Nevertheless, quantitative measures were estimated wherever they seemed relevant and valid.

Project Findings

Patterns of Magic Link™ Usage

The most important points of Magic Link™ usage analysis include the following:

- Traffic information was the most sought after information. The TranStar Main Screen was used the most by a wide margin since it was the default screen and it also provided real-time traffic information that may have been sufficient for many users.
- Magic Link™ logs showed a pattern of use centered on the morning and afternoon rush hours, with a noticeable percentage more likely to check in the morning.
- The Mode Choice screens were minimally used. This is noteworthy since encouraging participants (primarily SOV commuters) to change modes was a key objective of the operational test.
- The relatively high amount of time spent on the travel diary screen may indicate that it required considerable time to provide the required travel information and could have dampened interest in the *Smart Commuter* program.

Consumer Acceptance of Magic Link™

- Around 50 percent of participants rated the performance of Magic Link™ as very good or good. The highest rating was in Ease of Use which is surprising considering comments from the participants that indicated the Magic Link™ setup was somewhat complicated.
- Information Timeliness and Information Usefulness were the two lowest rated performance categories. This is disappointing given that *Smart Commuter* was designed to give accurate, real-time information.
- Participants' rated the traveler information provided by Magic Link™ lower than radio, TV, and the Internet, beating only the newspaper.
- No significant changes in travel behavior between the participants' baseline and post-test responses were evident. Participants' propensity to take the bus was only slightly higher than the baseline, suggesting that mode choice change did not occur to any significant degree. However, interpretations of these data could be somewhat unreliable because of the small number of survey respondents.
- Over half of control group and participants stated that they experienced less stress when making a travel change as the result of receiving traffic information. Approximately 80 percent said they would make the same change again.

- Almost 40 percent of participants claimed to be willing to pay for a traffic information service.

Lessons Learned

Typical of new systems and technologies, the *Smart Commuter* project was a challenging operational test. Overall, the public and private sector project team overcame a host of obstacles and, therefore, enabled the national evaluators to put together a list of lessons learned and recommendations that should add to the body of knowledge about ITS technologies and systems.

Design Lessons

The decision to discourage in-vehicle Magic Link™ use may have limited its utility. The fact that radio is typically rated highly as a traffic information medium may have indicated that an in-vehicle device would have been better received by users.

The decision to use the lower-cost, two media communications approach (i.e., wireless for transmission of real-time data to participants and telephone connection for uploading surveys and diaries and downloading transit schedule data) may have complicated the system for users. Technical problems with both likely exacerbated participant attrition.

Procurement and Contracting Lessons

Specifications in a solicitation should explicitly reflect the current state of technology while allowing for technological advancements. Contracts should provide the capability to upgrade to the latest technologies so that operating tests are not conducted with outmoded devices and software.

Acceptance testing procedures, requirements, and milestones need to be clearly spelled out in the contract to avoid confusion during deployment and operation. Confusion and disagreement over the acceptance testing procedures and related milestones had a variety of unfavorable impacts on the *Smart Commuter* project.

Deployment and Operations Lessons

Acceptance procedures should not only rigorously test the user components and central system, but must ensure that the data and information being collected, processed, and disseminated are as accurate, timely, and reliable as possible.

A system must not be placed in service before it is actually ready for deployment. The costs in terms of lost public confidence are potentially large.

Recruitment and retention of participants and control groups is imperative for evaluation purposes. The evaluation of a project will be compromised if the control or participant groups are too small and/or suffer substantial attrition.

The public sector needs to have a technical staff available to handle the most demanding technology issues. Lack of technical expertise on the *Smart Commuter* project team may have adversely affected the outcome of the project.

Project Management Lessons

Management by technically qualified people with sufficient dedicated time for the project is critical.

While controlling staff turnover on a project that extended as long as *Smart Commuter* would be difficult, the lack of continuity appears to have had detrimental impacts on the project. The resulting problems were obstacles to participant continuation.

In operational tests, user participation and related data collection and analysis should be considered a central project management concern. Some data collection decisions may have led to participant attrition.

Since operational tests involve extensive data collection, management should not overlook the potential of using this information flow as a way of detecting operating problems before they surface as a major issue with users.

Overall Conclusions

It is difficult to determine whether the original goals and objectives of the *Smart Commuter* operational test were accomplished. Ongoing technical problems, participant and control group attrition, external influences, and problems with evaluation data quality make it impossible to prove or disprove the effectiveness of the Advanced Traveler Information (ATIS) design concept.

The public sector believes the project helped enhance its understanding of what consumers want. Although METRO has no plans to continue the *Smart Commuter* project or reengineer it, the agency is interested in applying pager technology to ATIS with the benefit of its experience with *Smart Commuter*.

Both the public and private sector members of the project team concluded that the public sector needs to partner with the private sector in making travel information available to the public.

1. INTRODUCTION

This document presents the national evaluation of the Houston *Smart Commuter* Intelligent Transportation Systems (ITS) operational test. The Metropolitan Transportation Authority of Harris County (METRO) initiated the planning for the operational test in 1990, and completed the test in early 1999. The national evaluation was conducted by Multisystems, Inc. as a subcontractor to Cambridge Systematics, Inc. The latter firm was under a contract with the John A. Volpe National Transportation Systems Center (Volpe Center). The Volpe Center has the responsibility for conducting evaluations of field operational tests of Advanced Public Transportation Systems (APTS) for the Federal Transit Administration (FTA). A local evaluation was also conducted by the Texas Transportation Institute (TTI) of Texas A&M University under a separate contract with the Texas Department of Transportation (TxDOT).

1.1 Overview of Houston *Smart Commuter* Operational Test and Objectives

The Houston *Smart Commuter* operational test was designed to evaluate the potential for gaining more efficient use of major travel corridors through greater utilization of high-occupancy commute modes, shifts in travel routes, and changes in travel time through the application of innovative approaches using advanced technologies. The test was based on the hypothesis that commuters who have quick and easy access to relevant, accurate, and up-to-date travel information (e.g., existing traffic conditions, bus routes, bus schedules, how to use the bus, and instant ride-matching services) in their home and workplace will be more likely to use public transportation and other high-occupancy commute modes.

The development of the Houston *Smart Commuter* operational test was initiated in 1990. A planning and feasibility study, which was jointly funded by FTA, METRO, and TxDOT, was conducted by TTI in 1990-1991. This study included:

- An examination of the possibility of utilizing ITS technology to address Houston’s problem with traffic congestion, concerns with air quality, and other environmental issues;
- An analysis of available literature on commuting behavior and mode choice selection;
- An examination of the market potential for the operational test concepts through the use of focus groups and surveys; and
- Reviews of potential technologies for providing the real-time traffic and transit information to individuals in their home and workplace (including telephone, television, radio and videotext).

A series of reports were prepared documenting the different elements of the study. A final report of the planning and feasibility study was prepared to summarize the major elements of the operational test and present a project implementation program, budget and preliminary evaluation approach.

The *Smart Commuter* operational test originally included two different, but compatible, components. Both components were intended to make better use of Houston's extensive high-occupancy vehicle (HOV) facilities. These facilities include lanes in the I-10 and I-45/Hardy Toll Road corridors which are open to transit vehicles and carpools with three or more persons, and park-and-ride lots (Spring and Kuykendahl).[1] Both components were designed also to take advantage of the Greater Houston Transportation and Emergency Management Center, or Houston TranStar, which opened in 1995.

The I-45 North corridor, which is the subject of this national evaluation report, consists of both I-45 and the Hardy Toll Road. I-45 is a multi-lane, limited access highway running north from downtown Houston. As reported in the FY '95 Smart Commuter Status Report, I-45 had completed HOV lanes from downtown to Beltway 8. Shorter HOV segments north of that point were either under construction or in the design/planning phase. The HOV lane on the Hardy Toll Road, another multi-lane, limited access highway running north/ northeast from downtown Houston, was still under construction. [2] Motorists could use EZ Tags to pay their tolls automatically.[3] (A map of the corridor is shown in Section 3, Figure 3.1.)

The EZ Tag system was central to the *Smart Commuter* concept. By installing stand-alone tag readers spaced along I-45, Texas DOT created an automatic vehicle identification (AVI) system. By tracking the movement of EZ Tag-equipped vehicles, such as speed between tag readers, the AVI system provided the data from which some of the real-time travel conditions could be calculated for *Smart Commuter.*

This element of the test was aimed at encouraging use of public transit and other HOV modes for work trips to downtown Houston. This corridor is well served by buses operating in HOV lanes, which offer considerable time savings in peak hours. Funding was secured for a one-year operational test and was to include a six-month review and a one-year evaluation.

The I-45 North corridor operational test provided traveler information in two ways. The first and primary method was via a handheld computer, the Sony Magic Link™.[4] A commercial off-the-shelf product that was modified for the operational test, Magic Link™ provided the test participant[5] with real-time point-to-point travel times on I-45 HOV and regular travel lanes and the adjacent Hardy Toll Road, map displays, and other information described in Chapter 3. The second method was an automated, unstaffed Interactive Voice Response (IVR) telephone system.

The traveler information delivery system was designed to perform two functions central to the operational test. Each time a user connected to the main computer server via a wireline[6] analog

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[1] Towards the end of the project, a new program called QuickRide opened the I-10 HOV lanes to 2-person carpools who paid a toll electronically.

[2] "Houston Smart Commuter ITS Operational Test: FY 1995 Status Report." Texas Transportation Institute: The Texas A&M University System, November, 1995.

[3] EZ Tag is a typical electronic toll collection and traffic management (ETTM) system. The system uses wireless, high frequency radio transponders to exchange toll payment information with electronic toll sensors so that motorists do not need to stop at staffed tollbooths.

[4] Magic Link™ is a trademark of the Sony Corporation.

[5] In general, the terms "participant" and "user" will be used interchangeably in this report to denote individuals who were actually using the *Smart Commuter* system and related information devices such as the Magic Link™.

[6] Wireline will be used throughout the report to denote a communications link using a regular copper phone line as found in most private homes.

modem, the Magic Link™ automatically uploaded detailed information about when and how the handheld device was being used. The Magic Link™ was also loaded with an electronic version of the travel diary that was to be used every three months in accordance with the local evaluation data collection plan. Like the usage information, the travel diary responses were uploaded to the system server the next time a participant logged into the *Smart Commuter* server. This setup was developed to provide the basis for collecting the data needed to analyze system usage and travel behavior changes for both the local and national evaluation efforts.

Because the handheld system and/or reception of traveler information was not expected to be available under all conditions, an audiotext IVR telephone system was also provided as an information medium. It was accessible only by test participants using a six-digit identification number. It provided information almost identical to the Magic Link™ device via a menu driven user interface. The only exception was the inherent inability to provide map displays.

In the I-10 West corridor, instant rideshare-matching was to be made available to the employees at several employers in a non-downtown employment center. This type of commute is not well served by transit, but offers an HOV lane that is open to carpools of three or more occupants. This element of the test was aimed at encouraging use of carpools for work trips. This test component was put on hold and eventually deleted from the project.

1.2 Overview of the National Evaluation Process

Like other transit-related field operational tests, the FTA intended to evaluate *Smart Commuter* within the context of the national APTS program objectives. FTA has defined four principal objectives of the APTS program as follows:

1. Enhance the quality of on-street service to customers;
2. Improve system productivity and job satisfaction;
3. Enhance the contribution of public transportation systems to overall community goals; and
4. Expand the knowledge base of professional personnel concerned with APTS innovations.

It is important to note that the *Smart Commuter* APTS field operational test *as deployed* focused on its Advanced Traveler Information System (ATIS) features. In other words, it was through the effective provision of traveler information *to single occupancy vehicle commuters* that *Smart Commuter* aimed at encouraging a mode shift to transit, rather than direct technological treatments of the transit system. As such, the traditional transit performance characteristics were not testable under these conditions. Therefore, the APTS objectives and measures do not all directly relate to this project.

Within each of the four categories of national APTS objectives listed above, the FTA has defined several specific sub-objectives, which are listed in Appendix B. It is important to remember two points. First, each individual operational test typically addresses only some of the objectives and sub-objectives. Second, the definition of transit in the APTS program is very broad, and includes modes such as carpooling and vanpooling, as well as bus and rail.

1.3 Summary of *Smart Commuter* National Evaluation Objectives

The national evaluation objectives/subobjectives relevant to the *Smart Commuter* project include:

- Improve timeliness and availability of customer information;
- Reduce passenger travel time;
- Increase the extent and effectiveness of TDM programs; and
- Enhance HOV systems by reducing SOV use.

Note that the national APTS objectives apply to the entire national APTS program, while the local objectives are specific to this project. The national objectives also place greater emphasis on the transferability of the results of operational tests. As discussed in Chapter 2, the range of measures identified by the national APTS evaluation guidelines provided an excellent structure for evaluating the *Smart Commuter* test.

1.4 Local Evaluation Objectives

The local evaluation objectives for the *Smart Commuter* operational test in the I-45 corridor consisted of the following:

1. Identification and quantification of the effects of the provision of real-time information on commuter behavior in the suburb-to-downtown commute;
2. Evaluation of the net effect on corridor operations due to changes in commuter behavior;
3. Assessment of the effectiveness of the technology used; and
4. Dissemination of the information acquired during the planning and implementation of the operational test.

Judging from the local evaluation status reports produced by TTI,[7] only the first and third objectives were actually possible given the final design of the test and the related data collection. This is consistent with the evolution of the national evaluation effort.

1.5 Structure of the Report

The remainder of this report is structured to provide:

- More detailed understanding of the national evaluation;
- Thorough discussion of the national evaluation results; and
- A summary of the lessons learned in the course of the national evaluation.

[7] For example, Houston *Smart Commuter* ITS Operation Test: FY 98 Status Report (Research Report 1985-4), TTI, Revised edition February 1999.

2. CONDUCTING THE NATIONAL EVALUATION OF *SMART COMMUTER*

Chapter 1 introduced the *Smart Commuter* national evaluation. This section provides details on coordination with the local evaluation team, the national evaluation methodology, and discussion of the evaluation data. It also includes a discussion of the constraints on the national evaluation team as a result of data limitations.

2.1 Coordination with Local Evaluation Team

The national evaluator, Multisystems, coordinated its activities with the local evaluation program. The local evaluator, TTI, prepared a local evaluation plan in January 1994. All data collection and processing was to be performed by TTI using instruments designed jointly by both evaluation teams. However, due to TTI's role in the design of the operational test, the national evaluator and the local evaluator were each to conduct separate analyses of the data and prepare separate evaluation reports.

There was originally considerable overlap in the set of evaluation measures proposed for use in the local and national evaluations. The differences among evaluation measures derived largely from the different emphases of the two evaluation programs. The local evaluation concentrated more on the assessment of *Smart Commuter's* overall operating effectiveness, while the national evaluation sought to understand broader aspects of *Smart Commuter's* implementation and transferability. The national evaluation plan, therefore, was built on the local plan to define an effort that addressed these wider concerns in a manner consistent with the national APTS program objectives.

At the time the national evaluation plan was being developed, TTI had already developed the local evaluation plan. The national evaluation planning process identified several specific evaluation measures not explicitly identified in the local evaluation plan. However, discussions with the local evaluators revealed that many of these were implicitly included. The final result was a set of measures for each evaluation that was rather consistent. Nevertheless, the national evaluation offered an independent perspective and highlighted issues of transferability of results. In this manner, the local and national evaluations of *Smart Commuter* minimized any duplication of effort that might otherwise have occurred.

The national evaluator's activities with regard to data collection included reviewing data collection procedures and instruments and monitoring the data collection and initial processing. Unfortunately, the ability to participate in the data collection design was not afforded to the national evaluator to the extent envisioned in the evaluation plan. Moreover, late receipt of the data eliminated the chance that the national evaluation team could provide comments on the initial processing. Thus, not all the data desired for the national evaluation plan were collected or provided in the manner required.

In most cases, the local evaluators were to provide reduced, cleaned, summarized, and documented data sets for the national evaluation. Project staff interviews were the sole responsibility of the national evaluator.

2.2 Evaluation Methodology

The APTS Evaluation Guidelines suggest the use of the following six categories of measures in assessing whether an Operational Test has met its objectives:[8]

- APTS costs;
- APTS functional characteristics;
- User acceptance;
- Transit system efficiency;
- Transit system effectiveness; and
- Additional impacts.

The *Smart Commuter* national evaluation team originally identified a series of data sources that would support the estimation of measures of effectiveness in each of the areas. However, the national evaluation plan for the *Smart Commuter* project evolved over time in response to changes in and refinement of the project design and, by definition, the actual operational test. As a result, the national evaluation plan was updated several times to reflect the project changes and the latest information concerning the data that would be available during the second year of the *Smart Commuter* test. A final version was not submitted until March 1998.[9] This was to be the guide for this evaluation report.

The evaluation involved data from participant groups[10] and a control group. The participant groups were directly involved in the *Smart Commuter* test, using both Magic Link™ and the IVR system. The control group, which would use sources of travel information other than *Smart Commuter*, was designed to provide data for comparison to the participant groups.

Although the local evaluation team originally planned data collection at the 6, 12, 24 and 36 month points (in addition to the baseline data collected before the operational test began), it later collected data more frequently within the first and second year of operation. The national evaluation was more focused and envisioned analyses of the 12-month data for the evaluation report with an interim report based on the six-month data. Delays in obtaining data and general agreement of many of the local project team members that data from the first year of the operational test (e.g., from the first participant group) were not valid caused the national evaluation team to shift to a single evaluation period and final report.

The national evaluation methodology included both quantitative and qualitative aspects. The relative focus shifted somewhat from the quantitative to the qualitative as the data constraints became more apparent.

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[8] Advanced Public Transportation Systems: Evaluation Guidelines, U.S. Department of Transportation, John A. Volpe National Transportation Systems Center, Cambridge, MA: January 1994, p.25.

[9] Evaluation of the Houston *Smart Commuter* IVHS Operational Test, Multisystems, Inc. Submitted to the John A. Volpe National Transportation Systems Center, Cambridge, MA, March 1998.

[10] The original test design called for a single participant test group. Problems concerning the original participant group necessitated recruiting a second group to complete the study.

2.3 Evaluation Data

As the complexion of the *Smart Commuter* project changed over time, the national evaluation approach needed to adapt commensurately. Much of the data anticipated to be available proved to be virtually unusable or unavailable. The end result was that, once the second participant group test was well underway, it became evident that many of the measures of effectiveness included in the revised evaluation plan would be irrelevant. Consequently, as indicated above, the qualitative aspects took on a larger role in the evaluation.

The data used in the quantitative and qualitative analyses are discussed below.

2.3.1 Quantitative Analysis

Each of the data sources that proved to be available for quantitative measures presented some limitations related to sample size, continuity, attrition of the panel groups and data quality. The sources and their limitations are as follows:

- *Participant surveys and travel diaries:* Two sequential participant groups were assembled. Each group used the *Smart Commuter* system during periods with differing levels of system reliability. The first participant group experienced an attrition rate, as defined by the completion of both the baseline and post-test surveys, of 88 percent (239 of 273 original participants after 24 months) and the second group experienced attrition of 72 percent (165 of 230 original participants after 12 months). The travel diaries completed by each test group exhibited similar levels of attrition between the first and last sets.
- *Control group surveys and travel diaries:* The control group, which spanned the test phases of both the first and second participant groups, experienced an attrition rate of 87 percent (405 of 466 original members after 24 months, as defined by completion of both the baseline and post-test surveys). Unfortunately, these survey instruments were not coded in such a way to allow tracking of individual responses across the different data collection stages, making it impossible to make direct comparisons over time.
- *Log data of participant usage uploaded from the Magic Link™ devices:* There were significant anomalies in the *Smart Commuter* data. Complete documentation of the data field definitions was never received by the national evaluation team. This limited the types and extent of analysis that could be performed.
- *METRO and TxDOT ridership and traffic field counts:* Upon closer examination of the data, it was discovered that sample sizes and data collection methods were not sufficiently rigorous to permit the use of exogenous data such as park-and-ride (P&R) lot counts and highway volumes to determine the impact on corridor operations.

Quantitative analysis was performed on logs of Magic Link™ use by participants and on baseline and post-test surveys and diaries completed by both participants and the control group. This comparison was based on a panel of the second test group participants who had remained in the test during the year ending December 1998. The sample size was much smaller than originally planned due to the smaller size and ultimate attrition of the recruited group of participants. The control group data were similarly affected. Magic Link™ user log data were analyzed for second group participants during the period from December 1997 to February 1999. The analysis of surveys, diaries and logs was constrained by the quality and availability of cleaned data sets.

The results of the quantitative analysis are presented in Chapter 5.

2.3.2 Qualitative Analysis

The qualitative analysis addressed issues in four primary phases of the project:

- Planning and design;
- Deployment;
- Operation; and
- Evaluation.

The qualitative analysis derived from conversations and highly structured, on-site interviews with project team members. This included interviews with representatives from key project sponsors such as the local Federal Highway Administration (FHWA) office and TxDOT, project implementation staff, operation and evaluation staff, and the prime contractor and its assigns. It also involved the review of project status reports and other written documentation. Another key source of information was the participant comments extracted from the user log files, post-test surveys, and the e-mail help desk operated by TTI.

The results of the qualitative analysis, presented in Chapter 4, provided crucial background for understanding the evolution and operation of the *Smart Commuter* project and for formulating the lessons learned and recommendations presented in Chapter 6.

3. *SMART COMMUTER* PROJECT DESCRIPTION

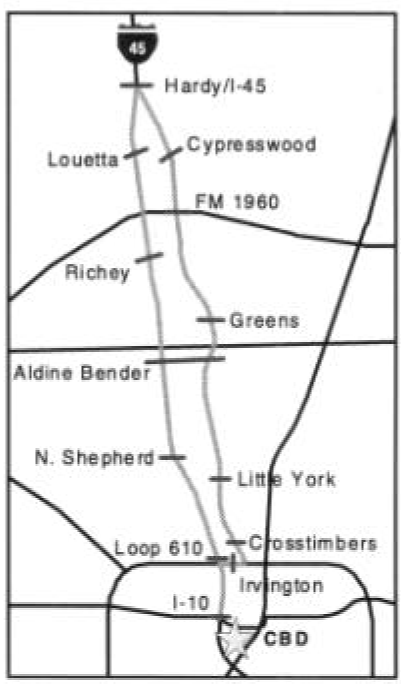
This chapter provides a description of the *Smart Commuter* operational test design, including both the design of the ATIS system and the structure of the project as it was planned.

Given the conditions at the time the project team was designing the *Smart Commuter* project, the system appeared to be an innovative way to provide real-time traffic information to users, especially given the unique infrastructure in the targeted corridor. This included the AVI system, HOV lanes, P&R lots, express transit services, and the two parallel routes (I-45 and Hardy Toll Road). The project team was very creative in pulling together disparate resources to create the *Smart Commuter* system. Many of its design decisions were excellent. In spite of these positive factors, several weak points were exposed as will be discussed later in this report.

3.1 System Design

The Houston *Smart Commuter* system was designed to provide real-time and static multimodal traveler information to commuters using I-45 North and the adjacent Hardy Toll Road (FM 1960). Figure 3.1 shows the primary area for which information was provided during the operational test.[11]

Figure 3.1: *Smart Commuter* Corridor[12]



[11] Figures 3.1 through 3.7 were taken from the Houston *Smart Commuter* ITS Operational Test: FY 98 Status Report (Research Report 1985-4), prepared by TTI in cooperation with TxDOT.

[12] The labeled cross-hatches on each route in the corridor show the approximate location and spacing of the Automatic Vehicle Identification (AVI) tag detectors.

Screen Name	Information Provided / Function
TranStar Main	The default screen when starting Magic Link™. It includes links to other Magic Link™ functions. It shows trip time and number of incidents on I-45 and Hardy Toll Road for inbound and outbound directions. Can press on map to get blowups of the Houston Corridor and Houston Downtown maps.
TranStar Upload	Screen used to connect via modem to the *Smart Commuter* server to upload data and to download current transit information.
Houston Corridor Map	Map of I-45, I-45 HOV, and Hardy Toll Road corridor, not including downtown. Can press on screen to scroll up and down and zoom in.
Houston Downtown Map	Map of individual streets in downtown Houston. Can press on screen to scroll up and down and zoom in.
HOV Info Map	Information about HOV hours of operations and access points.
Traffic Incidents	Lists incidents on I-45, I-45 HOV, and Hardy Toll Road for inbound and outbound directions.
Road Work	Lists road work on I-45, I-45 HOV, and Hardy Toll Road for inbound and outbound directions.
Transit Info	Main Screen for transit and P&R information. Provides links to detail information.
Transit Details	Detailed schedules and stop locations for #202 and #204 bus routes.
More Transit Info	Details about fares, transfers, and getting METRO schedules.
P&R Lots	Intermediate screen to choose P&R lot.
P&R Detail	Detail maps of Kuykendahl and Spring P&R lots.
Other Magic Link™ Features	Magic Link™ office tools such as calendar and address book.
Participant Diaries	Input screen for travel diaries.

Table 3.1: Magic Link™ Screens[13]

Figures 3.2 to 3.6 illustrate the screens available on the Magic Link™ device which were modified or created by the project team. Figure 3.2, the TranStar Main Screen, was the default that each participant saw whenever starting up the device. (Note that the IVR system was designed to provided similar information, with the most obvious limitation being the absence of graphical maps.)

The Magic Link™ device consisted of the modified Magic Link™ hardware and software connected to the *Smart Commuter* central server by an FM radio receiver and a traditional analog data modem. Both the receiver and the modem were added to the device for the operational test. Figure 3.7 shows the Magic Link™ package as it was modified for Smart Commuter participation.

3.2 System Architecture

To understand how the *Smart Commuter* system was designed to work, an explanation of the system architecture is helpful. Because *Smart Commuter* was a complex information and

[13] A field in the original database called "Testing" was removed from all analyses because documentation of this field's function could not be obtained.

Figure 3.2: TranStar Main Screen

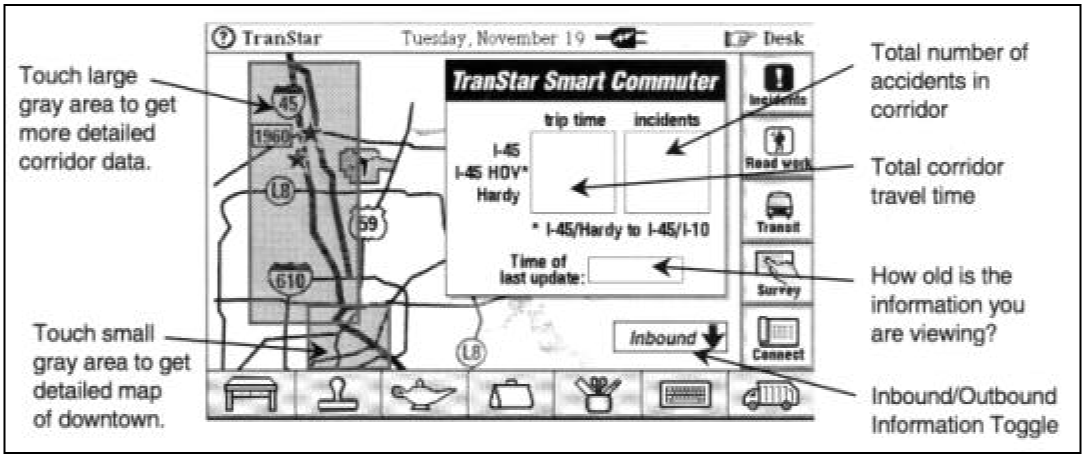


Figure 3.3: Transit Info Screen

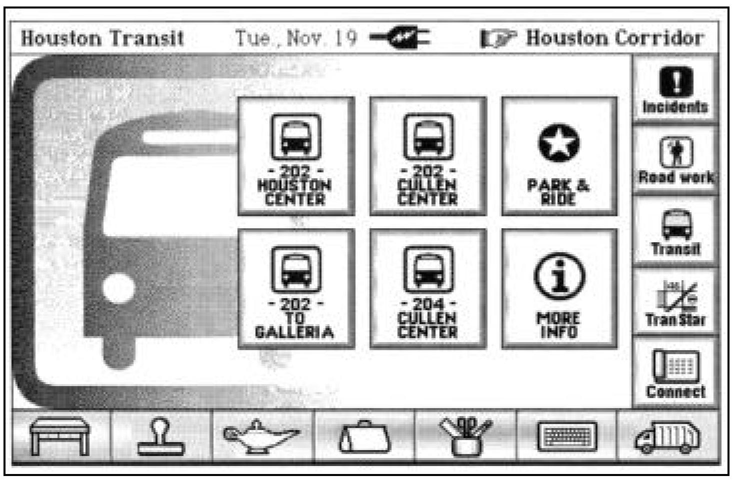


Figure 3.4: Transit Details Screen

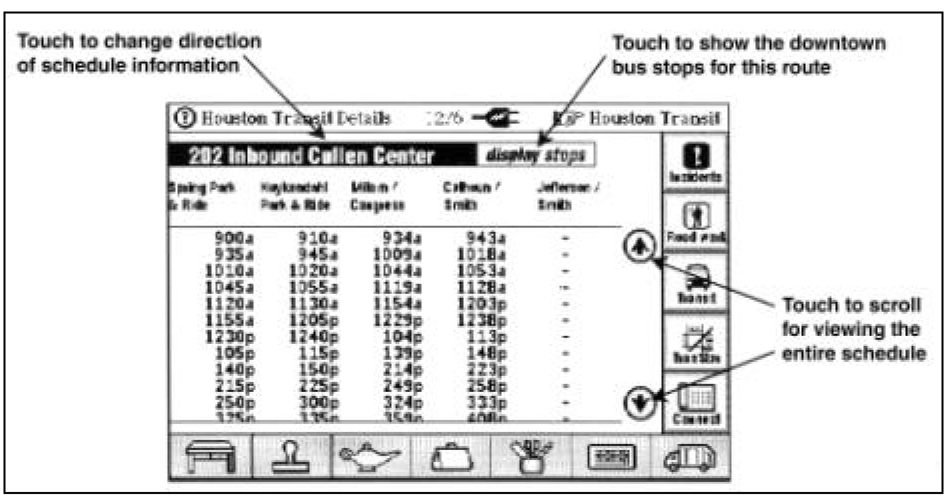


Figure 3.5: Houston Corridor Screen

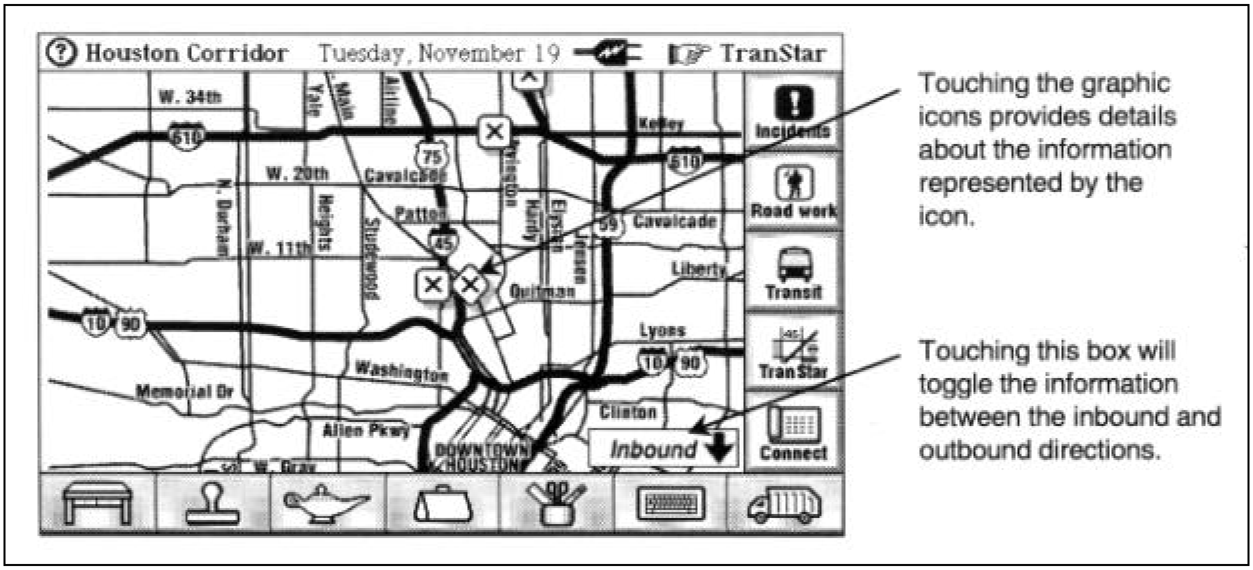
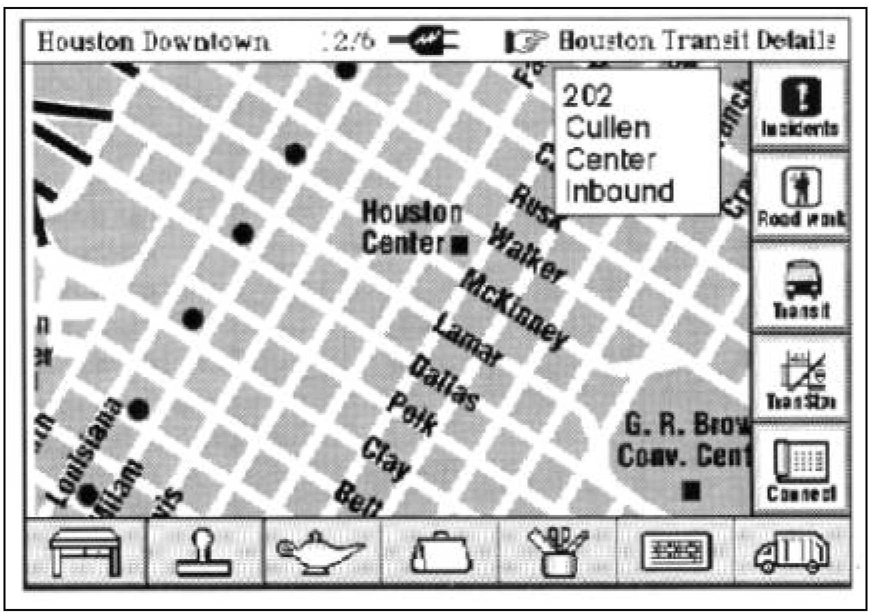


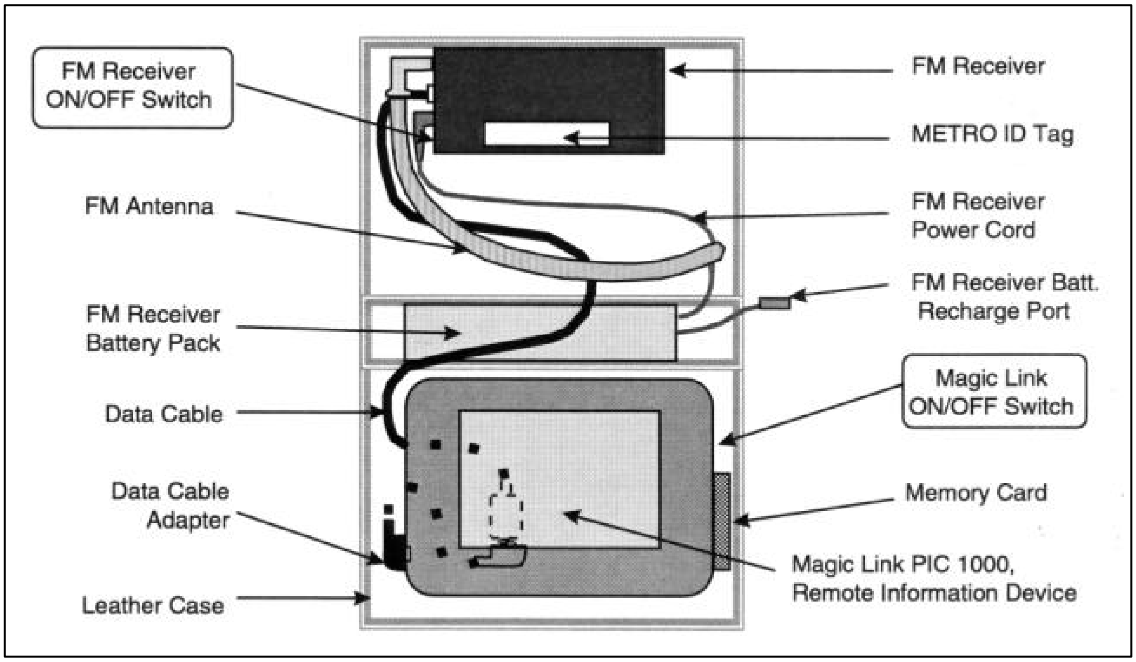
Figure 3.6: Houston Downtown Screen



communication system, only a high level approximation is possible in the context of this report. The system architecture is represented schematically in Figure 3.8.

Smart Commuter consisted of several hardware and software components that received, processed, formatted and distributed static and real-time traveler information via the two media to the official participant users recruited by the project team. In Figure 3.8, the actual *Smart Commuter* system is represented by the components within the dashed box. The TxDOT, TranStar, and METRO components provided data to *Smart Commuter* but were technically not part of the system.

Figure 3.7: Schematic of Magic Link™ Package



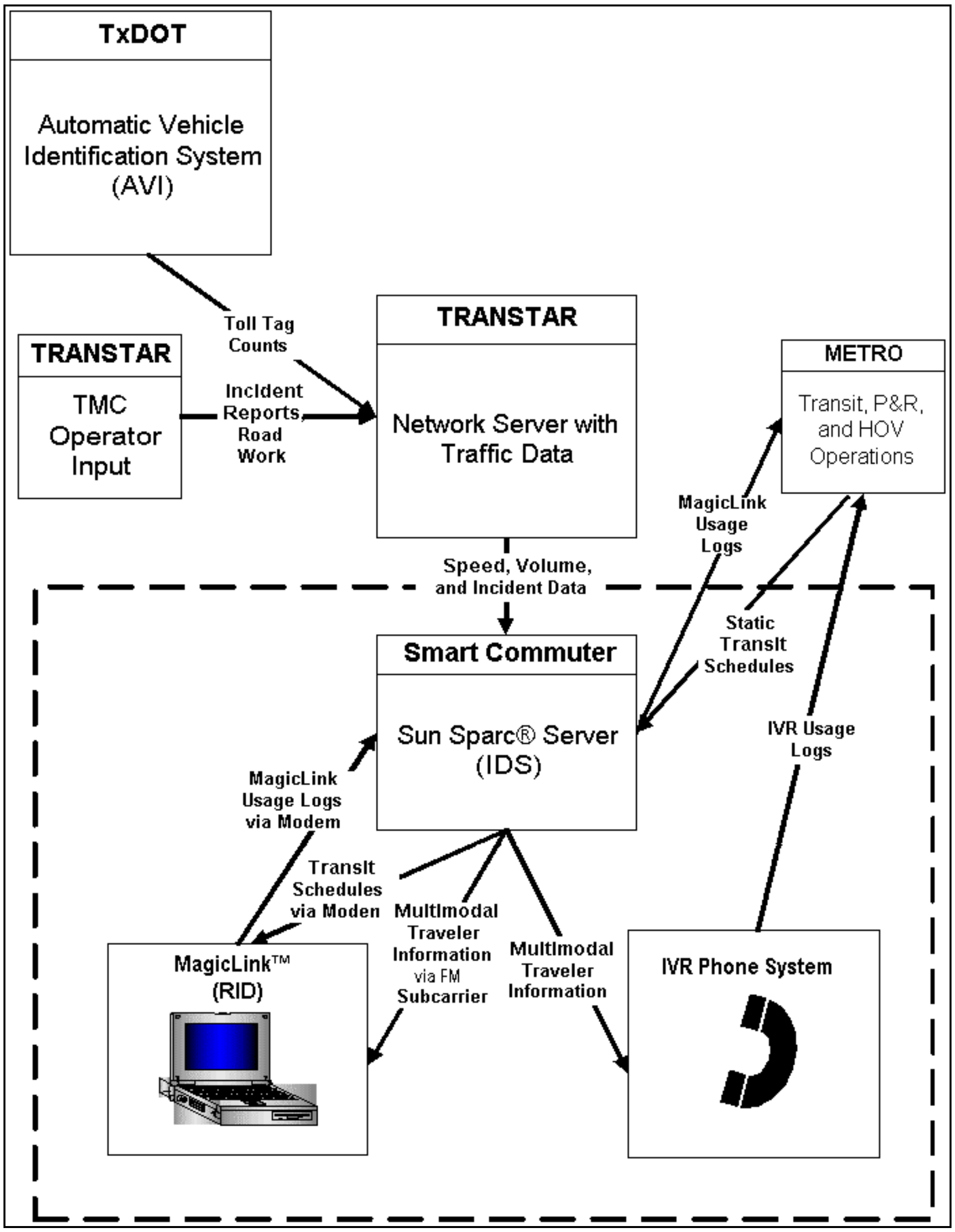
The basic flow of information through the system occurred as illustrated in Figure 3.8. The following list provides a narrative description of those information flows:

1. The TxDOT AVI system recorded data from electronic toll tags and passed it to the TranStar computer server for processing;
2. The TranStar server converted the data into traffic condition data, such as travel time and travel speed, for segments between each of the AVI toll tag detectors;
3. TranStar maintained a database of traffic incidents and road work that was manually recorded and loaded into its traffic information database;
4. Using the specifications defined by the Houston TranStar Interface Control Document, the *Smart Commuter* information delivery system (IDS) extracted information from the TranStar server and prepared it for distribution to the two *Smart Commuter* information media; and
5. The *Smart Commuter* IDS formatted the information and distributed it to the Magic Link™ devices and the IVR telephone system.

METRO also provided static information about transit schedules and P&R lots to the *Smart Commuter* system. As the diagram shows, the overall information system was designed to both distribute information to and collect information from the Magic Link™ units and the *Smart Commuter* telephone system. The key communication links included:

- A wireless FM communication system was used to send information from the Sun Sparc®[14] server to the Magic Link™ devices;
- The Magic Link™ devices used wireline analog modem and regular telephone lines to send information to the Sun Sparc® server and receive updated transit information from it; and
- All other information was transmitted via wireline communications.

Figure 3.8: *Smart Commuter* System Architecture



[14] Sun Sparc is a registered trademark of the Sun Corporation.

These communication links will be discussed in more detail in Chapter 4. The components unique to the *Smart Commuter* operational test were: the system interface control document (not shown) defining the data connections between the IDS and the TranStar real-time information database; the communications link between the Magic Link™ units and the IDS; and the design of maps and icons for the traffic information on Magic Link™. Also unique was the fact that Magic Link™ contained an electronic version of the travel diaries, a feature meant to make participation in the evaluation activities easier.

3.3 Project Schedule and History

A critical factor in operational tests and ITS deployments generally is the schedule. Many ITS projects do not meet their original schedules for a variety of reasons related to the technology being deployed and institutional factors. *Smart Commuter* shared this characteristic. An understanding of the project schedule and history helps provide a framework for understanding the overall project structure and evolution.

3.3.1 Overview of Schedule and History

The preliminary, conceptual design for *Smart Commuter* was completed in 1991 after several years of research led by TTI. A proposal for Federal funding was subsequently submitted and funding was approved in late 1992. Planning and design activities were conducted over the next two years by a joint working group made up of METRO, TxDOT, and TTI, culminating in March 1995 with a request for technical proposals (RFTP) to secure a contractor to carry out the operational test. The contract was awarded to a team lead by TRW in December 1995, about one year later than originally planned.

Design proceeded rapidly in the early months of 1996. Recruiting began in March 1996 (although earlier meetings with downtown employers laid the groundwork for this effort). The first functional test occurred in September 1996, and a second occurred between November and December 1996. By December 1996, the participant and control groups had been recruited and trained, and 273 Magic Link™ units were deployed. (See Section 4.2.1 for a description of the modifications made to the Magic Link™ for the *Smart Commuter* test.)

In December 1996, TRW began conducting the system acceptance test. Because of repeated failures to pass the entire set of requirements, the acceptance test was repeated in January, February, May, and July 1997. METRO finally accepted the system as operational in late August 1997.

In early 1997, a variety of problems with the *Smart Commuter* system became apparent largely through participant complaints. Because the project team determined that the first participant group had experienced too many problems due to the *Smart Commuter* system's lack of reliability, a second participant group was recruited in the fall of 1997. A second year of testing began around December 1997 with the training of the second participant group and distribution of Magic Link™ devices to them. (Note that some first participant group members continued to participate after the second group was initiated.) The I-45 portion of the *Smart Commuter* operational test was completed in December 1998 when the travel diaries were collected and the post-test survey was administered. The system continued to operate thereafter until it was shutdown in February 1999.

3.3.2 Project Phases

The *Smart Commuter* project can be described as a series of several distinct but overlapping phases. These encompass:

- Planning and design - preliminary research, development of the initial operating test concept, formation of a public sector working group, and securing funds for the project;
- Procurement and contracting - development of the RFTP and subsequent solicitation, selection, and contract award to a private contractor;
- Final design and deployment - design changes made after the contract had been signed and as a result of functional and acceptance testing of the equipment and software, and recruitment and training of participants;
- Operation - ongoing operation of the service with actual users and resolution of technical and operating problems; and
- Evaluation - the design of an evaluation methodology and execution of components over the course of the project to measure the impact of the test.

In reality, these phases overlapped, some by design or necessity. For example, the design was revised during deployment and operation. Evaluation activities needed to occur before, during, and at the end of the overall project.

Table 3.2 shows the key events of the *Smart Commuter* operational test in approximate chronological order. The next several sections explain the project phases more fully.

3.3.3 Procurement and Contracting

METRO began drafting the procurement procedure and documents for *Smart Commuter* during 1994. It used a two-stage procurement process. The first stage was the RFTP and the second step was the formal invitation for bids. The issuance of the RFTP was delayed until early spring 1995 pending finalization of an interagency agreement between METRO and TxDOT. The process of reviewing technical proposals, amending the technical scope, issuing the Request for Bids, evaluating the bids and awarding the contract was not completed until December 1995. A Notice to Proceed was promptly issued at that time. TRW quickly supplied the technical specifications for the software and hardware for METRO's review.

3.3.4 Final Design and Deployment

The major activities during this project phase included development, testing, participant and control group recruitment, and design modification. A brief description of critical activities is provided below.

Development activities

- Finalize the interface control document
- Purchasing Magic Link™ devices and the FM receivers Develop custom software for Magic Link™

Event or Milestone	1991	1992	1993	1994	1995	1996	1997	1998	1999
Preliminary design completed	▲								
Federal Funding awarded		▲							
Multisystems takes over National Evaluation				▲					
Decision to delay I-10 test				▲					
TranStar Web Site with traffic map initiated				▲					
RFTP issued for information delivery system					▲				
Four technical proposals received					▲				
TRW awarded contract as vendor for IDS					▲				
TRW delivers system design documents					▲				
Recruiting process begins; employers contacted						▲			
Before data collection begins						▲			
IVR phone system operational						▲			
15-day functional test of device and diary begun using 25 trial participants						▲			
Functional test completed						▲			
Pilot test started						▲			
Pilot test completed						▲			
Training begins with 60 participants						▲			
Control group survey mailed to owners of 4,000 vehicles observed on I-45						▲			
273 Magic LinkTM units deployed						▲			
450 control group surveys returned; 300 agree to be recontacted						▲			
New recruitment effort: marketing brochure mailed to 77,000 households							▲		
3-month trial of new radio station begins							▲		
June 1997 test group diary results in 110 usable responses							▲		
New 2nd transmitter reported to have solved FM transmission problem							▲		
September 1997 test group diary results in fewer than 50 responses							▲		
Another group of participants trained and provided with Magic Link™							▲		
December 1997 test group diary results in 117 responses							▲		
I-10 corridor deleted from the National Evaluation								▲	
Final revisions to the National Evaluation Plan								▲	
June 1998 diaries collected from second test group								▲	
I-10 corridor Test cancelled								▲	
Number of phone lines cut down from 20 to 6								▲	
Focus group held									▲
TranStar traffic map has 454,000 hits, >10 times that in October 1995									▲
Smart Commuter Test completed; Magic Link™ devices collected									▲

Table 3.2: Timing of Key Events or Milestones

- Obtain and configure the central *Smart Commuter* computer server (IDS)
- Obtain and implement the FM subcarrier service
- Develop the IVR telephone system

Testing activities

- Perform functional tests and modify system as needed, including communications
- Perform acceptance test
- Accept system

Recruitment activities

- Direct recruitment through downtown employers – information was distributed to 90 downtown employers and to the Downtown Houston Association
- Display *Smart Commuter* recruiting messages on the variable message signs (VMS) in the corridor
- Send press releases to the media
- Place information and recruitment booths at the local malls in the corridor

These start-up activities were largely accomplished between December 1995 and December 1996. However, problems with FM subcarrier reception and with some hardware components carried some of these activities over into the first half of 1997, especially the acceptance testing.

3.3.5 Operations

Although *contractually* the operational period began in late August 1997 when METRO accepted the entire TRW system, it *de facto* began when the first participant group began using the Magic Link™ devices in December 1996. The operations phase continued until participants turned in the units in February 1999 (although many participants turned the units in early when they dropped out of the operational test). During the first year of operation, TRW reduced its on-site presence once the de facto operation period began. Its local subcontractor conducted operations and maintenance activities during this period, including operating a user help desk, inventory control (repairing and replacing units as needed) and troubleshooting if the Sun Sparc® server went down.

3.3.6 Evaluation

The evaluation process began very early in the project. A local evaluation plan was issued by TTI in January 1994, and the first national evaluation plan was drafted by Castle Rock Consultants in July 1994. Multisystems assumed the role of national evaluator in August 1994. Based on a coordination meeting held in August 1994, the local project team and the national evaluation team agreed that a previously prepared national evaluation plan should be revised. A revised national evaluation plan was drafted in 1995 and revised again in 1997 and 1998 in response to changes in the project and expected data availability.

Pre-implementation data collection by the local evaluators took place in 1996. Exogenous data were assembled in June 1996 and control and test group surveys and diaries were collected in November 1996. The local project team requested that participants fill out diaries for one week every three months thereafter, although it was intended that only the data collected at the six-month intervals would be subjected to analysis by the local evaluation team. The national evaluation team was to review the six-month data but concentrate its analysis efforts on the baseline and one-year post-test data.

It became apparent that the first year test was subject to significant technical problems and the national evaluation team was advised to (and did) shift its analysis to a second year test. During the second year test, it was hoped that the attrition experienced among the first year participants would not be repeated. Unfortunately, this did not turn out to be the case. Consequently, the June 1998 travel diary response was very low. Efforts by the local project team to boost participation yielded a somewhat better response to the December 1998 post-test survey and travel diary.

Thus, a comparison of the December 1998 post-test with the baseline surveys and travel diaries became the focus of the national evaluation along with analysis of log data uploaded from the Magic Link™ units for the entire second year. The information became available to the national evaluation team in the summer of 1999, following a TxDOT review process.

3.4 Elimination of the I-10 Component

The I-10 component of *Smart Commuter* was delayed and eventually eliminated from the project in February 1998. The reasons for canceling the I-10 project included:

1. Another innovation, QuickRide, was introduced in the I-10 corridor in early 1998. This project involved what is known as a HOT lane (high occupancy toll). The change enabled two-person carpools to utilize the normally three-person minimum HOV lane for a $2.00 toll, provided users had signed up in advance and obtained the necessary EZ electronic toll tag.

   It was believed that conducting the *Smart Commuter* instant ridesharing or any other test in the I-10 corridor would be too much. Furthermore, the HOT lane would have detracted from the purpose of the original I-10 instant ridesharing concept, which was intended to enable drivers to use the HOV lane by forming carpools on a per trip or other short-term basis. With access to the HOV lane by two-person carpools paying a toll, a significant part of the potential market was already being tapped.

2. METRO had made other enhancements to its ridesharing program and was less interested in the instant ridesharing concept.

3. The local press had run several uncomplimentary articles on the *Smart Commuter* project and it seemed advisable not to pursue another project already associated with it.

4. METRO had become interested in pagers as a means of en-route travel information and sought to pursue a project that would be based on lessons learned from the *Smart Commuter* test.

FHWA agreed to shift the unspent portion of its funding for *Smart Commuter* to the investigation of pagers. (FTA funds had already been fully expended for the I-45 test.)

3.5 Funding / Cost Overview

The *Smart Commuter* operational test was originally estimated to cost $17 million over several years. The project proposal envisioned a project spanning four years, including a three-year operational test in the I-45 corridor and a two-year operational test in the I-10 corridor.

The I-45 North corridor project was estimated to account for $6.96 million of the $17 million, of which $3.91 million was to be expended in the first year. First year funding of $5 million was approved in 1992 as Phase 1 of the project. Grants from FHWA, FTA and TxDOT were included in the Phase 1 total. METRO provided half the local share. Table 3.3 provides a summary of these funding sources for the first year of the field operational test project.

Source	Amount
FTA	$500,000
FHWA	$2,000,000
TxDOT	$1,250,000
METRO	$1,250,000
Total	$5,000,000

Table 3.3: Phase 1 Funding for Houston Operational Test

The IDS was purchased by METRO from TRW based on its response to the RFTP in 1995. The cost of the system was $2.195 million. This included equipment, software and ongoing maintenance for one year after system acceptance. Approximately half of this amount was paid upon acceptance of the system in August 1997, much later than originally anticipated. Over the subsequent 12 months of the field test, TRW received monthly payments for operation and maintenance. An additional payment of $98,606 was made to cover a six-month extension to the operations and maintenance period so that the second participant group could complete its 12-month test period.

The above costs covered TRW and all of its subcontractors, but did not include the activities of METRO staff, TxDOT staff, or any special consultants they employed. METRO contracted directly with TTI for project management and technical assistance (such as system design and inventory control) during the test. The agency also contracted with a marketing specialist to assist in participant recruitment and training activities. TxDOT had a separate contract for $881,000 with TTI for the conduct of the local evaluation, an amount not reflected in the budget summary table.

3.6 Project Management Structure

In order to assist METRO in its project management responsibility, they recruited a project management team that included various public and private sector representatives. The role of the project management team was to ensure coordination with other projects and programs, provide a link to agency activities and assist the METRO Project Manager in obtaining needed support and responses from the pertinent agencies. Although TxDOT funded the local project evaluation efforts of TTI, it was under the overall direction of the project management team. The public and private sectors had specific roles in *Smart Commuter*.

3.6.1 Public Sector Responsibilities

METRO was the key agency responsible for conducting the project. Although the TRW contract covered hardware and software design and deployment, as well as ongoing operations and maintenance, METRO maintained an active role in all project phases. Tthe agency was involved in reviewing and accepting the system components, monitoring progress, and recruiting and training the participant and control groups. In the second year, METRO took on the additional responsibility of maintaining the help desk for participants and performing inventory control for the Magic Link™ devices. TTI assisted in many of these activities under its contract with METRO.

3.6.2 Private Sector Responsibilities

Private sector responsibilities for *Smart Commuter* were all under the TRW contract with METRO. METRO's point of contact was primarily the TRW Project Manager. During the operational phase, a local subcontractor served as TRW's agent for operation and maintenance activities and acted as the local point of contact when TRW did not have staff on-site. Amtech, another private company, was subcontracted to TxDOT for day-to-day maintenance of the AVI system.

4. *SMART COMMUTER* QUALITATIVE EVALUATION

As described earlier in this report, data limitations necessitated that the qualitative evaluation of *Smart Commuter* take on increased prominence in the national evaluation. A few of the major findings are mentioned below to set the stage for the qualitative discussion which follows.

Two of the most successful decisions made by the project team were to use functional rather than technical specifications to procure the *Smart Commuter* system and to involve both the public and private sectors in the project's operation. However, *Smart Commuter* suffered from a number of factors, both internal and external, which resulted in a smaller than desired number of individuals signing up for the participant and control groups and severe attrition among those that did. Internal factors included several technical problems (i.e., starting operations before the system was operationally ready, communications failures, early difficulties with the interactive voice response telephone system and the remote information devices, cumbersome travel diary requirements, late or insufficient training, and a lack of staff technical expertise to solve problems that arose). In addition, there was a general disinclination of commuters to change travel modes on a daily basis and a preference for en-route (radio or variable message signs) versus pre-trip information (which was sometimes out of date by the time commuters from distant areas reached the *Smart Commuter* project area).

External factors that reduced the utility of *Smart Commuter* included an AVI system that had a varying number of segments for which no traffic information was provided, incident information that was incomplete, a reduction in congestion due to additional roadway construction (thereby lessening the need for *Smart Commuter* type traffic information), and the introduction of the TranStar Web site which provided similar information.

The change in the RFTP specifications from a two-way communication link to two separate communications channels (involving a wireless system for broadcasting *Smart Commuter* information to the RIDs and a wireline connection to the IDS server for uploading user logs and travel diaries and downloading current transit schedule information) created operational problems.

Tests of the *Smart Commuter* system were conducted prior to beginning operations. The decision to go ahead (for reasons which are discussed later) even though the two functional tests of the system were not fully successful, was likely a factor in the high attrition rate in the first participant group.

These and other qualitative evaluation issues, organized according to the five project phases outlined previously, are discussed more fully in the rest of this Chapter.

4.1 Planning and Design Phase

The *Smart Commuter* project was conceived in the early 1990s when there was little experience with ATIS. The primary traveler information media were radio, TV, newspaper, and VMS. In an attempt to determine how to attract users to ATIS, TTI performed a review of existing market research in 1990. The study included review of a variety of prior traveler information studies. This review was followed by focus groups in the Houston area and an assessment of potential technologies.

The early research indicated consumer interest in pre-trip travel information as well as the potential for influencing travel behavior through the provision of such information. Unfortunately, the conclusions were limited by a dearth of quantitative data on the subject and the fact that much of the prior research provided only general indications of ridership and demand.[15] One of the findings covered in the TTI report was that 16 percent of Seattle area commuters would consider changing their travel mode based on pre-trip information. Commercial radio, a medium that can provide both en-route and pre-trip information, was used by 98 percent of the Seattle respondents. The next two highest ranked media were VMS (56 percent) and highway advisory radio (44 percent), both en-route information services.

Four focus groups were then conducted for TTI to examine local attitudes towards travel information. Two of these focus groups were of downtown-oriented commuters in the I-45 corridor. Key findings of these focus groups were:[16]

- Commuters establish preferred commute travel modes while route decisions remain more flexible on an ongoing basis;
- Despite preferring a regular mode, commuters see the potential for changing mode, route or departure time in response to timely and accurate information, although mode changes need to weigh the potential benefits against the time and inconvenience of a change;
- Traffic information is needed on alternative routes;
- Accuracy and timeliness are more important than the media used to convey travel information; and
- Any media would work at home and at the office but radio seems most effective to communicate to drivers en-route.

The project team evaluated four general types of technologies: telephone, television, radio and videotext. It ranked each using evaluation criteria in four categories: desired system characteristics, compatibility with other METRO and TxDOT projects, costs and potential for private sector involvement. Based on this evaluation, a videotext-based system was recommended for the I-45 North corridor operational test. This would be combined with a hotline telephone number to METRO's Transit Information System.[17]

By the time *Smart Commuter* offered service to the first participant group in December 1996, the ATIS market had developed considerably on the national scene. The interest

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[15] Working Paper Number 1: Review of Existing Market Research Information, TTI, October 1990. Pages 1-3.

[16] Exploratory Research on the *Smart Commuter* Concept, Gelb Consulting Group, Inc., Prepared for TTI, March 1991, pp. 3-6.

[17] Houston *Smart Commuter* IVHS Demonstration Project, Concept Design and Implementation Program Outline, TTI, Prepared for METRO, Texas State Department of Highways and Public Transportation (DOT) and the Urban Mass Transportation Administration (later FTA), June 1991, p.17.

in en-route traffic information had been documented in other research of operational tests such as the SmarTraveler demonstration in Boston, where mobile (cell phone) users made up the bulk of calls to the ATIS service.[18]

Locally, ATIS had become available to those Houston area residents with access to the Internet in December 1994. This ATIS service consisted of a traffic conditions map available on the World Wide Web site. It offered a new way to access travel information from the home and the office and presented much of the same information *Smart Commuter* proposed to provide. (In fact, the source of some of the information was identical to that subsequently used in the *Smart Commuter* operational test).

Since consumers typically gained access to the Web first in the work place, the Internet service may have partially supplanted the need for the *Smart Commuter* complementary IVR telephone system that was designed, in part, to be a back-up service in downtown office buildings where Magic Link™ might be unable to receive the FM subcarrier signal. However, the Internet was less commonly available at home (and even at many workplaces) in 1995 when the newly available Sony Magic Link™ system was proposed as the means of transmitting *Smart Commuter* data to the participants.

The Magic Link™ offered a level of portability that was not envisioned in the early *Smart Commuter* concept that called for information to be accessible at the home and at the office. This portability and the potential for mobile communications offered the prospect of providing en-route information to the potential user, even though the system was not intended for that purpose.[19] Indeed, users were told not to use the device while traveling in the car, but there is some evidence from the project team interviews and participant comments that suggests it was used in this way. For example, several participants commented that Magic Link™ was not convenient to use in the car, and others suggested that the device would be more useful if it could be used in the car.

While the delay in getting the project started could have provided a window of opportunity to refine some of the design assumptions to meet changing demands of the target population and to take advantage of technology development, redesign would have led to further delay. Any test of this type encounters challenges in the rapid pace of changing technologies and the related changes in the expectations of the target market. As discussed below, the use of functional specifications in the procurement process was intended to account for these uncertainties.

The availability of other device features to the user was expected to be an incentive for users to carry the Magic Link™ device during the test (although disabling the non-*Smart Commuter* features was originally considered.) However, participants commented in the informal exit interviews and in discussions with project staff that having to give the device back at the end of the test raised concerns about the privacy of the calendar, contact, and other information that Magic Link™ was capable of managing. In addition,

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[18] Evaluation of the Phase III of the SmarTraveler ATIS Operational Test, Multisystems, Inc., Prepared for Central Transportation Planning Staff, February 1995.

[19] Although the project team members were unanimous in saying that Magic Link™ was never intended to be used as an en-route device, the *Smart Commuter* RFTP was somewhat ambiguous on this point, stating that the device should have the ability to obtain updates at any time during a commute trip downtown (p. 10).

more compact, less cumbersome devices that could communicate with personal computers, such as the Apple Newton and 3Com PalmPilot, came on the market during the *Smart Commuter* test and likely reduced the appeal of Magic Link™ as a personal digital assistant. [20]

It appears that some agencies had concerns that a pre-trip information system of the *Smart Commuter* type could result in traffic information being out-of-date by the time participants living in distant areas reached the instrumented area. It also appears that some project team members felt that transit's relatively strong market share for downtown commuting (33 percent of the downtown-oriented commuters from the Kuykendahl market area used the HOV lanes in buses or carpools in 1985), coupled with the fact that only about 14 percent of SOV trips in the corridor were destined for downtown, limited the potential market for the service. (This could help explain why the participant recruiting effort fell short of its goals, an issue discussed in Section 4.3.2.)

The introduction of Web-based traveler information, construction in the I-45 North corridor, the installation of VMS, shakedown of the AVI system, and other infrastructure factors may have been anticipated to impact the *Smart Commuter*. These factors are discussed in subsequent subsections of this chapter.

4.2 Procurement and Contracting Phase

Houston METRO, the lead agency for the *Smart Commuter* project, issued an RFTP for *Smart Commuter* IDS in March 1995. Conceptually, the RFTP was very similar to the earlier draft design documents, although it added such necessary details as the requirement to create interfaces with existing traffic information systems from which *Smart Commuter* information would be drawn.

The RFTP emphasized functional rather than technical specifications. The local project team believed that this approach was necessary since technology moves too quickly to procure such a system in another manner.

Some of the key elements of the RFTP were:

- The successful bidder would be responsible for designing the interface to the existing traffic information system and uploading the traffic data into the *Smart Commuter* server;
- The operational test was to include 700 participants;
- The specifications emphasized that the RID (later the Magic Link™) and the IVR telephone system should be simple and user-friendly;
- The contractor was responsible for providing RIDs weighing less than 4.5 pounds to each participant;

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[20] The Magic Link™ was preceded by the release of the Apple Newton in mid-1993 and several other handheld communication devices from established electronics manufacturers such as Hewlett-Packard Co., Motorola Inc., Sharp Electronics Corp. and Sony Electronics Inc.

- A two-way wireless communication system between the RID and IDS was requested (in the initial RFTP); and
- The IDS was to be capable of updating information to the RIDs every three minutes.

Four private sector teams responded to this business opportunity. All except one proposed laptop computers, which did not meet the size and weight specifications set forth in the RFTP. The Magic Link™ unit proposed by TRW, the winning bidder, was reported to be the only commercial-off-the-shelf (COTS) computing device that would meet the physical specifications. It is unclear how the physical specifications in the RFTP were chosen, especially given the small number of COTS mobile computing products available at that time. It is also unknown whether these requirements discouraged some bidders. Members of the public sector project team acknowledged that some of the functional requirements were challenging. However, they made it clear to bidders that there would be flexibility to adjust some requirements in response to feedback.

One of the major changes in this regard was the specification that called for a two-way wireless communication network. Vendors advised METRO that such a communication solution would have been prohibitively expensive, and suggested having two separate communication channels instead. One would be a wireless system to broadcast real-time information from the *Smart Commuter* IDS to the RIDs, and the other a wireline (telephone modem) hookup with the IDS server for uploading information such as user logs and travel diaries from the RIDs and downloading current transit schedule information.

After the modifications to the technical specifications were made, the teams were invited to provide revised proposals and cost estimates. The RFTP ranked project management as the most important selection criteria, with qualifications of the firm and its professional staff also ranked very important. Cost was not part of the technical proposals. However, comments from several project team members interviewed for this report suggest that, in the end, cost was a key factor in the final selection. METRO, in fact, selected the contractor who submitted the lowest bid. The one-way wireless communication solution helped the successful bidder come in at a lower cost. Another firm apparently offered the two-way wireless system specified in the original RFTP but at a higher cost than the selected proposal.

The national evaluation team never received a copy of the fully executed contract with TRW to review for this report. The team was told that the RFTP and boilerplate contract contained therein was a reasonable facsimile of the actual contract, with some adjustments to reflect the communications links proposed by the TRW team. The evaluation team, therefore, could not determine if the contract clarified issues such as timing and requirements of the functional and acceptance tests, which were somewhat vague in the RFTP.

The testing protocol called for in the RFTP involved the following components:

- Two functional tests would determine if the IDS met the functionality requirements and intent of the specifications. The functional tests would determine if the IDS was correctly extracting the proper information from the TranStar server, was reformatting it as required for the RIDs, and then delivering it properly to the RIDs; and

- An acceptance or system test would determine that the *Smart Commuter* system was operational, exclusive of the IDS, if it operated "without errors, malfunctions, or down-time for a minimum of 95 percent of the scheduled operating time…(and)…no more than 5 percent of the RIDs deployed shall malfunction during the thirty (30) day test period at any one time."[21]

The functional tests were focused only on the collection, processing, and distribution of information to the RIDs. In contrast, the system test concentrated on the entire system, including the integration between the IDS and RIDs and operation of the RIDs themselves.

The functional tests were intended to be consecutive. Approximately 25 RID units were used by METRO staff and others for testing the IDS. The second functional test was to be done within 15 days after any deficiencies in the first test had been fixed. After successful completion of the re-test, the contractor was to begin distribution of the RIDs.

According to the description of the acceptance test in the RFTP, if the overall system failed (i.e., the IDS and RIDs operating together), "the complete Systems Test shall be repeated for the amount of time remaining on the original thirty (30) day period or for fifteen (15) days, whichever is greater."[22]

Although the contractor and METRO reported that there were no significant contractual issues, the interviews conducted with the project team suggest that there was disagreement between METRO and the TRW team with respect to the testing and acceptance procedures. The contractor objected to the fact that if the system failed certain elements of the test plan it had submitted, METRO required that all parts of the test plan be repeated.

Although the RFTP stated that the contractor would be responsible for distribution of the RIDs and associated participant training, METRO, with the assistance of TTI and other consultants, assisted with the training.

4.3 Final Design and Deployment Phase

While not normally considered a separate project phase, final design and deployment is addressed separately in this section since significant design changes may take place after a contract has been signed and deployment begins. Because some technological unknowns may not be uncovered until software is written, equipment procured, or testing begins, deployment is a critical phase of a high-technology project like *Smart Commuter*.

4.3.1 Remote Information Device Technology

At the time that the *Smart Commuter* RID system was being procured and deployed, the mobile computing technology needed for the project was not mature. The RFTP called for a laptop computer of 4.5 pounds or less, which did not exist. Handheld computing

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[21] METRO RFTP No. 94X233P, Attachment No. 1, 7/26/94, page 31.

[22] Ibid., page 31.

devices were very limited at the time, and most likely did not have the power or I/O[23] capability that would be needed for the project. The Sony Magic Link™ was one of the few, and possibly the only, truly portable and relatively small devices available that met the weight threshold and other functional specifications. (Based on the interviews, it appears that the weight requirement changed from 4.5 pounds in the RFTP to 3 pounds during final design and deployment). Once the Magic Link™ units were purchased (in early1995), any advance in technology would have been difficult to incorporate into the test.

4.3.2 Recruiting Participants

METRO was responsible for recruiting the participants with the assistance of TTI. The contractor urged METRO to begin recruiting while the development activities were still taking place in the belief that the recruiting process would take considerable time. The recruiting began in the Spring of 1996 while the functional testing was started in September. Because METRO was not ready to accept the system, training and distribution of units was delayed by 3 months. Attrition in the recruited pool of participants was reported to have occurred. Further recruiting was done in late 1996 and early 1997.

METRO had originally intended to find enough participants at downtown Houston employers, but was not able to do so. The original recruitment approach focused on employer ridesharing coordinators. However, the timing of the *Smart Commuter* start-up coincided with the elimination of Clean Air Act regulations on large employers, essentially eliminating the coordinators as recruiting sources. As a result, METRO hired a separate marketing consultant in mid-1996 to assist with the recruitment. Additional recruitment methods included invitations to participate displayed on the changeable message signs on I-45, press releases, and information booths at malls near to desired participants' homes. When the first participant group was trained and equipped, it only had 273 members instead of the 700 originally envisioned. As noted earlier in this Chapter, the shortfall could have been caused in part by the fact that HOV market share was already relatively high and the percentage of SOV trips destined for downtown was small.

Similar problems occurred with the control group. METRO engaged TTI to modify the recruitment approach, using license plate numbers recorded from vehicles traveling on the general purpose lanes on I-45 during the a.m. peak. Instead of having the specified 700 control group members, the project team ended up with only 450 (of whom, only 300 agreed to be contacted again).

4.3.3 Functional and System Testing

The functional tests were designed to look at specific functions of the *Smart Commuter* server while the acceptance test was to be an overall system test comprised of "action-

[23] I/O, or Input/Output, refers to any operation, program, or device whose purpose is to enter data into or extract data from a computer. The term is used here in the sense of I/O ports, the physical outlets on a computer which allow it to perform information exchange.

response" tests between the Magic Link™ RIDs, the IVR telephone system, and the Sun Sparc® server (the IDS).

The initial schedule called for acceptance testing following a six-month development period. In actuality, the first acceptance test occurred about nine months after the contractor's Notice to Proceed (NTP) and the final acceptance test was 20 months after the NTP.

Problems were identified during the first functional test of 25 units in September 1996. These included difficulties with the Magic Link™ software, the FM communications link, and the modem communications link. TxDOT staff also found that there were inconsistencies between the information provided by *Smart Commuter* and TranStar.

The second functional test, involving about 45 Magic Link™ units, was conducted around November and December 1996. According to the project team, it was considered more successful than the first, but still not fully successful. Based on the results of this test, however, METRO began distributing units to the initial 273 recruited participant group users.

TRW began conducting system acceptance tests in December 1996 and continued them in January, February, May, and July 1997. After the May test, METRO sent a memorandum of non-compliance to TRW and gave the contractor 60 days to resolve all remaining problems. TRW responded with renewed efforts, including the hiring of an independent communications expert to address the wireless communication problem. Performance improved and the acceptance checklist was completed successfully during the final acceptance test in July 1997. The unit mortality test, designed to test the durability/reliability of the units under extended hours of use, was conducted concurrently. Because the contract called for 30 days of continuous operation at a 95% success rate before full acceptance, full acceptance occurred only on August 24, 1997. According to the contract, the one-year operations and maintenance period began on that date.

During the first six months of the *de facto* operational test (i.e., starting in December 1996), a variety of technical problems cropped up and had to be resolved quickly because the participant group was already involved. These are discussed in Section 4.4.2.

4.3.4 Role of the AVI System

The *Smart Commuter* project was dependent on TranStar for information on travel speeds. TranStar in turn was dependent on the AVI system that TxDOT had in place to monitor vehicles with EZ tags. However, the general sense from the project team interviews was that the AVI data were not optimally reliable. In an informal test spanning several months, the national evaluation team found that real-time traffic condition information on the TranStar Web site (which came from the same source as *Smart Commuter* information) was often unavailable for varying route segments during rush hours. TRW questioned whether the spacing of AVI tag readers, which the RFTP indicated were spaced 1 to 4 miles apart, was close enough to support the speed and volume algorithms.

Although it is impossible to measure the impact of the AVI system on the quality of *Smart Commuter* information without detailed logs from TxDOT and TranStar (which was outside the scope of the national evaluation), it seems likely that it had some negative impact on the operational test. For example, information gaps would leave the participants with incomplete travel information so that they would have difficulty making travel decisions. The data gaps may also have lowered participants' confidence in the overall information system. This problem was an external impact (discussed further in Section 4.5.1) over which METRO and the *Smart Commuter* contractor had little, if any, control.

4.4 Operational Issues

The *Smart Commuter* project experienced a number of operational issues as discussed below.

4.4.1 Operational Timing

The sequence of system acceptance and the start-up of the operational phase seem to have had a significant impact on the project's operation. As introduced in Section 4.3.3, participant training and start-up of the operational test occurred before all of the requisite testing had been successfully concluded. Some participants started using Magic Link™ as much as nine months before the system was officially accepted. For the participants, the project team, and the local and national evaluators, the test was proceeding as if the system had been accepted in December 1996. This is in contrast to the RFTP, which seems to indicate that the operational test would not commence until after system acceptance. Nevertheless, there were some compelling reasons to get the operational test started:

- The full operational test had been delayed from its original schedule numerous times for other reasons;
- Participants had been recruited and might be subject to further attrition if the project did not commence; and
- There was the desire to have something concrete to show at the ITS America Annual Meeting held in Houston in April 1997.

Participants beginning to use Magic Link™ in December 1996 faced the technical difficulties that were identified during the functional tests. A result of this situation was that TRW was in the position of having to operate the full system while it was still being debugged. This overlap of activities would have meant the contractor was dealing with final deployment and testing while also addressing immediate problems the participant group was encountering. Such a situation would seem to have the potential to complicate the successful deployment of the Smart Commuter system.

4.4.2 Technical Issues

By definition, a field operational test is meant to use technology in new ways, which invariably results in a variety of technical challenges. *Smart Commuter* was no different in this regard. What might differentiate *Smart Commuter* from other projects is the complications it experienced as a result of the timing issues discussed in the previous section.

4.4.2.1 FM Subcarrier

The final *Smart Commuter* design included transmission of real-time traffic data from the information server to the Magic Link™ devices using an FM subcarrier radio frequency. Officially called a Subsidiary Communications Authority (SCA) channel, it is an unused sideband of a commercial FM radio station that has the capacity to transmit information such as music. [24] The Magic Link™ devices were each equipped with a special antenna and receiver designed to pick up the specific subcarrier signal.

A communications consultant hired by the contractor in mid-1997 to help resolve the wireless communication problems pointed out several potential concerns about using an FM subcarrier channel. The power of an SCA signal is by definition very low because it emanates from the inherently weaker sideband signal of a radio station. This makes reception by a device like Magic Link™ much less predicable depending on the distance from the broadcast tower, the power of the signal and its location, the terrain around the receiver,[25] and the power and other technical characteristics of the receiver itself.[26]

Under the original broadcast setup for *Smart Commuter*, the FM subcarrier signal was broadcast from two radio towers located approximately 45 and 60 miles south of downtown. TRW did a sample check of reception, found shortcomings in reception in several areas and informed METRO of the situation. Apparently, neither TRW nor METRO understood how widespread the problem was. However, METRO had recognized that there might be reception problems and had planned from the outset to address isolated problems by incorporating the IVR telephone system as a back-up service.

As it turned out, the radio station transmitters had insufficient power to overcome all of the physical barriers, including the sheer distance to the Woodlands area where many of the participants lived. The fact that the selected transmission towers were located south of the city (where Houston's radio towers tend to be located) and the target reception area was heavily wooded and located substantially north of the city increased the likelihood of these communications shortcomings. Whether the receiver strength of the Magic Link™ antenna was also a factor was not determined.

To remedy the situation, the communications consultant, who also represented a commercial radio station, suggested the use of his client's tower 13 miles southwest of the city in place of the two original transmission towers. The receivers were modified or

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[24] One commonly recognized user of FM subcarrier services has been Muzak™, the company that provides background music to office and stores.

[25] As with many types of broadcast signals, hills, foliage, buildings and other features of the landscape can interfere with reception.

[26] SCA signals are more susceptible to two types of broadcast problems – multipath interference and signal fading. Multipath is more severe in the downtown locations where buildings cause radio signal refraction and prevent direct (line of sight) signals. Signal fading occurs when the power of the original signal is diminished as a factor of the power level of the original signal and distance to the receiver.

replaced as needed to handle the new broadcast frequency. Even with a better located tower and stronger signal, interviews with the project team as well as participant comments indicated that the reception problems were not completely cured during the operational test (although the system did pass the acceptance test in July 1997).

The end result was that Magic Link™ users had repeated difficulty connecting to *Smart Commuter* to get current real-time information. This was an oft-repeated theme in the comments of *Smart Commuter* participants. It was also identified as early as the first functional test in September 1996. Several project team members suggested that this was a major reason why many members of the first participant group dropped out. Several also indicated that the communication problem participants were having was not identified until several months after participants began using the system and that the project team should have included technical staff with specific skills in this area to assess the situation when it first arose and to assist with problem solving later on in the project.

4.4.2.2 Participant Data Uploading/Downloading

Because two-way wireless communication had not been included in the selected design, the project team had to establish a wireline modem-based communication link so that participants could upload their usage logs and travel diaries to, and download updated transit information from, the Sun Sparc® server at *Smart Commuter*. Like the wireless communication link, the modem connection proved to have difficulties. Problems with the modem communication link were initially identified during the first functional test in September 1996 and subsequently by participants. TRW made improvements to the communications software and modem to resolve the problem but it is not clear from participant comments whether the modem problem was ever fully resolved.

4.4.2.3 Magic Link™ Power Supply

Recharging the units' batteries presented a problem for some participants. There were actually two different types of rechargeable batteries involved with Magic Link™. One powered the FM communications receiver and the other allowed Magic Link™ to operate on DC power. Not only did users need to be mindful of recharging two different batteries, but one needed to be completely discharged before recharging while the other required recharging before it became fully discharged. Understandably, this proved to be somewhat confusing to Magic Link™ users. (Refer to Figure 3.7 in Chapter 3 for a picture of the Magic Link™ configuration.)

4.4.2.4 IVR System

The IVR phone system was designed like other automated telephone information systems. Participants would call the specified number, punch in their password, and follow the automated instructions to obtain the traffic information they were seeking. Users would select a travel direction in the corridor and then the system would provide information on a segment-by-segment basis in order. The IVR system included shortcuts that enabled participants to reach desired information quickly instead of going through each layer of the standard automated design.

The IVR system was not functioning correctly when the first participant group was trained in December 1996, so this group did not receive training in its use. A particular difficulty was that the system would remain silent for a period of time if there were no data available for the roadway segment a caller had selected. The software was eventually reprogrammed (by summer 1997) to state “no data” under these conditions.

The project team interviews clearly showed that the IVR was minimally used by participants. The representative of the firm that designed and operated the system said that it received an average of about six calls per day but it was designed to handle 20,000 calls per day, 10,000 during the peak period, and 700 (the original target number of expected participants) in one hour. Although the system originally had 20 incoming phone lines, when the contractor moved its offices in August 1998 and had to replace the lines, it recommended reducing the number of lines to six since usage was so low.

It is not clear why the IVR was used so little, as it was supposed to provide an alternative to Magic Link™ and handle any coverage gaps the FM wireless system might have.

4.4.3 Project Management

The organizational structure of the *Smart Commuter* project was described in Chapter 3. Representatives of both the public and private sectors felt that the organizational structure adopted for the project was a good model. It was felt that the public sector was in the position to provide the necessary traffic information while the private sector was best suited to add value and distribute the information.

The following subsections discuss specific issues around the day-to-day operations and management of the operational test.

4.4.3.1 Staff Turnover

There was substantial turnover in project management staffing for both the public and private sectors. For example, there were five METRO project managers during the course of the project, and the individual holding that position for most of the operational phase was not responsible for the earlier planning, procurement, design, and testing. Similarly, TxDOT with its general oversight role, had four project managers during the *Smart Commuter* project. The fact that the project lasted much longer than originally planned raised the likelihood of staff turnover impacts. One way METRO addressed this situation was to rely to a greater extent than expected on technical assistance from TTI.

The private sector experienced similar turnover. There was general agreement among project team members interviewed for this report that the loss of continuity created by the turnover had real, if intangible, impacts on the success of the operational test of *Smart Commuter*.

4.4.3.2 Contract Oversight

Contract oversight was performed by METRO. TTI was under contract to METRO to provide technical assistance with design and implementation. Concurrently, it was under contract to TxDOT (Research and Technology Transfer Division) to conduct evaluation activities (local evaluation as distinct from this national evaluation). For project implementation activities, METRO and TTI would generally act on their own unless TxDOT input was needed. TxDOT indicated that its role transitioned to an advisory and review role after the initial planning efforts. TxDOT was also responsible for construction activities related to the AVI system, while METRO was responsible for the *Smart Commuter* design.

There were two related contract oversight issues during the project, both of which were discussed earlier. First, there was confusion and disagreement over the full testing protocol. Stemming from that was the delay in payment to TRW, apparently tied to final acceptance issues. Several project team members interviewed suggested that the slow resolution of contract issues between METRO and the contractor over the testing requirements and related withholding of payments did not engender an environment conducive to quick resolution of outstanding technical problems. However, METRO staff felt that this leverage was effective in getting TRW to resolve problems that delayed acceptance.

4.4.3.3 Maintenance and Troubleshooting

During the operational phase of the project, TRW employed a local subcontractor to perform maintenance support. The firm was the point of contact for any operational problems in the system. It provided daily status reports to METRO. In general, however, the project team indicated that the system otherwise ran itself, automatically paging support staff when problems arose. TranStar staff would also contact the *Smart Commuter* maintenance contractor if problems with TranStar's database arose that might have an impact on the *Smart Commuter* server. The support staff was confident that they knew at all times whether the system was up or down.

The contractor set up a help-line for participants to address any problems they were having. It produced a monthly help-line report for METRO, but the evaluation team was not able to obtain the reports to analyze what types of problems were occurring and how they were resolved. METRO took over the help-line after 12 months (for the second participant group phase). To supplement the help-line, TTI was tasked with setting up an e-mail-based help desk. It operated between January 1997 and January 1999. One shortcoming of this system was that the help desk was only available to participants who had their own connection to the Internet either at home or from work.

No special mechanism existed to inform participants when the system was malfunctioning. Participants only realized this when they connected to *Smart Commuter* and got the message "no data available." There was no way for a participant to know whether the problem was due to the AVI system, the *Smart Commuter* server, the radio transmission or reception, or a problem within the Magic Link™ itself.

4.4.3.4 Participant Retention

All three groups recruited for the testing and evaluation of *Smart Commuter* experienced dramatic attrition. The magnitude of attrition was similar among the control group, first participant group, and second participant group. The control group may have dwindled because they had no incentive to continue (recall that they did not get to use *Smart Commuter*) and the duration of the operational test stretched from one year to two.

The cause for attrition is most clear for the first participant group. It is generally agreed that the ongoing technical problems with the overall *Smart Commuter* system during the first six months were substantial enough to cause many individuals to drop out. This led to the recruitment of a second participant group in late September 1997. METRO tried to stem the losses by creating a participant newsletter that was mailed out six times over the course of the project (in March, June, August and December 1997, May 1998, and January 1999). METRO produced the first newsletter specifically to address problems that had been identified and to assure participants that the problems were being addressed. Ways to work around specific problems were also provided to help participants skirt some of the difficulties.

Why the second participant group experienced similar attrition is more difficult to explain. The project team stepped up its outreach efforts, added the e-mail help desk, and took other actions to maintain participation. Nevertheless, as will be seen in Chapter 5, after an initial spike of activity in Magic Link™ use by the second group, usage declined steadily thereafter.

The number of diaries that METRO and TTI asked participants to fill out may have also been a factor in participant attrition. Each quarterly diary required a participant to record fairly extensive detail about their commuting habits for five work days. Although the travel diary was not explicitly identified as a problem by the project team, response improved toward the end of the project when the diaries (and surveys) were mailed, giving them a more traditional way to fill them out.

4.5 External Factors

Many of the factors that made the I-45 North corridor unique and a good test bed for the *Smart Commuter* operational test also encompassed hidden factors that may have affected the project's operation. Elements such as the TranStar facility, extensive HOV network, park-and-ride lots, and downtown express transit services were important to the operational test concept. Yet, infrastructure such as the AVI system and construction in the I-45 North corridor may have had both positive and negative influences on the project's outcome. This section looks at some of these external factors and how they might have affected the operational test results.

4.5.1 AVI System

The process for collecting and processing the travel speed information from the AVI system was not defined as part of *Smart Commuter* and therefore not a subject of evaluation. Nevertheless, the evaluation must comment on this as an external factor that might have influenced the project outcome.

TxDOT representatives characterized the AVI information as available for at least 90% of the time in 1996 and 1997 (although "available" was not clearly defined). There were reported to be one or two times per year when the entire AVI system was down. At other times, there were instances where specific segments had no information. The two principal reasons for lack of data were an inadequate number of vehicles with tags using a segment or AVI detector outages. TRW also suggested that the number of detectors was too low and their spacing (3-4 miles) too far apart, and that the system was not as rugged as systems designed to provide information for public dissemination.

If the cause of the data gaps were an inadequate number of vehicles with tags using the segments, this problem should have been reduced since the number of EZ tags increased over time. The problem would likely be worse on the HOV lanes due to the smaller number of vehicles, but the HOV speed may have been more constant and of less interest to participants. The fact that there was limited access to the HOV lanes could also be expected to improve the data, since exits in regular travel lanes present a significant challenge to developers of traffic speed algorithms.

If the cause were AVI detector outages, affected roadway segments would be without current information on travel times. TRW indicated that, during the first year of *Smart Commuter* operation, approximately one AVI tag reader per week was not working properly. The plan for dealing with AVI outages was to have an independent maintenance contractor address short-term outages within 24 hours. Any longer outage would be handled by modifying the AVI system to link different tag readers to ensure a constant flow of AVI data to TranStar (and by extension, *Smart Commuter*). During the longer AVI outages, travel time data were supposed to remain available through the application of software routines designed to compensate for any gaps.

Also, many of the comments from the e-mail messages to the help desk, user log records, and survey responses indicated that traffic information was not always current. This could have been due to the fact that traffic conditions had changed by the time participants reached the AVI-covered segments. The extent to which this might have affected the *Smart Commuter* project results is not known. Modifications to the AVI system in the study corridor occurred during the project, but the project team was not able to identify any impacts this might have had on the operational test.

4.5.2 Incident Data Problems

In addition to the intermittent lack of traffic condition data from the AVI system discussed above, the incident and road work information that *Smart Commuter* was supposed to provide to participants was not fully reliable. During the first functional test, concern arose because incidents that had been identified at TranStar were not being reported by the *Smart Commuter* system. Even after the operational test began, participants complained about seeing incidents on their commutes that had not shown up on Magic Link™. The missing incident information affected the perceived reliability and accuracy of *Smart Commuter*.

4.5.3 Changing Technological Landscape

The TranStar Internet site became available before *Smart Commuter* went into operation. The Internet site was not part of *Smart Commuter,* although it displayed the same travel time information. (Incident information compiled by TranStar was not displayed on the Internet site but was transmitted to *Smart Commuter*). *Smart Commuter* test developers did not foresee the advent of the Internet. The accessibility of the Internet site from the home and office may have eclipsed to some extent the benefits of *Smart Commuter*.

The Internet site also provided broadcast media with easy access to the most up-to-date information. Thus, even those who did not access the Internet themselves may have benefited as radio stations reported information about the segments represented on the Internet site traffic map.

The overall usage of the TranStar Internet site grew rapidly. In October 1996, before the first participant group began using *Smart Commuter*, the Web site recorded 69,000 visits or "hits.". In October 1997, before the second participant group began using *Smart Commuter*, the number of hits was 236,000. In June 1999, after the *Smart Commuter* evaluation period was over, the number was 454,000.

The relatively new VMS system which had been implemented on the I-45 North corridor provided information to travelers en-route. Since *Smart Commuter* participants were told not to use *Smart Commuter* while driving in their car, the VMS system could provide information to participants that was more up to date at some key locations on their trip. Although the VMSs do not provide pre-trip information, their introduction during 1995 and 1996 may have detracted from participant interest in *Smart Commuter*. In fact, participant comments included several which specifically talked about the utility of the VMS network.

4.5.4 Test Corridor Construction and Reduced Congestion

The congestion levels in the I-45 North corridor were reported to have improved over the course of the project for unrelated *Smart Commuter* reasons. There were many improvements made in the I-45 North corridor where the operational test took place. Some of these improvements (for example, rebuilding the elevated portions of I-45 in the downtown area) occurred before the first participant group began using *Smart Commuter*. Other improvements happened during the first participant group test – I-45 was widened from six to ten lanes north of Highway 8. As a result, congestion reportedly decreased, thereby reducing somewhat the usefulness or need for pre-trip information. The project team reported in interviews that park-and-ride lot usage declined after the widening of I-45.

4.6 Qualitative Evaluation Conclusions

Several issues regarding the *Smart Commuter* project are worth noting.

- It appears that the project team's decision to use primarily functional rather than technical specifications during the procurement was a wise choice. It provided flexibility to negotiate with bidders, mitigated some of the technological issues, and allowed sensible changes to be made in the final contract.
- Some of the findings from the market research and the focus group did not necessarily support the preliminary design concept (i.e., that the availability of timely traffic and modal information will affect a commuter's mode choice on a trip-by-trip basis).
- Procuring new technology and systems within the framework of an operational test presents inherent difficulties. Besides the fact that technology and the target market may be changing, existing technological components may have never been combined to provide the intended services. Such an environment creates unknowns that are not predictable or controllable once they emerge. One way of minimizing potential difficulties is ensuring that each part of a public-private project team has specialized technical capabilities to address problems arising in the most critical components and processes.

- Testing requirements must be clearly stated and carried out fully and all significant operational problems resolved before deploying a system like *Smart Commuter* to the public, even with a small participant test group. The benefits of doing so will far outweigh the risks and impacts of proceeding on an unstable technical foundation.
- The timing of the operational start-up was a major shortcoming of *Smart Commuter*. The system should not have been put into service before it had been thoroughly tested and operating satisfactorily. This caused *Smart* Commuter to start off on a negative note.
- Several factors likely contributed to the high rate of attrition, including initial operational problems, RID malfunctions, traffic data reliability and availability shortcomings, the requirement to fill out a one-week travel diary on a quarterly basis, and the availability of similar traffic information on the Internet.
- Despite the internal and external challenges, the project team designed a potentially viable ATIS service whose field-testing would make a significant contribution to the state of knowledge of ATIS. Given the overall immaturity of the ATIS market while *Smart Commuter* was being designed, and the prolonged time between the initiation and completion of this project, there were limitations as to what the project team could have reasonably done to control for market and technology factors which, in retrospect, seem so important.

5. *SMART COMMUTER* QUANTITATIVE EVALUATION

Chapter 4 gave a detailed evaluation of the *Smart Commuter* project from a qualitative perspective. This chapter uses the quantitative data sources described in Chapter 2 to estimate a variety of numerical measures of the *Smart Commuter* operational test's success and impact on participants. It begins by quantifying how the *Smart Commuter* system was used. This is intended to provide a context within which to explore the variety of metrics related to consumer acceptance covered in Section 5.2. Although there were many possible measures to estimate, the national evaluation team selected those of the greatest general interest and transferability to other projects. Note, too, that the analysis focuses primarily on Magic Link™ and not the phone system since there were no telephone log data available to crosscheck against survey and travel diary data, and the project team agreed that the IVR system was hardly used.

Principal quantitative findings included: preference for traffic information over mode choice information; good to very good Magic Link™ performance ratings from about half of participants; preference for radio, the Internet, and television over Magic Link™ or telephone as information medium; significant decline in Magic Link™ use over time; little change in participant commute travel from baseline pattern; and 40 percent of participants indicating willingness to pay for travel information. However, the relatively small number of participant surveys and travel diaries returned diminishes, to some degree, the ability to draw conclusions with a high level of confidence.

The quantitative evaluation elements are discussed in the following sections.

5.1 Levels and Patterns of *Smart Commuter* System Use

This section provides an overview of how the Magic Link™ was actually used by *Smart Commuter* participants. The log data employed in the analysis of Magic Link™ usage includes log records uploaded from the Magic Link™ devices to the IDS for the period from 12/4/97 to 2/8/99. Only records of the second participant group (which began using *Smart Commuter* in December 1997) were included in this analysis. This decision was made to limit the potential confounding effects of significant technical problems experienced by the first participant group during the first year of the test. This assumes that most of the technical problems (such as the FM and modem communication links discussed earlier in this report) had been resolved by the time the second participant group started.

Every time a participant used Magic Link™ for any purpose, a record of which screens were used (and for how long) would be added to the log file resident on each Magic Link™ device. Each of these complete records was defined as a “user session.” If any time was recorded on a particular screen, it provided evidence of a “screen hit." Thus, the total length of an individual user session was comprised of the sum of its individual screen hits. Since some of the subsequent analyses were done by individual screen and others by function, Table 5.1 shows how screens were grouped functionally (NA in the group column indicates that a particular screen was not joined with others).

Whenever participants logged into the *Smart Commuter* server via modem (either to upload a completed travel diary or download updated transit schedule information), the log of all user sessions since the last connection to the server was uploaded to the server's user log database. That database was the primary information source used to evaluate how the Magic Link™ device – and by extension the overall *Smart Commuter* system – was used by the second participant group. The log data probably provide a more reliable picture of actual Magic Link™ use than user perceptions reported in the participant survey.

Screen Name	Functional Group
TranStar Main	NA
TranStar Upload	NA
Houston Corridor Map	Traffic Conditions
Houston Downtown Map	Traffic Conditions
HOV Info Map	Traffic Conditions
Traffic Incidents	Incidents
Road Work	Incidents
Transit Info	Mode Choice
Transit Details	Mode Choice
More Transit Info	Mode Choice
P&R Lots	Mode Choice
P&R Detail	Mode Choice
Other Magic Link™ Features	NA
Participant Diaries	NA

Table 5.1: Combination of Magic Link™ Screens for Data Presentation Purposes

5.1.1 Magic Link™ Sessions

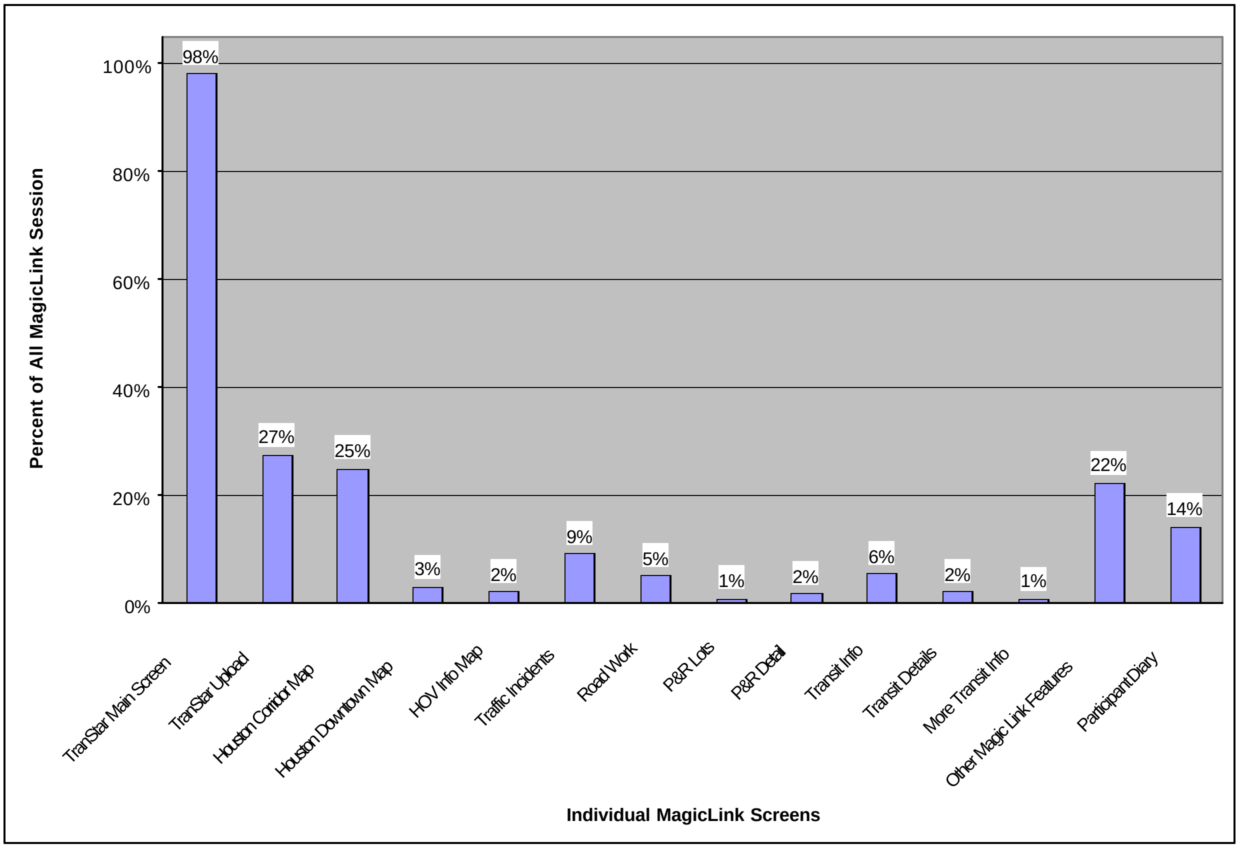
Evaluating Magic Link™ user sessions and screen hits provides the context to understand participant response to the system and the impacts on their commutes discussed in the next section. Three primary indicators are discussed:

- The number of hits on each Magic Link™ screen relative to the overall number of user sessions;
- The contribution of each Magic Link™ screen hit to the total length of all user sessions; and
- The length of the average screen hit.

5.1.1.1 Frequency of Use of Particular Screens

Figure 5.1 shows the percentage of the total user sessions that included screen hits for each of the individual Magic Link™ screens. The percentages are calculated by dividing the number of screen hits by the total number of valid user sessions (n=10,084).[27]

Figure 5.1: Screen Hits as a Percentage of All User Sessions



Since the TranStar Main Screen was the default start-up screen whenever the device was turned on, it is logical that 98 percent of the sessions included it as a screen hit.[28]

While the fact that the TranStar Upload screen was used 27 percent of the time may seem high, the reader is reminded that this is the percentage of hits rather than of time spent. One way of looking at this figure is that, on average, slightly more than one-quarter of the user sessions involved uploading travel diary data and/or downloading transit schedule data via modem.

More than 45 percent of the sessions involved accessing static or real-time traffic-related information (based on grouping the screens by function as shown in Table 5.1). This probably understates the use of Magic Link™ for obtaining traffic information since the

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[27] A user session was considered valid if it met several criteria. Approximately 10% of the initial 11,249 records for the second participant group were omitted using the following rules: Magic Link™ Main = 0 AND Magic Link™ Upload = 0; Magic Link™ Main = 0 AND Magic Link™ Upload > 0 AND Total Session Time = Magic Link™ Upload; Total Session Time > 10 hours.

[28] Theoretically, the percentage should be 100, but achieving this would have violated the heuristics used to clean the log data of illogical data points and outliers.

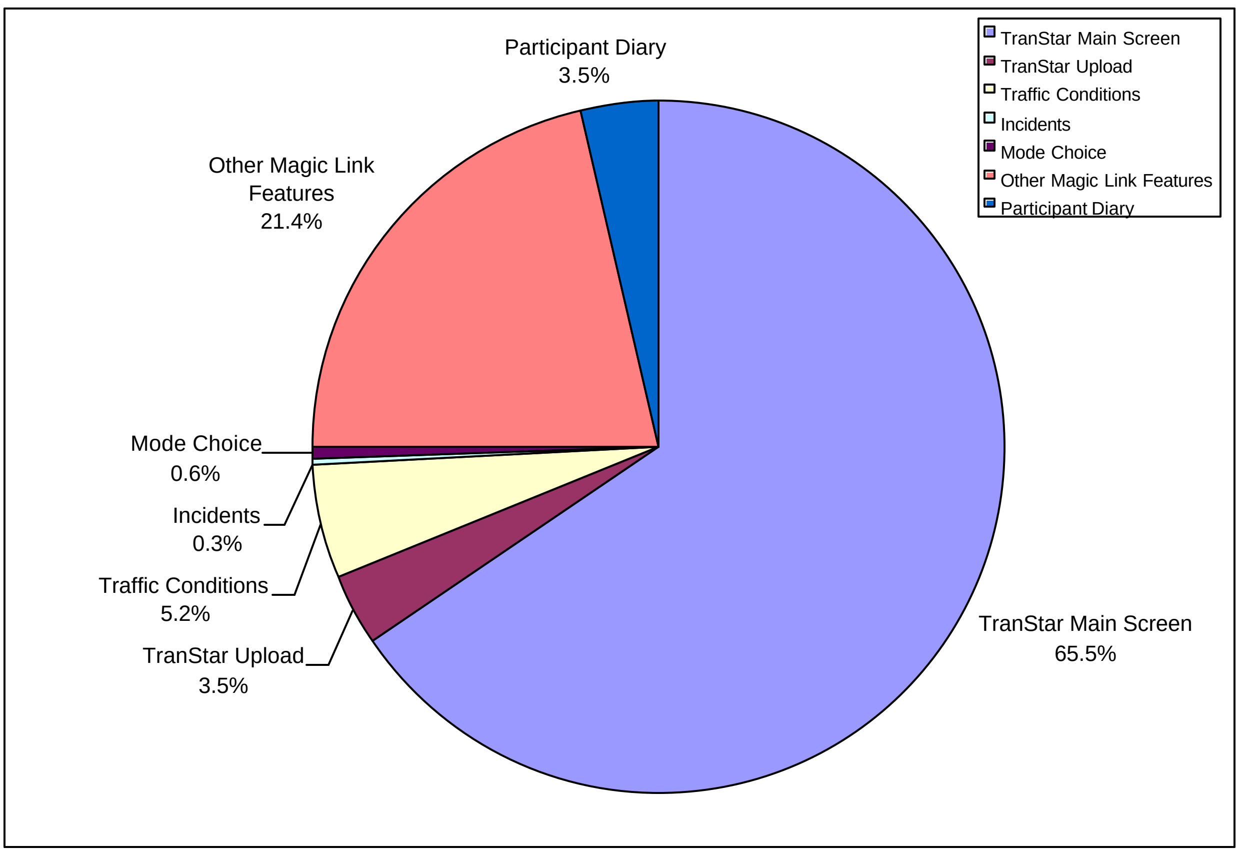
TranStar Main Screen included real-time traffic information by corridor and direction that may have been sufficient for certain users and/or purposes. Transit information and P&R (grouped into the Mode Choice group in Table 5.1) were accessed in 11 percent of the user sessions.

Traffic information stands out as Magic Link™'s most popular feature on a frequency-of-use basis. The use of other (non-*Smart Commuter*) features of Magic Link™, such as the calendar and address book (22 percent), and Participant Diary (14 percent) is also notable, especially since they are larger than any of the primary traveler information functions (except for the TranStar Main Screen and the Houston Corridor map screen).

5.1.1.2 Each Screen's Share of Total User Session Time

To assess the overall use of the Magic Link™ devices, the total time spent on each Magic Link™ screen was divided by the duration of all valid user sessions. Figure 5.2 shows the percentages resulting from this calculation. The functional groups in Table 5.1 are used since the majority of individual screens produce figures that are too small to have practical significance or to display graphically.

Figure 5.2: Screen Time by Functional Group as a Share of Total User Session Time



It is not surprising that approximately 65 percent of all Magic Link™ session time was on the TranStar Main Screen because it was the default screen and provided actual traffic information. The TranStar Upload screen constitutes a smaller share of Magic Link™

use when viewed by duration rather than the number of screen hits. The Mode Choice group is very low (0.6 percent), suggesting that either very few sessions involved a substantial consideration of mode shift or that the information was not viewed frequently since it was static.

Excluding the Other Magic Link™ Features category (because it does not provide traveler information) and the TranStar Main Screen, the Traffic Conditions group appears to be the most extensively used part of the system, at just over 5 percent of session time. As noted earlier, this is inherently understated because of the traffic condition information offered on the TranStar Main Screen. The Incidents group is also likely to be understated for the same reason.

Why the Other Magic Link™ Features category is so large is not clear, since both anecdotal evidence and the participant survey results suggest that most participants did not use the address book, contact manager, and other features not related to traveler information. (Perhaps other household members used the Magic Link™, or the participants did not remember the extent to which they used the Other Magic Link™ Features.) The share of the Participant Diary screen is relatively high compared to the traveler information screens. An extensive quarterly travel diary required of all users explains why this is so.

5.1.1.3 Average Session and Screen Duration

The average length of a user session was calculated to be just over 20 minutes (excluding sessions with no duration or invalid records defined earlier in footnote 29). Figure 5.3 shows the average time spent on each functional group of Magic Link™ screens. The figures were calculated as the total time recorded in the user log database for each functional group divided by the number of valid (non-zero duration) screen hits in each category.

As would be expected given its function and content, the TranStar Main Screen has the highest average hit duration of 13.6 minutes among *Smart Commuter* functions (n=10,010). This long average duration suggests that many users may have left the device on during their commute to obtain future updates. This supports the hypothesis that many used *Smart Commuter* as an en-route information system in their cars.

Although Other Magic Link™ Features has a high average, its relatively low hit rate (2,277 hits) suggests that the statistic is comprised of the behavior of a smaller share of users and relatively long individual screen hits. The Mode Choice group, at a 1.1-minute average per hit, seems low considering the project objective of encouraging mode shifts. However, this number is consistent with Figure 5.2 and the survey results in Section 5.2.

5.1.1.4 Session Start Times

The average session start time shown in Figure 5.4 provides a picture of what time participants started each Magic Link™ session. This could be important for determining a variety of user preferences and peak system demands.

Figure 5.3: Average Screen Hit Duration by Functional Group

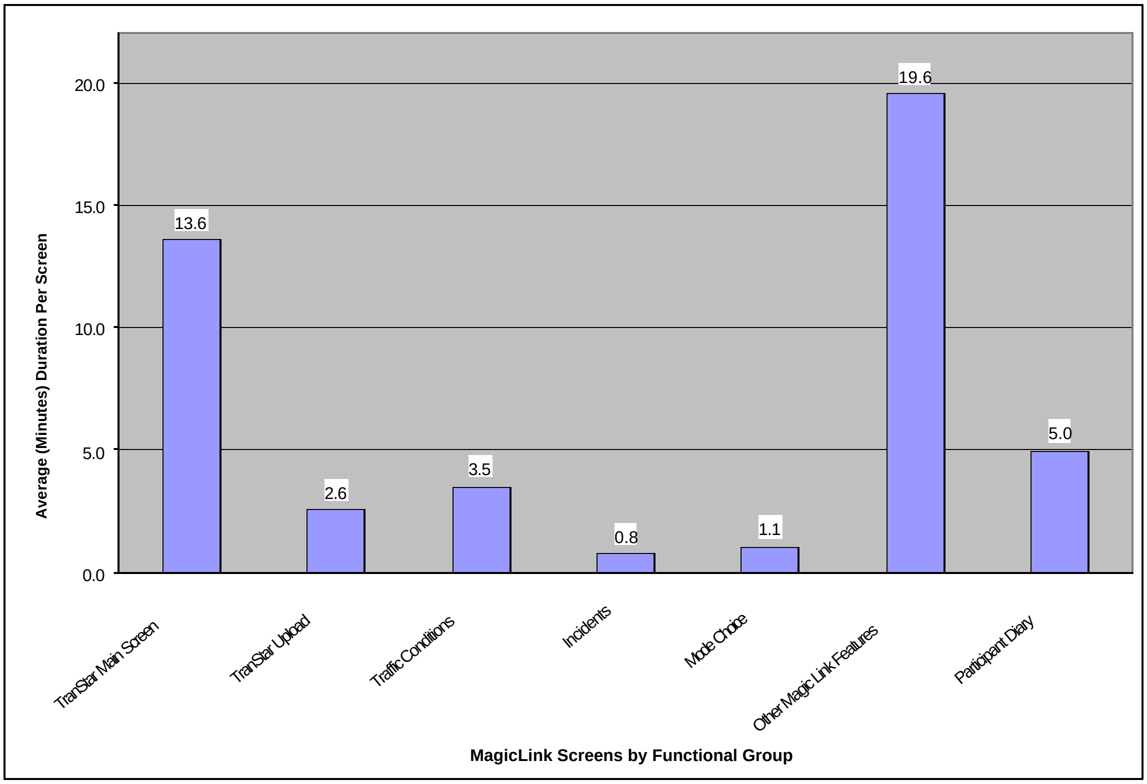
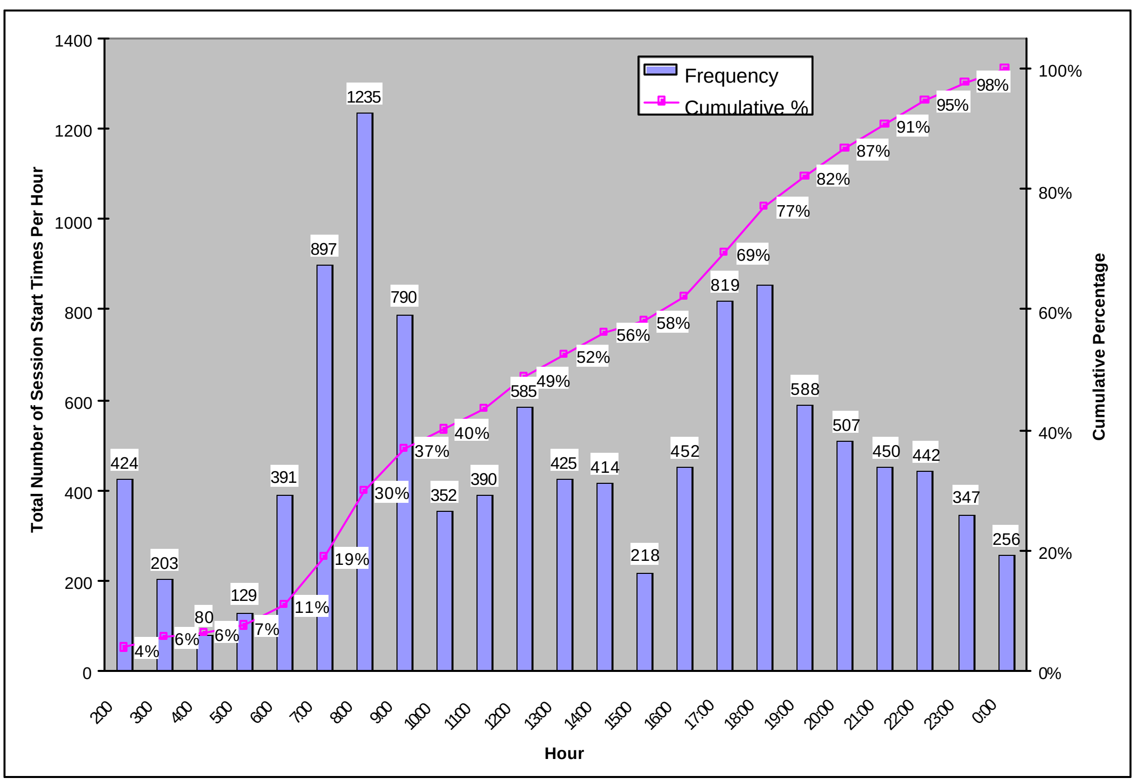


Figure 5.4: Session Start by Time of Day

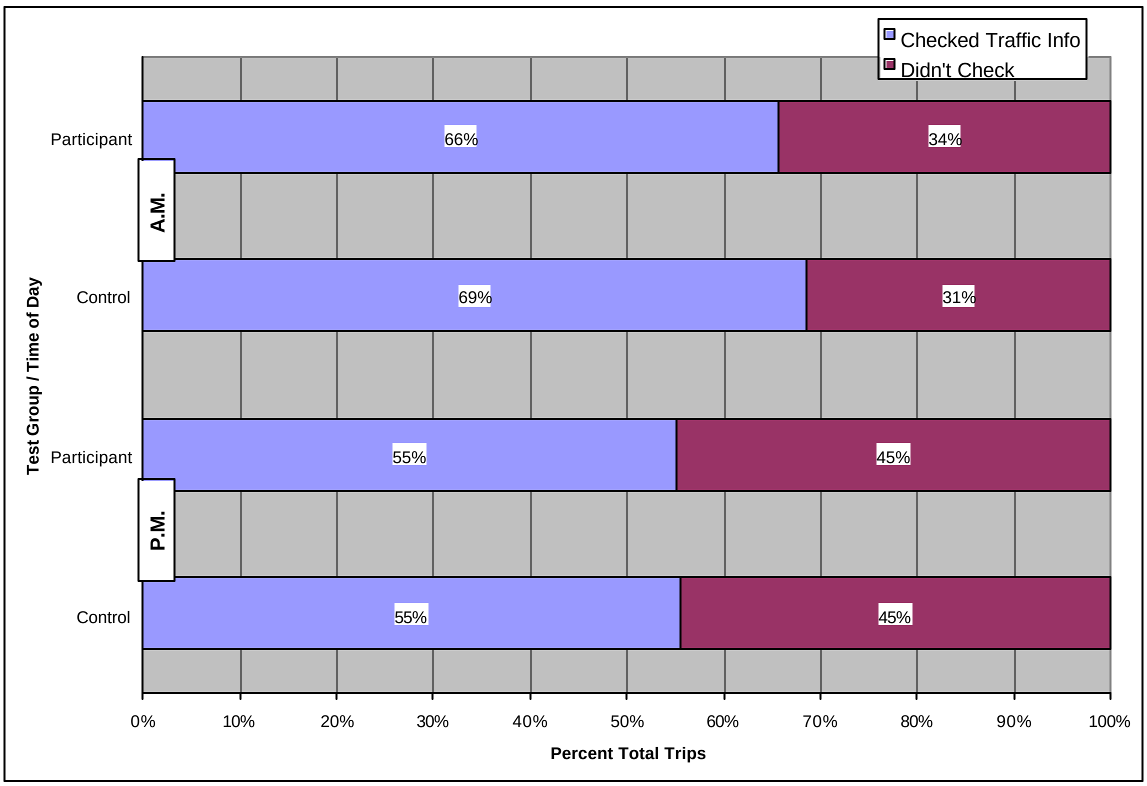


As would be expected for a traditional commuting population, the data result in a bi-modal distribution, with the primary mode peaking during the 8:00 a.m. hour and the secondary mode peaking during the 6:00 p.m. hour. Although there is a more pronounced peak of use in the morning, the Cumulative Percent line in Figure 5.4 shows that just under half of user sessions had started by 1:00 p.m.

5.1.1.5 Accessing Traffic Information

Figure 5.5 shows what share of the participant and control groups checked traffic information (via the Web, radio, television) before leaving or while commuting in the morning and afternoon. The data for this figure are from the total number of trips recorded in the diaries. The results of the final travel diary showed similarity between participants and the control group in terms of whether they checked traffic information sources. Although one might have expected the participants to be more likely to check travel information because of *Smart Commuter,* the data do not show evidence of this.

Figure 5.5: Percent of Participant and Control Groups Checking Traffic Information in the Morning vs. Afternoon



5.1.2 Magic Link™ Upload/Download Times

The log data allows us to look at the time of day participants uploaded data to the *Smart Commuter* server. Figure 5.6 presents a bi-modal distribution, with the activity split almost evenly by the 3:00 p.m. hour, as shown by the Cumulative Percent line. The X-axis labels represent the beginning of the hour (e.g., 10:00 a.m. includes all activity between 10:01 and 11:00 a.m.).

Figure 5.6: Uploads by Time of Day

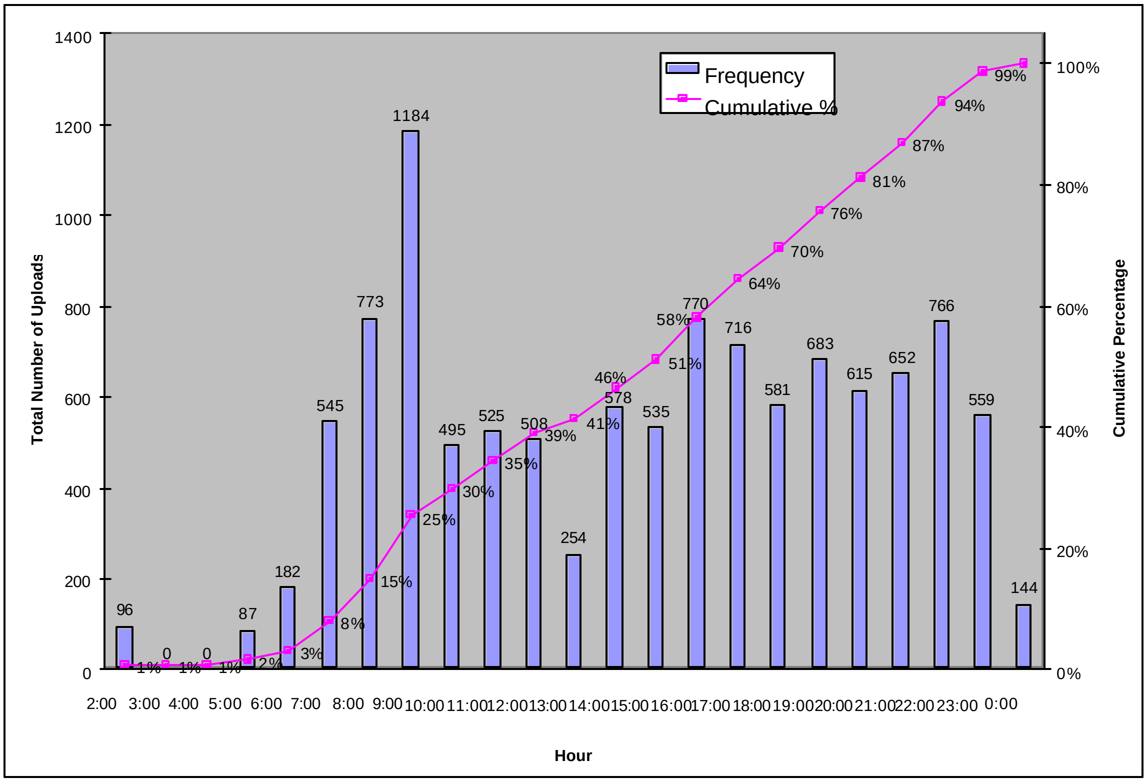


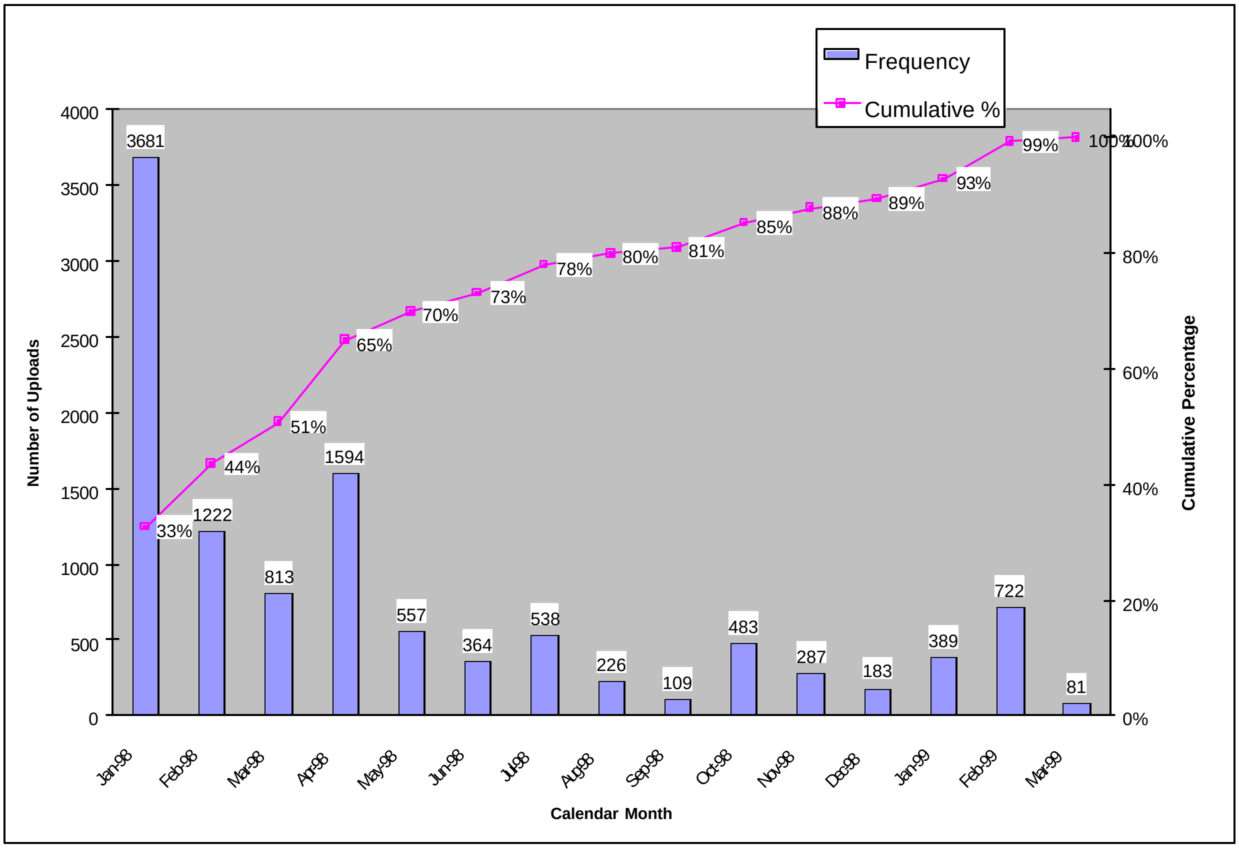
Figure 5.6 illustrates a wide distribution of upload times over the course of the day. Interestingly, the primary mode of this distribution is the 9:00 a.m. hour. This seems counterintuitive if one hypothesized that commuters would be more concerned with obtaining travel information than connecting with the *Smart Commuter* server. Perhaps many participants had noticed a message on Magic Link™ during the inbound commute to update their transit schedules or to upload their diaries and did so upon arriving at work. Also interesting is the number of participants who uploaded during traditional work hours, or approximately 49 percent. After 4:00 p.m., there is a fairly even distribution of upload times throughout the evening.

5.1.3 Magic Link™ Use Over Time

Upload activity also provides a good picture of participation in the test over the course of the project. Two measures were used. Figure 5.7 shows how the upload activity of participants was distributed across the second group's 14-month test period.[29] Figure 5.8 shows the number of sessions per month between January 1998 and February 1999.

[29] Although the test period was designed to be 12 months, all 14 months were included to ensure that each travel diary cycle was included.

Figure 5.7: Uploads by Month

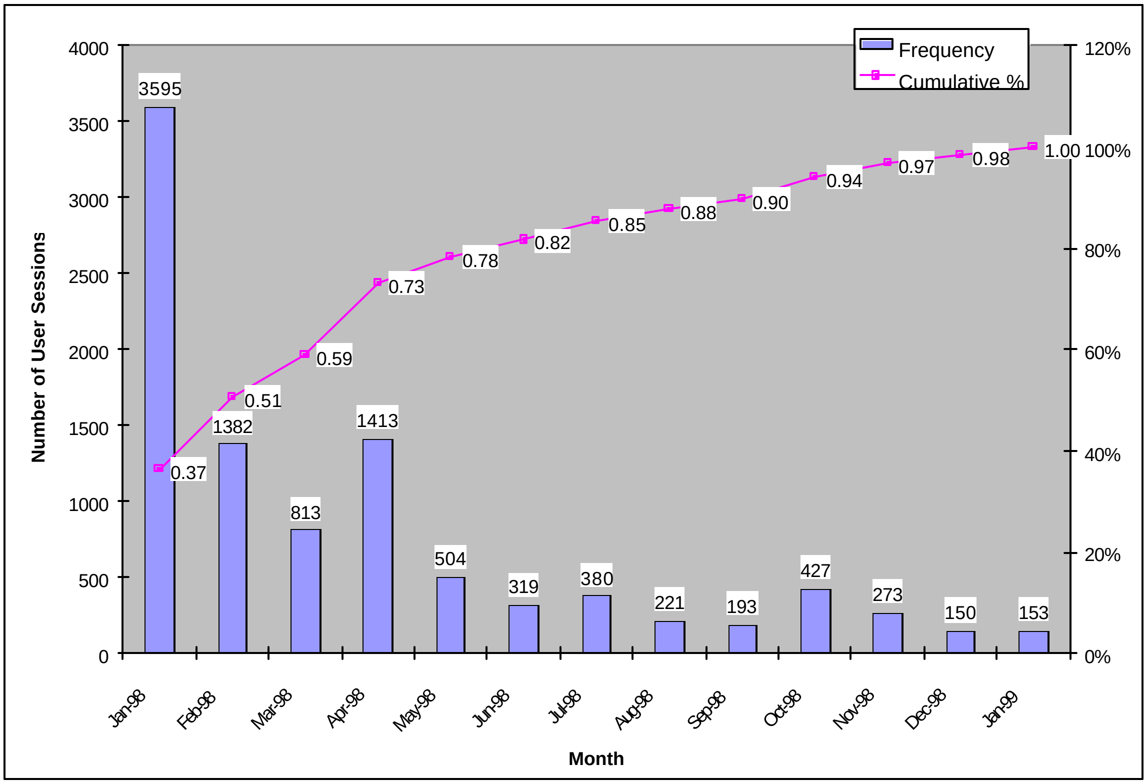


The bars in Figure 5.7 show significantly more upload activity just after the second group was trained in December 1997. Although there is a significant overall decline in Magic Link™ use over time, there are occasional peaks of activity. Oddly, these do not correspond to the quarterly travel diary uploads scheduled in June and December 1998. Perhaps these relate to METRO transit schedule changes becoming available for uploading or instructions from the project team to upload travel diaries that were late.

Reinforcing the picture of declining activity, the Cumulative Percentage line in Figure 5.7 shows that 65 percent of the uploads had taken place by the end of the fourth month of the second year of the operational test. It is known that progressively fewer second group participants participated in the preparation of travel diaries as time went on, even though paper travel diaries were mailed out in December 1998 to give individuals an alternative to using the diary on Magic Link™. Figure 5.8, Magic Link™ sessions per month, supports this finding by showing the steady decline in user sessions.

As Figure 5.9 shows, despite the decline in the number of participants, the average sessions per continuing participant per day remained relatively stable. The most notable feature of the plot is the steep decline in both July and August. This may be partially explained by a seasonal factor.

Figure 5.8: Total Magic Link™ User Sessions per Month



5.2 Consumer Acceptance: Participant and Control Group Evaluation of *Smart Commuter* and Other Information Sources

Because of limitations in the survey data sets, the evaluation team needed to decide which subset would most fairly and accurately reflect the experience of *Smart Commuter* participants. The team sought to include as much data as possible in the analysis while limiting the confounding of results by factors such as high attrition of respondents. Therefore, the national evaluators decided to include in the analysis only responses of first or second participant group members who had completed both the baseline and post-test surveys.[30] This approach presupposes that these survey participants would reflect the attitudes of users of a reasonably stable *Smart Commuter* information system. This assumption is impossible to test with the available data.

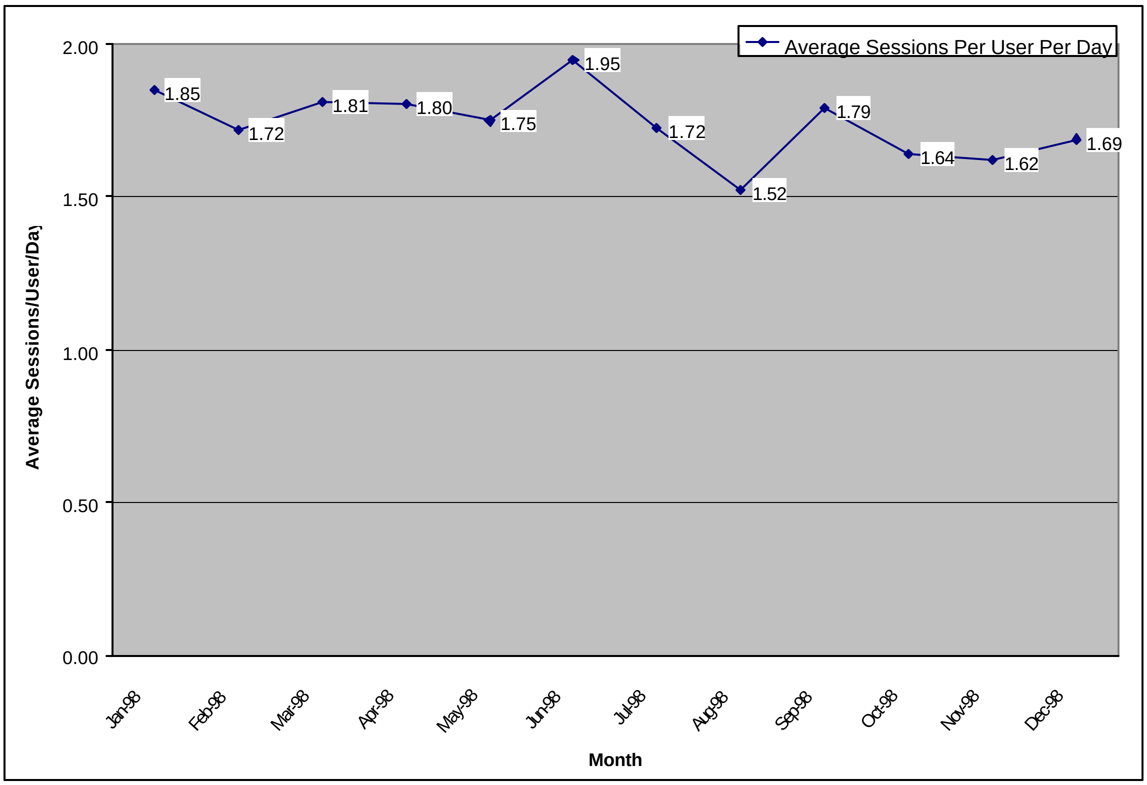
Arguing that perceptions of persons who dropped out are also important is valid. The evaluation team has incorporated input of users who dropped out by examining various qualitative data sources such as the e-mail help desk logs, survey comments, and log comments.

A similar challenge existed in deciding which control group surveys to use in this analysis. Because the tracking of control group surveys did not allow matching of baseline and post-test surveys, it was impossible to create the same type of panel as for participants. This would have provided a more comparable data set. The result is that

[30] Resulting in the following: n_{group1}=34, n_{group2}=65, n_{panel}=99)

control group baseline and post-test surveys are used in their entirety and therefore do not control for the high attrition rate in the same manner as the participant group. Note, however, that if the control group attrition were relatively random, it would be unlikely to create a bias in the data. As compared to the participant group, the expectation of random attrition could be supported; one could argue that since the control group was not using the Magic Link™ system, its individual members would not have experienced the frustration and dissatisfaction of the participant group.

Figure 5.9: Average Magic Link™ Sessions per Participant per Day



5.2.1 Comparison of the Participant and Control Groups

To establish that key characteristics of the participant and control groups are similar enough to compare and contrast them, this section explores several demographic and commute measures.

5.2.1.1 Respondent Demographics

To determine whether the participants are representative of the target population and whether the control group mirrors the type of individuals in the participant group, the two groups were compared along several demographic measures available from the baseline (pre-implementation) surveys. Table 5.2 shows these comparisons.

Judging from the measures in Table 5.2, the control and participant groups are reasonably similar. Both groups contained more males than females, although the participant group had an even larger representation of males. The household incomes were very similar, especially if one focuses on the median rather than average income. Approximately 63 percent of households in each group have 2 vehicles (266 and 62 responses, respectively). Just over 64 percent of participants reported having exactly 2 persons of driving age (63 responses) compared to 60 percent for the control group (275 responses).

Measure	Control Group	Participant Group
Male / Female (number of responses)	60% / 40% (461)	74% / 23% (97)
Average and Median Annual HH Income (number of responses)	$40,200 / $40,000 (425)	$45,000 / $40,000 (92)
Average Passenger Vehicles Per HH	2.1	2.1
Average Persons 16+ Years Old Per HH	2.2	2.2

Table 5.2: Comparison of Control Group and Participant Demographics

Table 5.3 shows the distribution of ages for the members of both groups and Table 5.4 shows the ethnic make-up. The participant group contained 7 percent fewer persons in the 21-34 years old range and 6 percent more persons in the 45-54 years old range.

Age Range	Control Group	Participant Group
21 – 34 (number of responses)	25% (112)	18% (17)
35 – 44	32% (148)	35% (34)
45 – 54	27% (126)	33% (32)
55 – 64	14% (62)	14% (14)

Table 5.3: Age Distribution of Participant and Control Group

Race/Ethnicity	Control Group	Participant Group
White (number of responses)	80% (361)	80% (75)
African American	6% (26)	8% (8)
Hispanic	8% (30)	5% (5)
Asian		4% (4)
Other		**2% (2)**

Table 5.4: Race/Ethnicity Distribution of Participant and Control Group

Two general conclusions can be reached through these demographic comparisons. First, given the measures examined, the control and participant groups are quite similar. This holds true despite the fact that the participant group statistics are only for the panel described earlier. This lends credence to the method of selecting the participant panel, as it resulted in a data set that is demographically very similar to the entire baseline control group. The similarities between the participant and control groups may indicate that they would not differ significantly in their attitudes toward a new technology.

5.2.1.2 Commute Characteristics

An important comparison to make between the participant and control groups is the characteristics of their commute prior to the operational test (as recorded in the baseline survey). Substantial differences in commute distance or length could lead to differences in perceptions regarding Magic Link™ and other travel information media. For example, commuters with substantially longer travel times or slower travel speeds may be more or less likely to seek out travel information.

Table 5.5 shows that both groups have relatively similar commute experiences in terms of average travel time, distance, and speed. Another factor for comparison is the modes typically used for commuting <u>before</u> the operational test. The baseline survey results show some similarity in mode choice between the participant group and the control group, although the data suggest that control group members were somewhat more likely to drive alone than participants, and participants reported a higher likelihood of carpooling or taking the bus. Figure 5.10 shows the mode choice of participants and the control group.

Measure	Control Group	Participant Group
Average Travel Time - min.	51	52
Average 1-way Trip Distance - mi.	28	30
Average Speed - MPH[31]	32.9	34.5

Table 5.5: Comparison of Participant and Control Group Commute Characteristics

The mode choice as recorded in the travel diaries (Figure 5.11) shows a similar preference of the control group for driving alone.

5.2.1.3 Participant and Control Group Comparison Conclusion

Despite the differences in preferences for driving alone, the relative similarity of commute and demographic characteristics suggests that the two groups are suitably comparable for the purposes of evaluating and comparing other measures such as user acceptance and attitudes toward travel information services. It also means that, to the extent that the control group represents the target population as a whole (and no claim is

[31] Actually an average of averages calculated from the travel time and distance figures in the same table.

Figure 5.10: Mode Choice and Frequency of Commute Trips

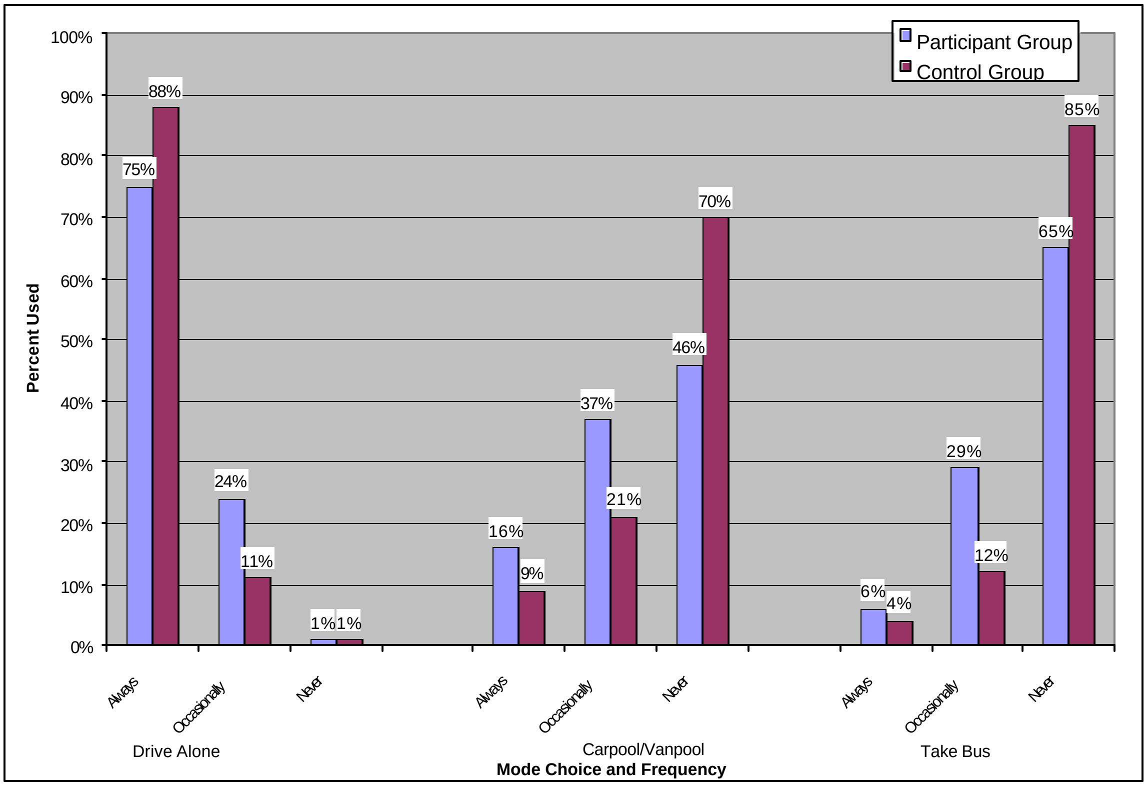
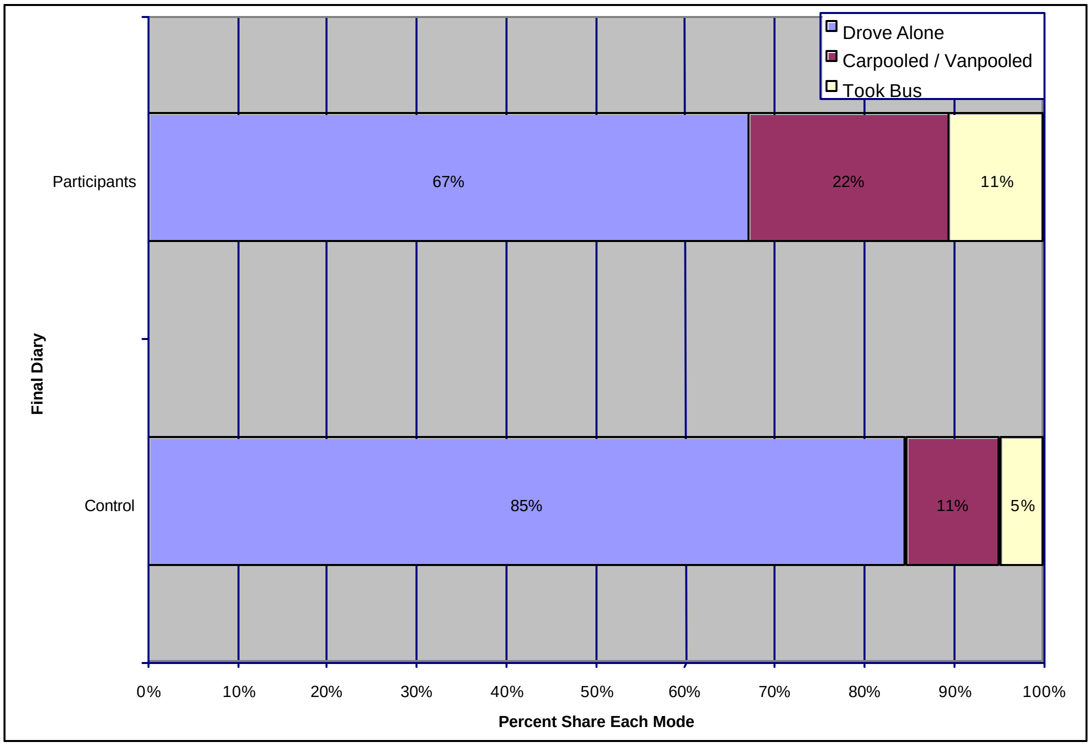


Figure 5.11: Mode Choice and Frequency



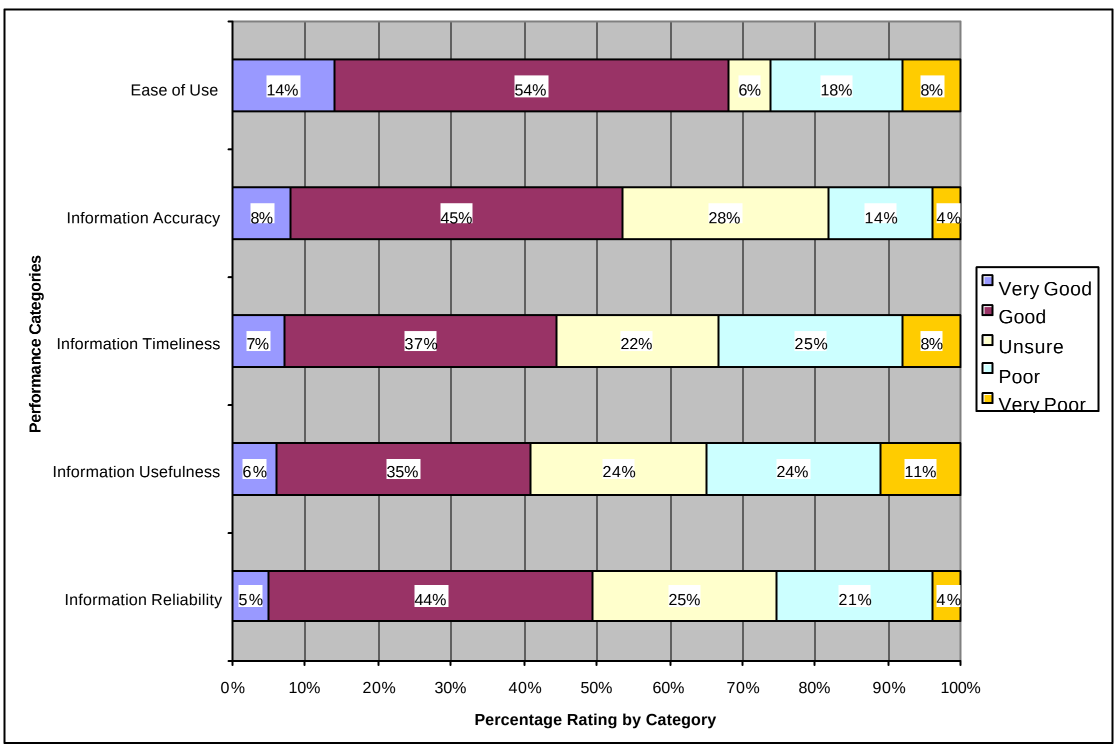
made here to that effect), the results of the participants' trial of *Smart Commuter* could be cautiously extrapolated to a larger commuter population.

5.2.2 User Acceptance of *Smart Commuter*

Participants' evaluation of the *Smart Commuter* information conveyed via both the Magic Link™ and the IVR telephone system provides important feedback on the system's design and performance. In the post-test survey, a battery of questions was asked to ascertain participants' perceived satisfaction[32] with several characteristics of the *Smart Commuter* information and media.

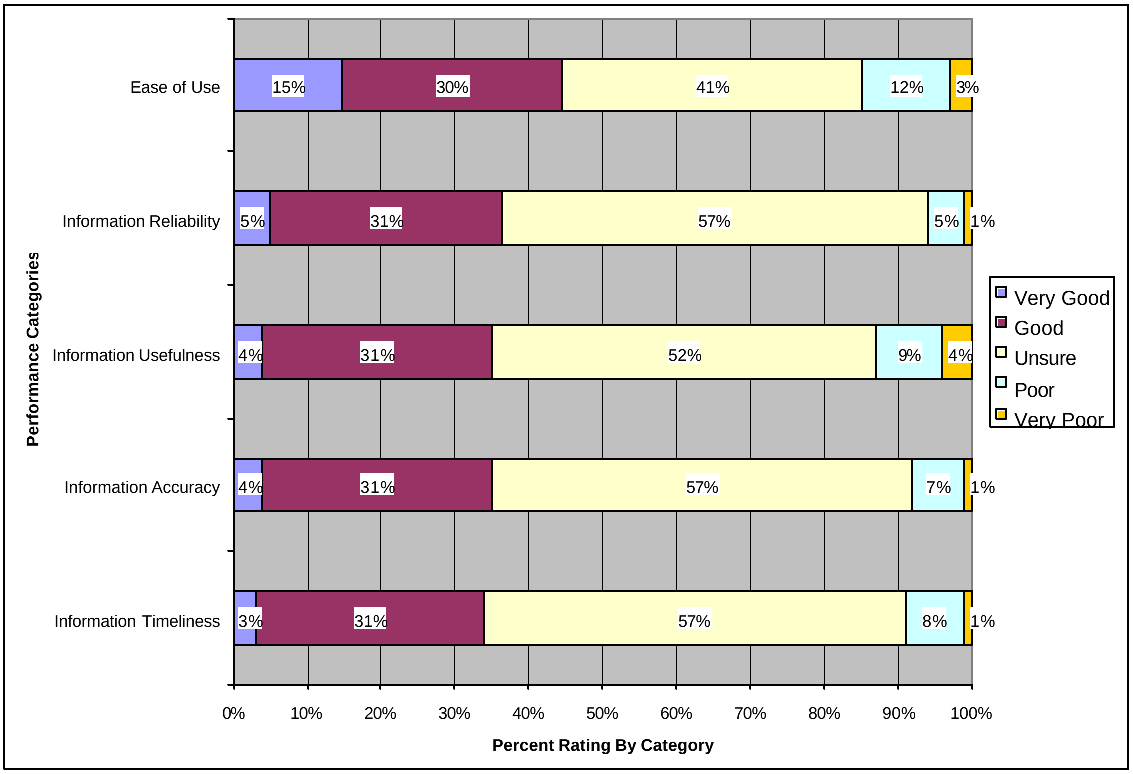
Figure 5.12 shows how participants in the survey panel rated Magic Link™ performance for five performance measures. Figure 5.13 shows the same analysis for the *Smart Commuter* IVR telephone system.Magic Link™ performance was rated as good or very good (99 responses) from a low of 41 percent for Information Usefulness to a high of 68 percent for Ease of Use. The fact that Ease of Use was rated the highest is positive given the potential technical complexity of the device. Not only was the Smart Commuter test done before portable computing devices had achieved much market penetration, but project team interviews indicated that having two batteries and an FM receiver complicated use of the device.

Figure 5.12: Participant Evaluation of Magic Link™ Performance



[32] The term "perceived" is used because respondents were allowed to answer the questions without regard to whether they had actually used a medium or how frequently they did so. Indeed, other questions in the survey show that relatively few respondents used each of the information media. Therefore, these ratings are influenced by respondents who had little or no experience with a particular medium.

Figure 5.13: Participant Evaluation of IVR Telephone System Performance



Some concern might be raised by the fact that Usefulness of Information and Timeliness of Information were given the lowest performance ratings. One would hope that real-time traveler information would score higher in these categories. As discussed earlier in the report, however, those rankings could be affected by the fact that many users lived so far outside the information coverage area that pre-trip real-time information had a good chance of being outdated by the time they entered the coverage area. Note that, although some users may have used Magic Link™ as a mobile device, it was not intended for that use and there may have been problems associated with the FM reception since it was not designed to be used in a car.

Probably the most important statistic from the telephone system performance evaluation was the Unsure rating. Unsure responses accounted for 57 percent in the three performance categories of Reliability, Accuracy, and Timeliness. Ease of Use had the smallest share of Unsure responses, at 41 percent. This large block of undecided respondents is likely related to the fact that, according to the project team, relatively few participants actually used this component of the *Smart Commuter* information system.

5.2.3 Comparison to Other Information Media

Since the *Smart Commuter* project did not operate in a vacuum, it is useful to compare participants' attitudes toward other travel information sources that they were asked about in the post-test survey. The other media included were radio, television, newspaper, and the Internet.

In order to facilitate comparisons, an average performance rating for *Smart Commuter* and the other media was calculated by assigning a numeric value to each performance level. Thus, Very Good was given twice the value of Good, and Very Poor and Poor were given the negative values of Very Good and Good. The resulting values were:

Very Good, 2;

Good, 1;

Poor, -1; and

Very Poor, -2.

The Unsure rating was omitted but respondents could have selected it if they were truly neutral about a medium or if they had little or no experience with it. Both cases would tend to unnecessarily underrate performance. Since an Unsure response is still a valid indicator in its own right, Table 5.6 provides the percent of respondents who selected that rating for each of the traffic information media. The fact that the telephone system had the greatest share of Unsure responses is not surprising given the apparent fact that few *Smart Commuter* participants used it. Magic Link™'s 20 percent share seems reasonable both for its magnitude and the fact that it was second lowest behind radio.

Media	Percentage
Telephone System	40%
Newspaper	32%
Internet	29%
TV	23%
Magic Link™	20%
Radio	11%

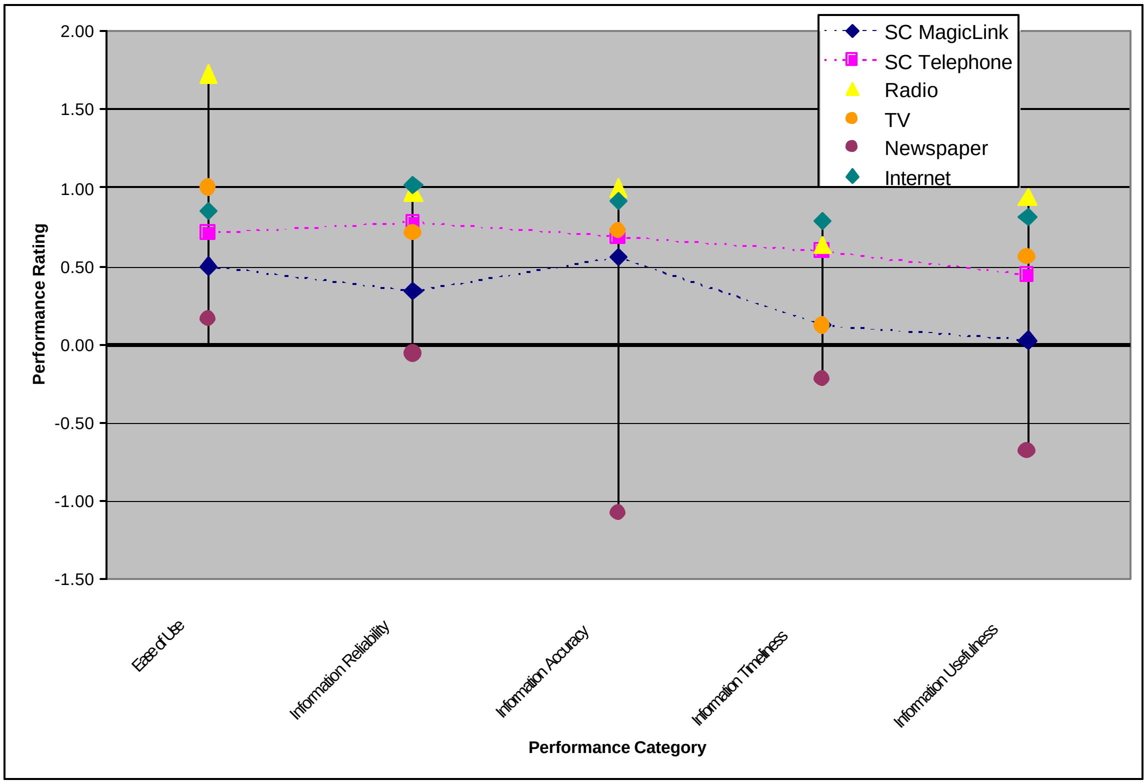
Table 5.6: Percent of Respondents Unsure of Media Performance

The average values (with Unsure omitted) thus provide comparable satisfaction ratings for each medium. This comparison is shown in Figure 5.14. The Y-axis of Figure 5.14 is the satisfaction rating derived from the performance values listed above and theoretically extends from +2.00 (Very Good) to –2.00 (Very Poor). Ratings around 0.00 are close to neutral, meaning that positive and negative ratings tended to offset one another. The X-axis lists the performance characteristic being rated.

Consistent with other research on ATIS services, radio generally received the highest ratings and newspaper was generally given the lowest performance ratings. Magic Link™ was rated second lowest in all performance categories.

Although telephone received higher ratings than Magic Link™, this is likely due to the fact that the high percentage of Unsure responses was removed before the ranking process, resulting in an artificially high rating. Nevertheless, the small number of participants that did have sufficient experience with the telephone system rated it higher than Magic Link™.

Figure 5.14: Comparison of Participants' Rating of *Smart Commuter* to Other Traveler Information Media



Figures 5.15 to 5.18 plot the performance ratings by both the participant and control groups for each information medium as the basis of comparing the two groups' satisfaction with each. Participant ratings are identified with a "P" and control group ratings with a "C" in the legend of each figure. The participants' performance ratings of Magic Link™ and *Smart Commuter* IVR telephone service are plotted on each graph for comparison purposes.

The main findings from Figures 5.15 to 5.18 include:

- Both the control and participant groups rated radio very similarly, and the highest among all media, including those of *Smart Commuter*;
- Participants generally rated TV much lower than members of the control group. Compared to participants, the control group rated television especially high in terns of accuracy and usefulness;
- Participants generally rated newspaper lower than the control group, with the biggest difference coming in information accuracy. Surprisingly, the participant group rated timeliness higher. Both groups rated newspaper lower than all other media, including Magic Link™ and the IVR telephone system; and
- Both test groups rated the Internet highly, with small differences depending on the performance category. In several categories, the Internet was rated as high as radio.

Figure 5.15: Comparison of Participant and Control Groups' Ratings of Radio Performance

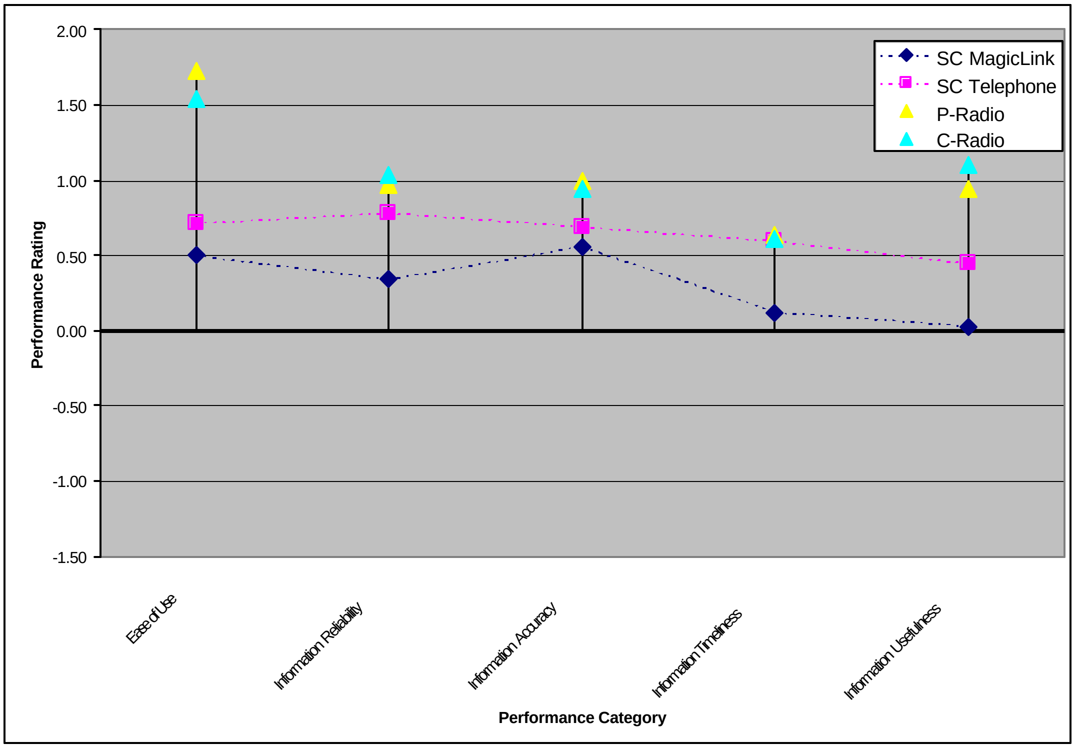


Figure 5.16: Comparison of Participant and Control Groups' Ratings of TV Performance

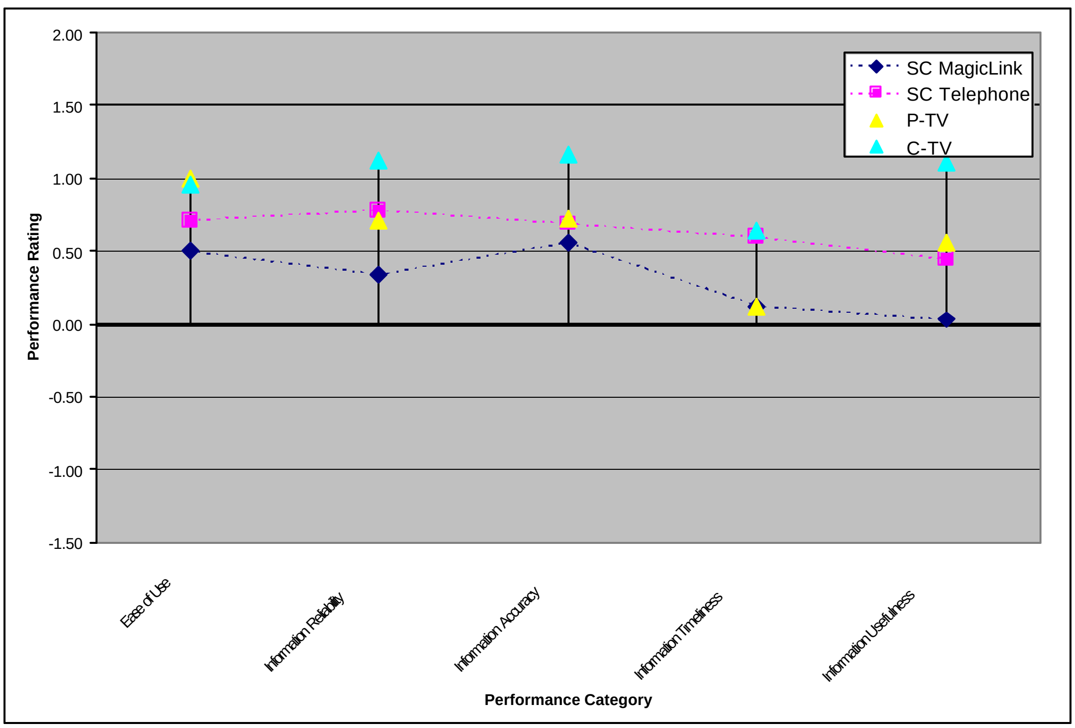


Figure 5.17: Comparison of Participant and Control Groups' Ratings of Newspaper Performance

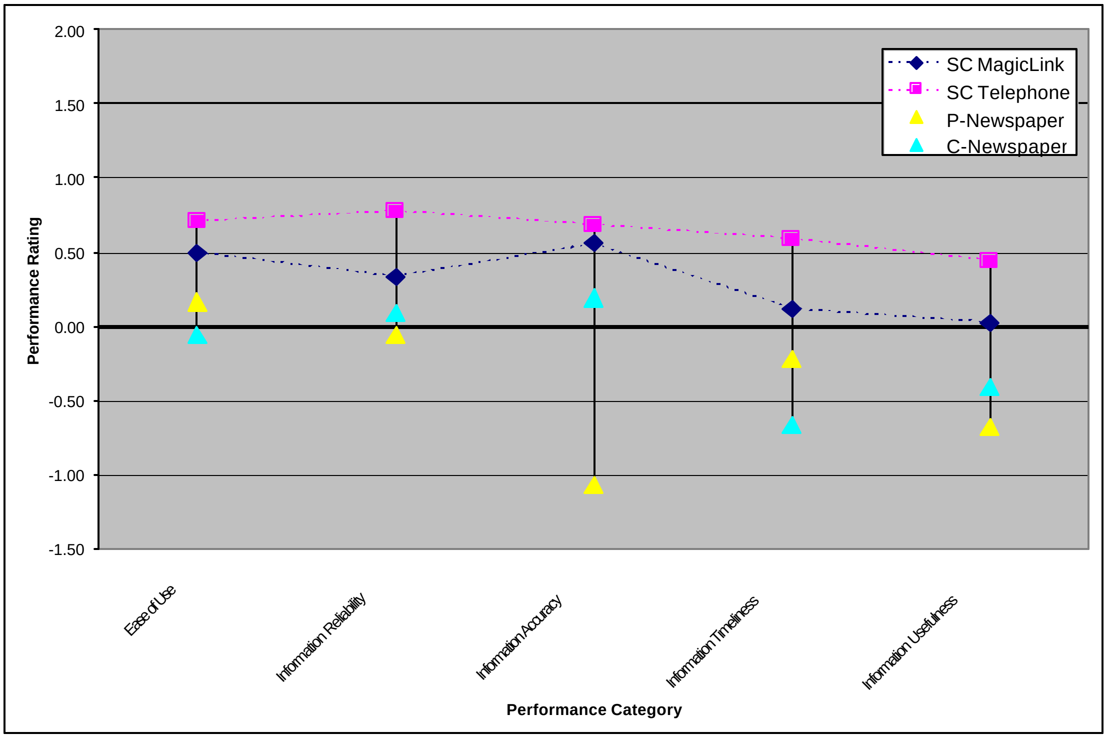
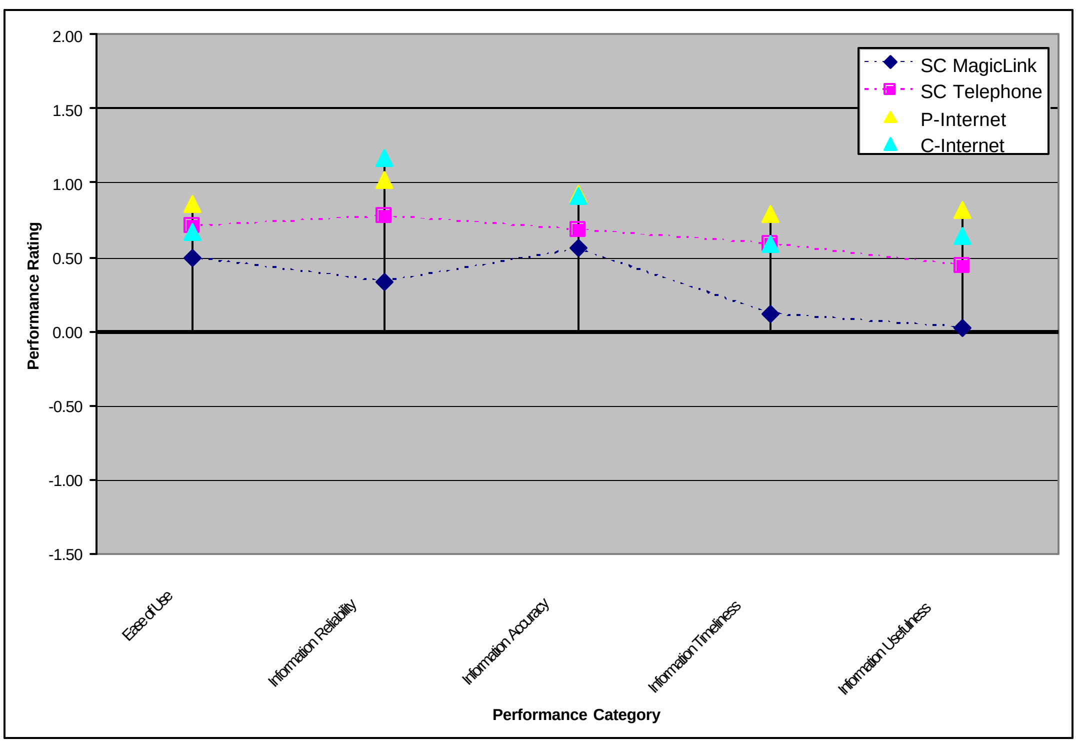


Figure 5.18: Comparison of Participant and Control Groups' Ratings of Internet Performance



While quantitative data are imperative for analyzing a field operational test, what participants say can provide useful input to the designers of future ATIS systems. Comments made by the participants in the user logs, surveys, and e-mails to the TTI help desk give a flavor of some specific reactions to *Smart Commuter*. A representative cross-section of comments from the e-mail information is shown in Table 5.7.

"I generally find it to be a bigger hassle than it is worth."
"Secure an AM or FM radio frequency and run continuous 'real-time' traffic reports on the entire city."
"The same level of data is available today by reading METRO's electronic billboards on I-45."
"It has not been used once by me…. It was obvious to me that the objective … was impractical with this device."
"The computer/radio is totally unreliable."
"I was leaving it on for my entire commute and it was dying about every two days."
"The information I get has no effect on my commuting mode, schedule or method."
"It is inconvenient to carry the unit with me … in addition to other items that I have with me."
"I have endless problems with the Magic Link™." (from February to October 1998)
"It has become more of an inconvenience than any benefit."
"I am also finding that the radio is as good and sometimes better than the computer."
"Have difficulty receiving info, both in office buildings and at home."
"I find that the data downloaded before my departure is outdated by the time I reach critical points in my travel route."
"The information on the Main Screen is becoming increasingly unreliable." (December 1997)
"The Internet info is more reliable to me than the TRW computer."
"The device …is too big, not very easy to read in the early morning, should be able to run off the car's 12 volt system, should have a stand/holder for the car, should have a lighted screen, should use FM to send in survey information, would be nice to have audio capability."
"You must deliver a significantly better product to capture a market... your competition is the radio stations that update traffic every 10 minutes and do not endanger the driver while delivering that information.
Despite the above comments, there were happy users:
"This '*Smart Commuter*' thinks the device is great and looks forward to continued usage."
"I have found the *Smart Commuter* very interesting."
"I have found the information to be pretty accurate and very useful."

Table 5.7: Sample Feedback from *Smart Commuter* Participants

5.2.4 Impacts on Participant Commuting Behavior

The major premise of the *Smart Commuter* project was to encourage different mode choices or other travel changes in response to receiving real-time data in a convenient manner. This section uses data from both the surveys and travel diaries to explore if and how participant travel behavior changed during the *Smart Commuter* test. Comparisons to the control group are provided as a frame of reference for the participant results.

Table 5.8 shows how frequently both the participant and control groups used three key travel modes - Drive Alone, Carpool/Vanpool, and Take Bus – with comparisons provided for the baseline and post-test surveys. As with other analyses earlier in the report, the participant group includes only the panel of persons who responded to both the baseline and post-test surveys. The control group includes all responses from both phases of the survey process. Unfortunately, the sizes of the resulting post-test data sets were small and detract from the confidence one can have in the conclusions.

Behavior	Frequency	***Participant Group (Panel)***		***Control Group***	
		Baseline (n=273)	**Post-test** (n=99)	**Baseline** (n=466)	**Post-test** *(n=61)*
Drive Alone	Always	75%	76%	88%	86%
	Occasionally	24%	22%	11%	10%
	Never	1%	2%	1%	3%
Carpool/Vanpool	Always	16%	15%	9%	10%
	Occasionally	37%	31%	21%	27%
	Never	46%	54%	70%	63%
Take Bus	Always	6%	8%	4%	12%
	Occasionally	29%	28%	12%	15%
	Never	65%	64%	85%	73%

Table 5.8: Comparison of Participant and Control Group Mode Choice During Project Period

There are several noticeable differences in Table 5.8 that are presented graphically in Figures 5.19 to 5.21. First, the participant group was initially somewhat less likely to drive alone and more likely to take the bus or carpool/vanpool than the control group (Figures 5.19 and 5.20). This behavior pattern among participants changed little from the baseline to the post-test survey, with the exception of an apparently significant shift from occasionally to never carpooling (Figure 5.20). Second, the control group exhibited a shift towards taking the bus while the participant group did not, in an apparently counterintuitive outcome (Figure 5.21). However, the small number of individuals in each of the cells in Table 5.8 limits the ability to draw conclusions with an adequate level of confidence. For example, the 8 percent increase in the control group always taking the bus consists of only five individuals.

Figure 5.22 plots a comparison of the changes over the course of the test as the percentages of each group choosing each mode. The numbers used for this comparison are derived from Table 5.8. (Note that positive and negative percentages do not necessarily correlate with “positive” or “negative” results. The reader must look at the mode and frequency categories to make this interpretation. For example, the 1.0 percent increase in the participant group always driving alone would not be a positive development, while the 1.0 percent decrease in the participant group never taking the bus would be.)

Table 5.9 shows the distribution of how frequently participants changed their travel behavior *due to specific information from Magic Link™*. (Note that interpreting these results is difficult because the terms frequently and infrequently were not defined quantitatively.) Even though the control group did not use Magic Link™, their behavior changes due to other information media are included for comparison purposes.

Figure 5.19: Comparison of Participant and Control Group Mode Choice: Drive-Alone

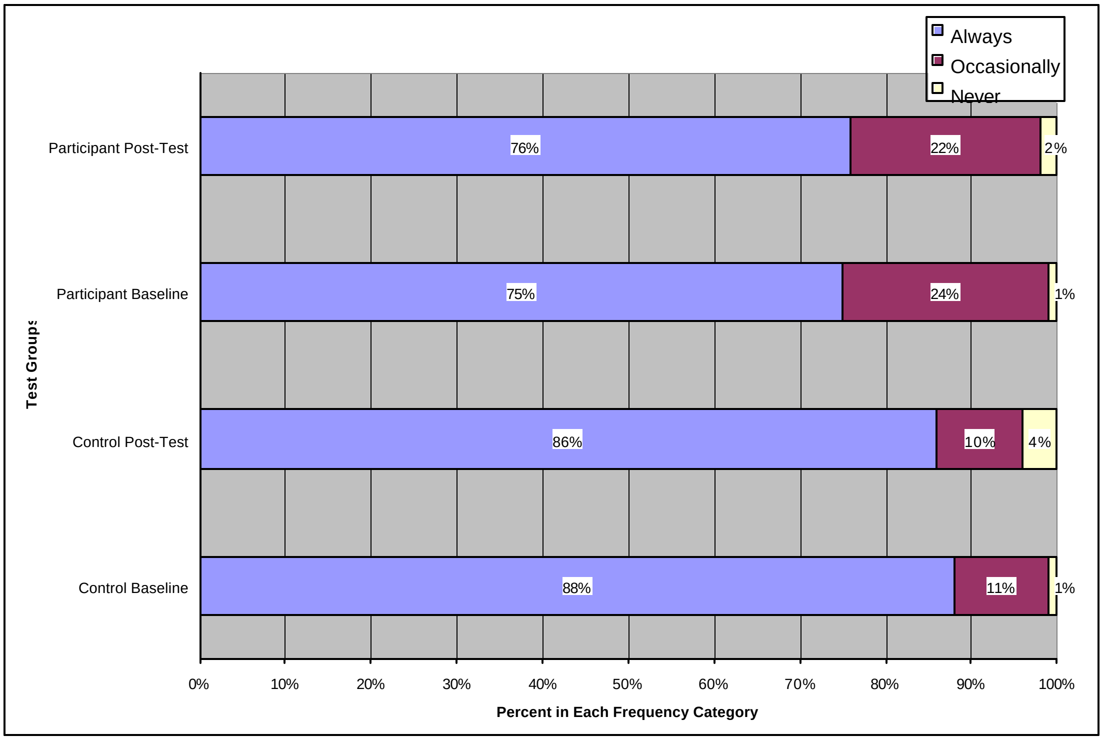


Figure 5.20: Comparison of Participant and Control Group Mode Choice: Carpool/Vanpool

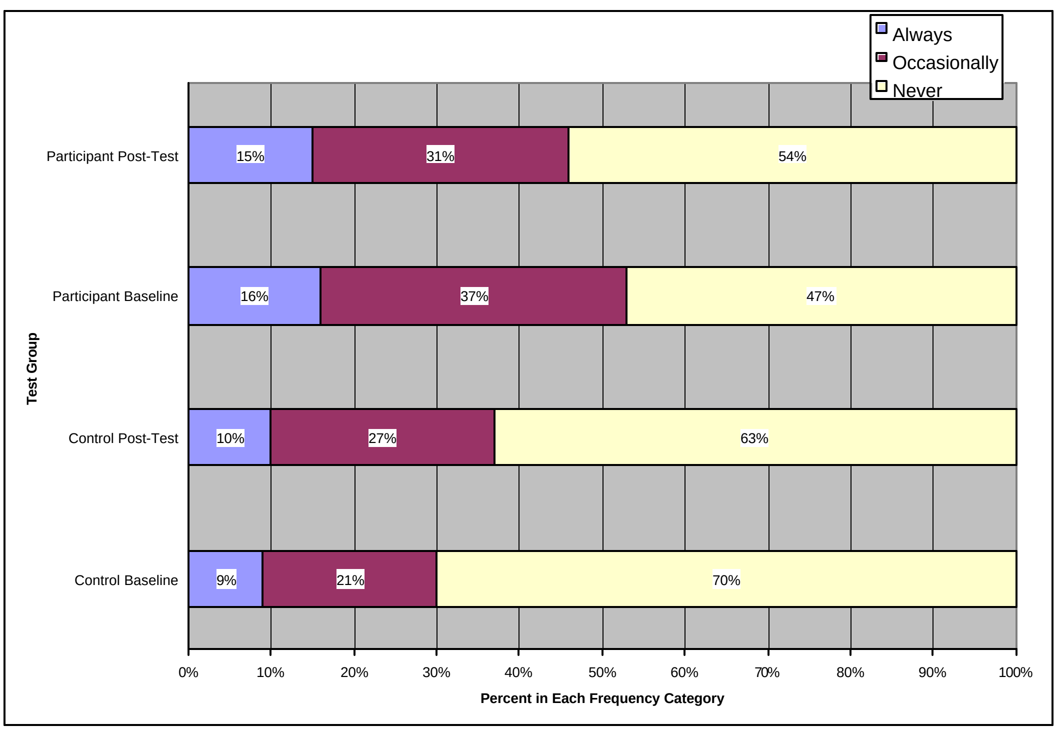


Figure 5.21: Comparison of Participant and Control Group Mode Choice: Take Bus

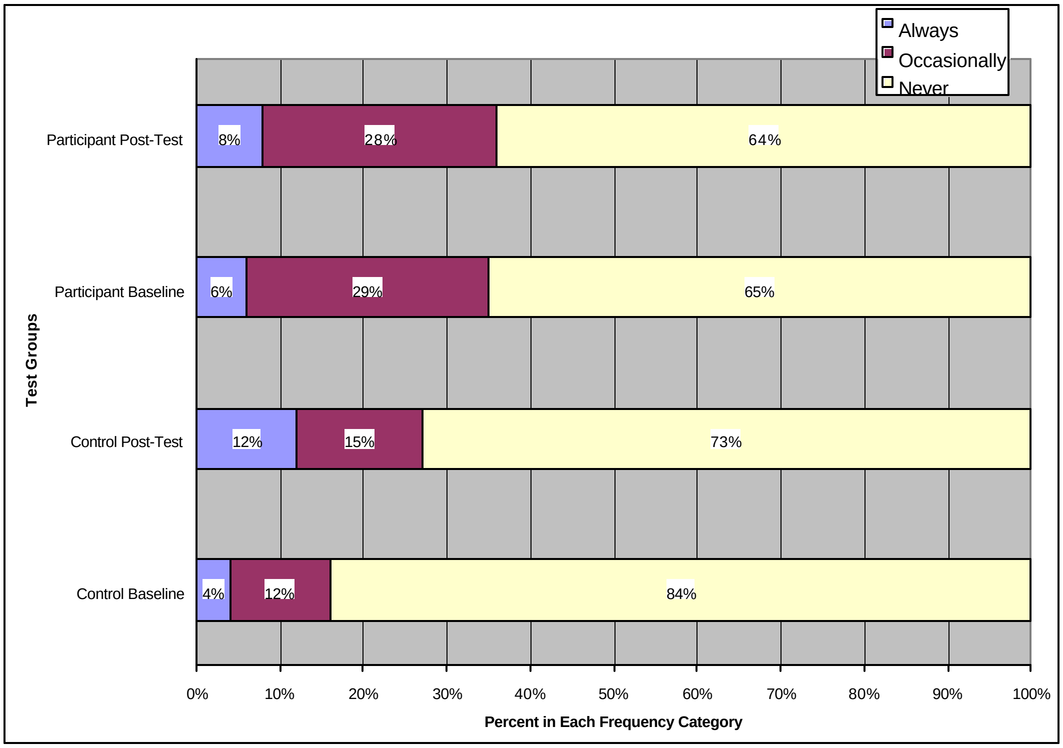
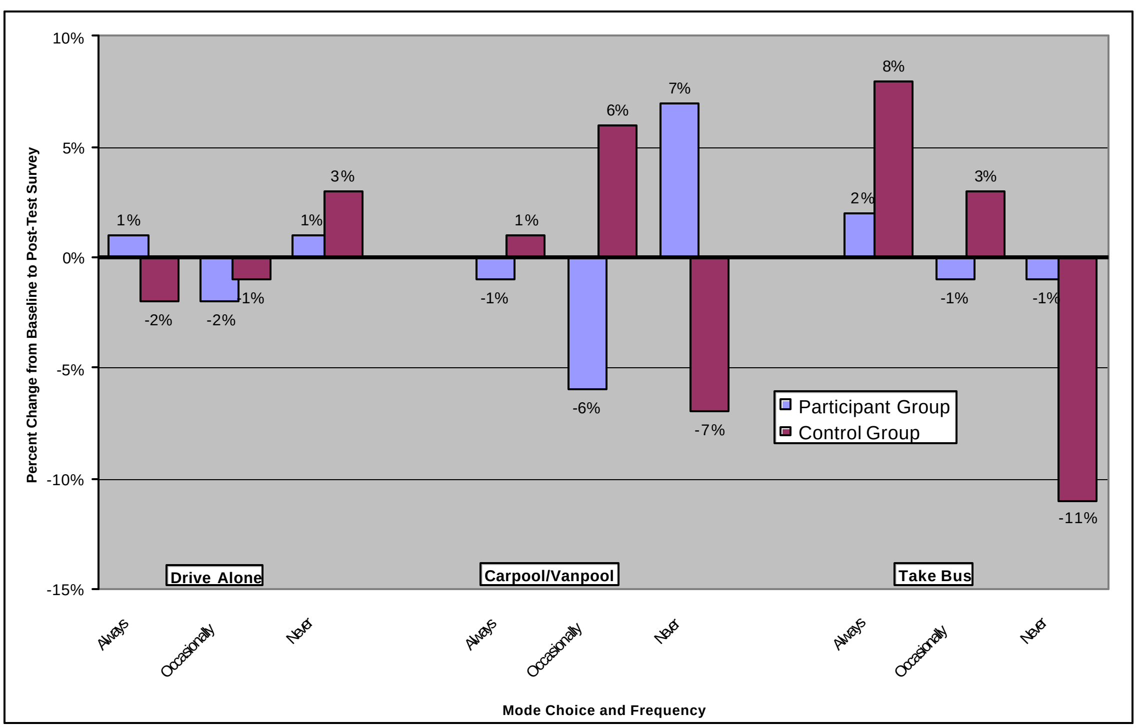


Figure 5.22: Comparison of Participant and Control Group Mode Choice: Change in Behavior from Baseline to Post-Test



Response	Participant Group	Control Group
Yes, Frequently	14%	35%
Yes, Infrequently	50%	50%
No	35%	8%

Table 5.9: Percent Change in Reported Travel Behavior of Participants and the Control Group

Interestingly, a much larger proportion of the participant group reported never making changes (i.e., the “No” response) and a larger proportion of control group members reported frequently making travel behavior changes (i.e., the “Yes, Frequently” response). One possible reason for this disparity is that, with the high attrition rate of control group members, those that continued for the entire two-year control period may have had characteristics that disposed them to changing their travel behavior more frequently than members of the participant group. However, the participant panel likely has its own built-in biases given the sampling strategy described earlier in the report.

The next logical question is: When participants (as a result of using Magic Link™) or the control group made changes in travel behavior, did they switch mode or make some other change? Figure 5.23 compares this aspect of travel behavior change, without regard to the frequency of the change. Note that these were multiple response questions and the percentages shown are based on the total number of responses rather than respondents.

Overall, the figure shows a reasonable similarity between behavior of the participant and control groups.

5.2.4.1 Traffic Information Media Used

Figure 5.24 shows the percentage of control and participant group respondents to the final travel diary that checked each traffic information medium before or during their commute. Because the data source is the travel diary, the percentages are based on the total trips recorded rather than individuals. It is likely that the travel diaries are more accurate records of behavior than the retrospective survey, except that the survey presumably reflects behavior over a longer time period.

As expected, radio is the most popular and newspaper the least popular. (Because the question was multiple response, the percentages do not add up to 100.) On average, therefore, participants and the control group consulted approximately 1.15 media per trip.

When the travel diary data were analyzed further, it showed that, in approximately 17 percent of trips where Magic Link™ was used, a change in travel behavior based on that information was also reported. Note, however, that this is based on only 13 (of 74) trips.

5.2.4.2 Impact on the Commute Experience

Respondents were asked several questions about the impact that the resulting travel behavior changes had on their commute experience. Both the participant and control groups were asked about a number of “quality of trip” characteristics. Since the number of responses was so low on most questions, only a comparison of whether the

Figure 5.23: Comparison of Types of Travel Changes in the Past Year Reported by Participants (Due to Magic Link™) and by the Control Group

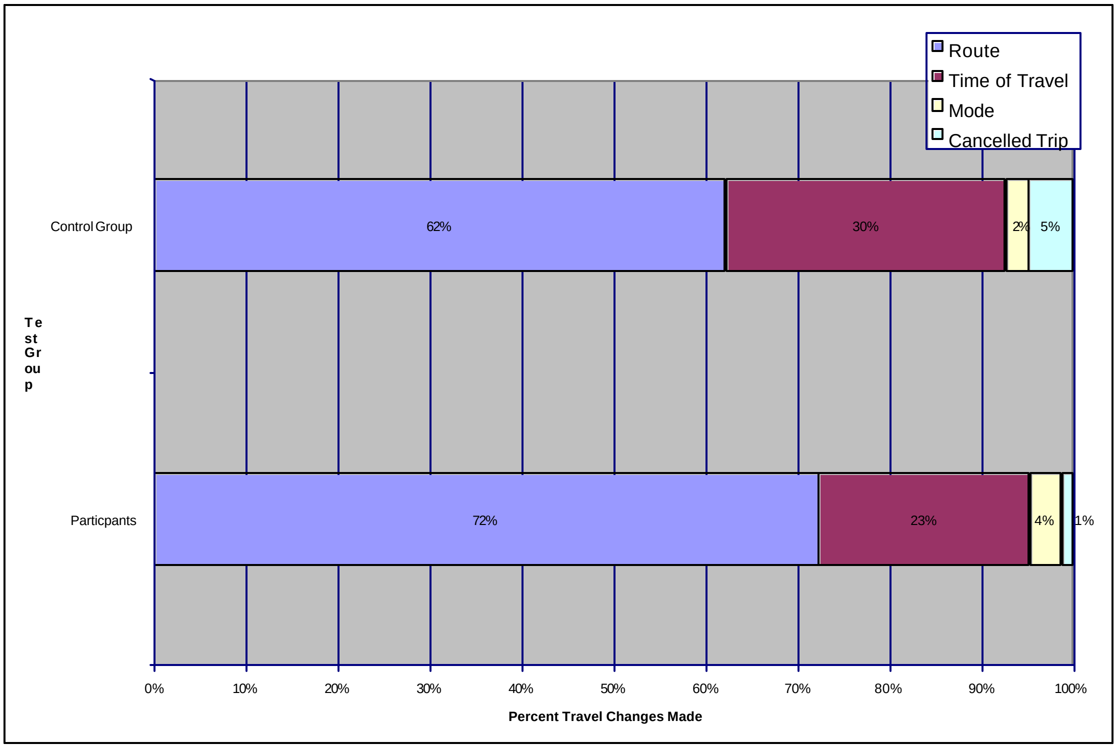
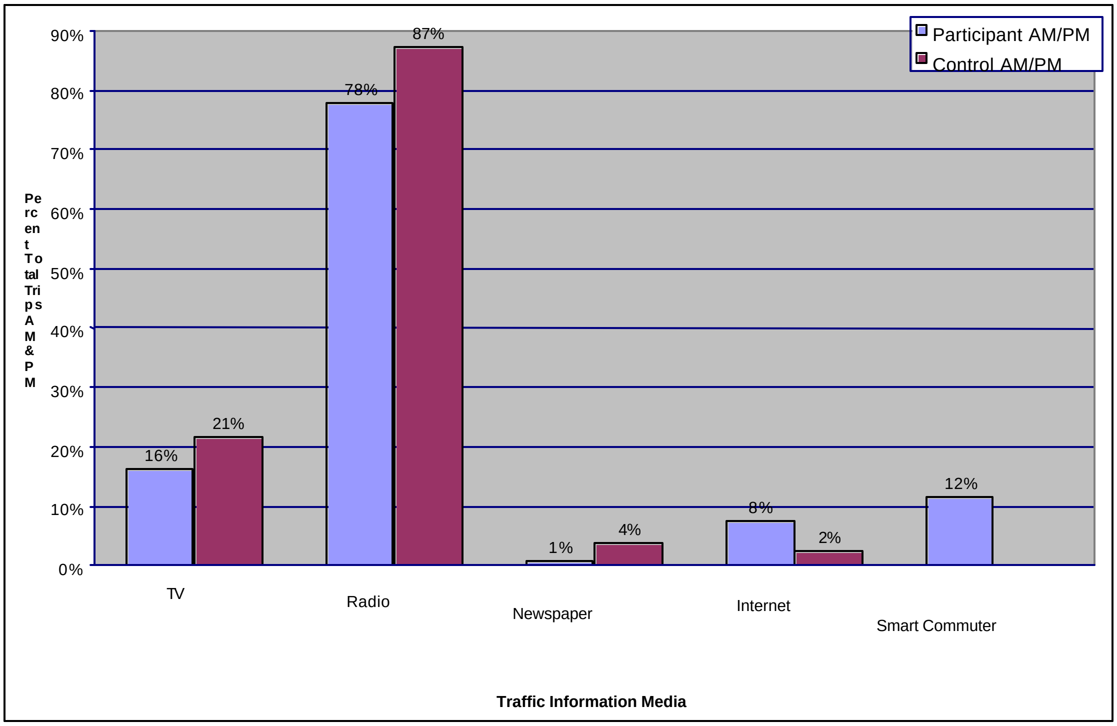


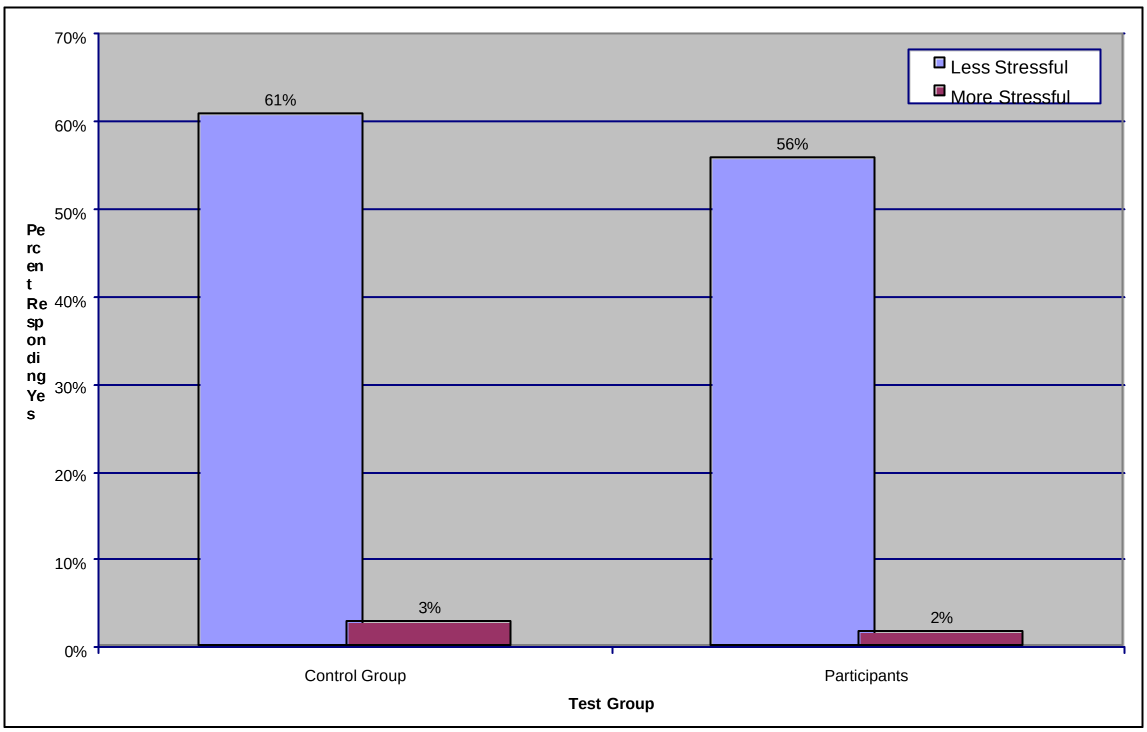
Figure 5.24: Comparison of Media Checked Before or During Commute by Participant and Control Group



respondent's modified trip saved them time or was more or less stressful are included in this analysis. The average time reportedly saved by participants from making a change based on *Smart Commuter* information was 16 minutes (n=26), compared to 15 minutes (n=18) for changes made by the control group based on any travel information, an apparently insignificant difference.

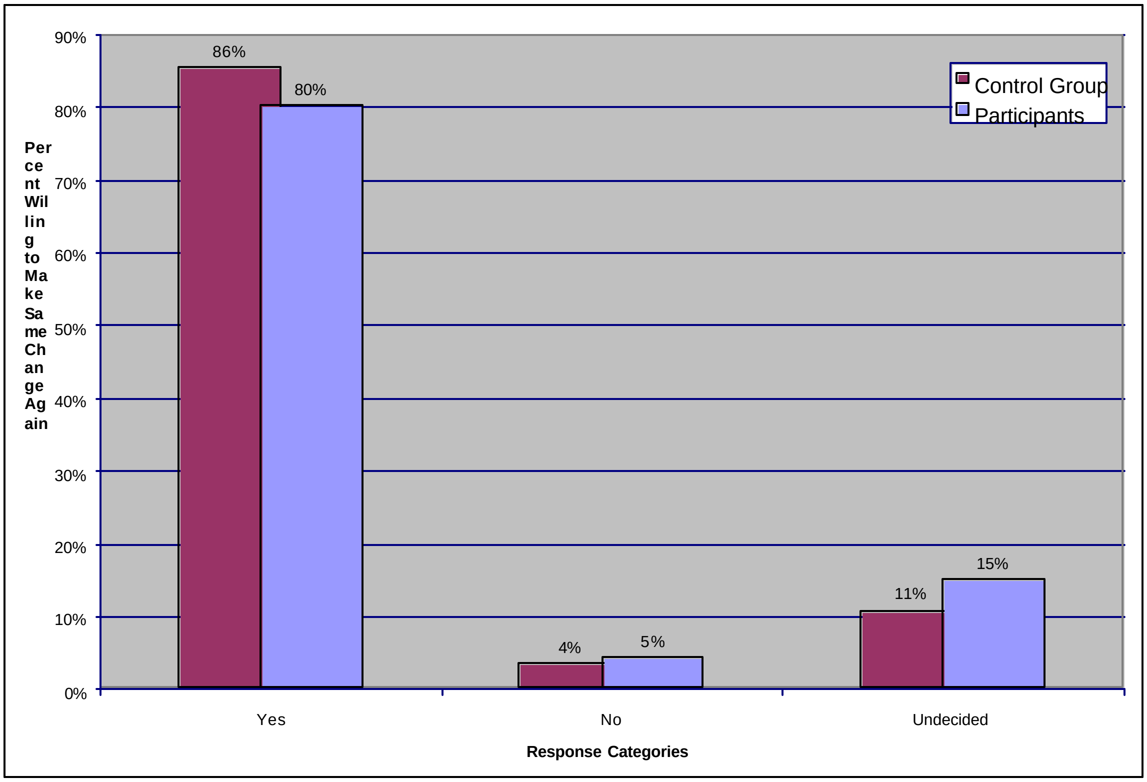
Figure 5.25 shows the comparison of how travel behavior changes affected the stress levels of participants and the control group. Overwhelmingly, participants indicated that the travel change made in response to *Smart Commuter* information reduced their stress (56 percent, n = 50), but so did the control group (61 percent, n = 37). While one might have expected that the quality of information provided by Magic Link™ would have reduced participants' stress more than control group commuters, the statistics do not bear this out.

Figure 5.25: Comparison of Stress Level Impacts due to Travel Changes in Response to Traffic Information - Participants vs. Control Group



When asked whether (based on their experience with *Smart Commuter* and/or other information media) they would make the same travel change given the same information in the future, the responses of the participant and control groups were about the same. As can be seen in Figure 5.26, 80 percent of the participants (53) answered yes, 5 percent said no (3), and 15 percent were undecided (10). Among the control group, 86 percent answered yes (47), 4 percent responded no (2), and 11 percent were undecided (6).

Figure 5.26: Comparison of Whether Travelers Would Make Same Change Again Based on Experience



If *Smart Commuter* information were perceived by participants as superior in accuracy or benefit, one would expect to see a relatively higher percentage of affirmative responses from the participant group than the control group and fewer "Undecided" responses in Figure 5.26. However, this was not the case.

A final measure of customer acceptance is willingness to pay for a traffic information service. In the post-test surveys, both the participant and control group were asked if they would be willing to subscribe to a service providing current traffic information at reasonable cost. Table 5.10 compares the responses of the two groups.

Response	Participants	Control
Yes (responses)	39% (41)	24% (14)
No (responses)	61% (65)	76% (44)
n=	109	61

Table 5.10: Comparison of Participant and Control Group Willingness to Pay

Almost 40 percent of the participants who responded to the question said they would be willing to pay for such a service. This is a substantial percentage, especially in light of the variety of difficulties the participants faced during the *Smart Commuter* operational test. This result is strengthened by the fact that the participant group was more likely (39 percent vs. 24 percent) than the control group to say they would pay for a traffic information service. The average amount participants indicated they would be willing to pay *per month* was approximately $9.50 (based on 25 responses, or 23 percent of the question respondents).

5.3 Quantitative Evaluation Findings and Conclusions

Analysis of the respective demographic and commuting characteristics of the participant and control groups suggested that the two were quite similar and provided a reasonable basis for comparison and contrast. Also important was the relatively similar mode choice characteristics found in the pre-implementation (baseline) travel diaries.

Measuring the usage patterns of Magic Link™ was possible because of the user log files maintained on each device. The analysis used only data from the second participant group because it was decided this would reflect relatively stable operation of the *Smart Commuter* system.

Findings and conclusions from the use and acceptance analyses included the following:

- The TranStar Main Screen was used the most by a large margin due to the fact that it was not only the default screen but also provided real-time traffic information that may have been sufficient for some users and purposes. The information on other *Smart Commuter* screens may appear to have been less important to participants than it actually was. In particular, the real-time traffic screens may have logged less time because sufficient information was available on the TranStar Main Screen.
- Even excluding the use of the TranStar Main Screen for traffic information, the Traffic Information functional group provided the most popular *Smart Commuter* information.
- As expected, the usage logs showed a bi-modal pattern of use centered on the morning and afternoon rush hours. In addition, there was substantial use during the middle of the traditional nine-to-five workday. Both the participant and control groups were about equally likely to check traffic information before or during the morning or afternoon commute, with a noticeable percentage more likely to check in the morning. There are some hypotheses that could explain the less pronounced peak during the afternoon commute, none of which could be tested with the available data. Perhaps more participants check *Smart Commuter* in the morning because getting to work late has more consequences that getting home late. Also, anyone who chose to park and ride in the morning would have no mode choice to make in the afternoon and less interest in the travel times on the SOV lanes which would be most likely to vary.
- The Mode Choice group was minimally used relative to other Magic Link™ functions. One possible explanation for this is that all of the transit data were static and were only updated periodically when participants logged into the *Smart Commuter* server. This is noteworthy since encouraging participants (who were primarily SOV commuters) to change modes was a key objective of the operational test.

- User logs indicated that use of the Other Magic Link™ Features was surprisingly high, and does not jibe with the survey results, which indicated very little use of these non-*Smart Commuter* screens.
- The relatively high usage of the travel diary screen may suggest that it required more time than anticipated to keep up with the required data collection.
- The patterns of system use seem to indicate that *Smart Commuter* was generally used in a way that the project team would have hypothesized, save the anomalies previously noted. Any similar operational tests done in the future may want to explore the seeming lack of interest in Mode Choice information and the pattern of attrition.
- There was a steady, dramatic decline in Magic Link™ use over time after substantial activity during the first full month of the second participant group test period. Despite the declining participation, the average number of user sessions per continuing participant per day remained relatively stable.
- Around 50 percent of participants rated the performance of *Smart Commuter* via Magic Link™ as good or very good. The device (and the information it provided) was rated highest in Ease of Use. The Ease of Use rating was surprising considering comments from the project team and participants that indicated the Magic Link™ setup was somewhat complicated. The fact that Information Timeliness and Information Usefulness were the two lowest performance categories indicate that *Smart Commuter* did not always provide accurate, real-time information as it was designed to do. Issues that make these results harder to interpret were that survey respondents may have had trouble differentiating 'accuracy' from 'reliability' since the terms were not specifically defined and reliability of the device was not distinguished from reliability of the information.
- Ratings of the IVR telephone system were not very useful given that the service was used very infrequently compared to Magic Link™. This was evidenced by the fact that over 50 percent of participants selected the Unsure rating for all but one performance category.
- The participants' and the control group's ratings of the non-*Smart Commuter* information media were generally consistent with one another. Both rated radio the highest and newspaper the lowest. Participants' rating of Magic Link™ beat only the newspaper.
- Since Magic Link™ provided virtually the same information as the Houston Real-time Traffic Information on the Internet,[33] the fact that the Internet received the second highest overall rating may suggest that the nature of information provided by Magic Link™ was viewed favorably. If that were the case, other factors not captured in this analysis would be responsible for Magic Link™'s lower rating. In other words, the higher rating of the Internet could be due to unique characteristics of the medium and not the information provided.

[33] This point was confirmed by the project team interviews. The Web page is located at http://traffic.tamu.edu/incmap.asp. However, note that the Web page has changed since the *Smart Commuter* project ended.

- Participants' propensity in the post-test survey to take the bus was only slightly higher than the baseline suggests mode choice change, which had been anticipated by the project team, did not occur. Interpretations of these data could be considered somewhat unreliable because of the small numbers of respondents in each response category.

- The fact that a greater percentage of participants than the control group made route changes could be due to the fact that *Smart Commuter* provided specific congestion and incident information that a commuter would need to make this type of decision. This would tend to support the original *Smart Commuter* hypothesis that commuters will make changes in response to accurate and timely information. However, another reason could be that those who were inclined to make route changes were more likely to perceive benefits from *Smart Commuter* and were more likely to remain an active participant throughout the project. Those who were less likely to make route changes may have dropped out, thus biasing the results.

- Given the newness of *Smart Commuter*, and some of the lower than expected ratings of *Smart Commuter* , its use in 12 percent of commute trips seems reasonably good.

- Encouragingly, approximately 80 percent of participants said they would make the same travel changes again based on their experience. The fact that almost 40 percent of participants said they would be willing to pay for a traffic information service even with the difficulties encountered during the *Smart Commuter* operational test, is substantial. If one assumes that the service the participants envisioned when answering the question resembled Magic Link™, as it was the service they were most familiar with, that result is even more significant.

6. LESSONS LEARNED FROM THE *SMART COMMUTER* OPERATIONAL TEST

Typical of new systems and technologies, the *Smart Commuter* project was a challenging operational test. Overall, the public and private sector project team overcame a host of obstacles, and therefore, enabled the national evaluators to put together a list of lessons learned and recommendations that should add to the body of knowledge about ITS technologies and systems.

6.1 Design Lessons

Because of the extended planning and design horizons required by many ITS operational test and deployment projects, ATIS systems such as Houston *Smart Commuter* have difficulty responding to the rapid changes in technology. The relatively slow deployment pace of these projects would be more manageable if ATIS contracts made provisions to modify or update technologies as they become available over time.

In the case of *Smart Commuter*, the initial project concept changed little once the procurement process started, but advances in handheld computing technology and the growth of the Internet made the Magic Link™ concept less consistent with consumer expectations by the time the project was actually underway. Note, for example, that the Internet received higher performance ratings than Magic Link™.

Development in the ATIS market itself, toward in-vehicle devices for en-route traveler information, may have made the functional specifications used for the *Smart Commuter* procurement too limiting. The specifications did not envision a device for en-route use in a car (and the project team expressly cautioned participants not to use Magic Link™ as a mobile device). The fact that radio is typically rated highly as a traffic information medium, despite some obvious limitations, may have indicated that an in-vehicle device would have been better received by users.

Some of the Magic Link™ design choices turned out to be limitations. In particular, the decision to use the lower-cost, two media communications approach (i.e., wireless for transmission of real-time data to participants and wireline connection for uploading of surveys and diaries and downloading of static transit schedule data) may have complicated the system for users. Technical problems with both seemed to have magnified the barriers to participation. Also notable was the use of two different types of rechargeable batteries, which turned out to be less than user-friendly for participants.

While AVI was a central component of the real-time traffic information provided by *Smart Commuter*, the quality of information from the AVI system was less than optimal. Future applications of this technology for the same purpose must ensure that the source of information is reliable and accurate (e.g., that there are a sufficient number of AVI tags in use and that spacing of detectors is adequate).

6.2 Procurement and Contracting Lessons

Perhaps some of the adverse impacts of early design decisions and operational factors that might affect projects like *Smart Commuter* in the future could be addressed by changes to the procurement and contracting approach. One aspect to consider is the type of procurement rules that work best for this type of contract. More specifically, low bid procurement may not be the most appropriate given that higher bids may provide more reliable technology alternatives.

Specifications in the RFP should explicitly recognize the changing technological landscape. The resulting contracts should take advantage of emerging technologies. Given the generally long deployment period for ITS projects, the public sector should ensure contractually that it will benefit if technology advances so that operating tests are not conducted with outmoded devices and software. The major constraint on achieving this are the fixed budgets used for these projects, which may not have the necessary slack to incorporate typically more expensive systems and components.

6.3 Deployment and Operations Lessons

A system should not be put into operation before it is actually ready for deployment to users. Acceptance procedures should not only rigorously test the user components and central system, but must ensure that the data and information being collected, processed, and disseminated are as accurate, timely, and reliable as possible. A few shortcomings in this area can quickly lead to participants losing confidence and continuing to rely on the information media they are accustomed to, even if the potential of real-time information would be greater.

In ITS operational tests requiring participant and control groups, recruitment and retention of these individuals is crucial for evaluation purposes. The evaluation of a project will be compromised to the extent that the control or participant groups are too small and/or suffer substantial attrition. With *Smart Commuter*, it appears that the initial participant training was not sufficient for the level of technical competence of the participant group. Some participants were reported to have dropped out right after the training session. Initial participants may have also quit once they realized how much time it would take to perform tasks related to the evaluation, such as filling out the quarterly travel diaries.

An operational test project team should anticipate and prepare for initial problems right after deployment so that user assistance is sufficient to maintain participation levels and public confidence. In a project of this nature, it is imperative to provide quick help to users encountering difficulties.

6.4 Project Management Lessons

Continuity in project management on the part of both the public and private sectors is important. While controlling turnover on a project that extended as long as *Smart Commuter* would be difficult, the lack of continuity appears to have had multiple impacts on the project.

Management by technically qualified people with sufficient dedicated time for the project is also critical. In the case of *Smart Commuter*, having both wireless and wireline communications expertise may have helped avoid, or at least quickly resolve, communications problems. Lack of expertise on the project team in essential technical fields may have contributed negatively to the outcome of the project.

In operational tests, user participation and related data collection and analysis should be considered a central project management concern. Requiring test participants to complete quarterly travel diaries may have been excessive and led to attrition. In hindsight, linking of travel diary data collection to the *Smart Commuter* Magic Link™ device was not optimal. The project team seemed to have somewhat better response to paper survey instruments.

Since operational tests involve extensive data collection, management should not overlook the potential of using this information flow as a way of detecting operating problems before they surface as major issues with users. It appears that some of the data, such as the Magic Link™ user logs, could have been monitored regularly to quickly identify, quantify, and respond to possible problems.

6.5 Conclusion

Although technical problems, participant and control group attrition, external influences, and problems with evaluation data quality hampered the Smart Commuter operational test in the achievement of its hoped for results, the public sector believes the project enhanced its understanding of what consumers want. Although METRO has no plans to continue the *Smart Commuter* project or reengineer it, the agency is interested in applying pager technology to ATIS based on its experience with *Smart Commuter*.

Both the public and private sector members of the project team concluded that the public sector needs to partner with the private sector to make travel information available to the public. Both parties bring specific skills and resources that neither has alone.

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APPENDIX B. NATIONAL APTS OBJECTIVES

The first national objective relates primarily to improving the transit service provided to riders.

- Enhance the quality of on-street service to customers
    1. Improve timeliness and availability of customer information;
    2. Increase convenience of fare payments;
    3. Improve safety and security;
    4. Reduce passenger travel time; and
    5. Enhance opportunities for customer feedback.

The second national objective concentrates primarily on the internal management of transit, (although such improvements can result in changes to transit service provided to riders).

- Improve system productivity and job satisfaction
    1. Reduce transit system costs;
    2. Improve schedule adherence and incident response;
    3. Increase usefulness of data for service planning and scheduling;
    4. Enhance response to vehicle and facility failures;
    5. Improve information management systems and management practices; and
    6. Reduce worker stress and increase job satisfaction.

The third national objective deals with broader community and national goals.

- Enhance the contribution of public transportation systems to overall community goals
    1. Provide discount fares to special groups;
    2. Improve communication with users having disabilities;
    3. Enhance the mobility of users with disabilities;
    4. Increase the extent and effectiveness of Transportation Demand Management (TDM) programs;
    5. Enhance HOV systems by reducing Single Occupancy Vehicle (SOV) use; and
    6. Assist in achieving air quality and energy goals and mandates.

The fourth objective relates to expanding the knowledge base of individuals who are interested in the application of advanced technologies to improve public transit, including both individuals in the public transit field and those outside the field.

- Expand the knowledge base of professional personnel concerned with APTS innovations
    1. Conduct thorough evaluations of operational tests;
    2. Develop an effective information dissemination process;
    3. Showcase successful APTS innovations in model Operational Tests; and
    4. Assist system design and integration.

QUICK FAHRENHEIT - CELSIUS TEMPERATURE CONVERSION

°F	-40°	-22°	-4°	14°	32°	50°	68°	86°	104°	122°	140°	158°	176°	194°	212°
°C	-40°	-30°	-20°	-10°	0°	10°	20°	30°	40°	50°	60°	70°	80°	90°	100°

For more exact and or other conversion factors, see NIST Miscellaneous Publication 286, Units of Weights and Measures.
Price $2.50 SD Catalog No. C13 10286

Updated 6/17/98

APPENDIX C. BEFORE TRAVEL SURVEY—TEST PARTICIPANTS AND CONTROL GROUP MEMBERS

I-45 NORTH FREEWAY
TRAFFIC INFORMATION SURVEY

Thank you for participating in this very important study. As a traveler on the I-45 North Freeway, please complete this survey and the attached travel diaries for the week of **November 18-22, 1996**.

Home Zip Code________________

Work Zip Code_________________

1. How often do you use the following modes of transportation for commuting to or from work?

	Always or Almost Always	Occasionally	Never
a. Drive alone	‘ 1	‘ 2	‘ 3
b. Carpool	‘ 1	‘ 2	‘ 3
c. Vanpool	‘ 1	‘ 2	‘ 3
d. Ride the bus	‘ 1	‘ 2	‘ 3
e. Other (Specify) ______________________	‘ 1	‘ 2	‘ 3

2. Are you aware of a Park & Ride bus lot located near your home? ‘ 1 Yes ‘ 2 No

2.1 Which Park & Ride bus lot is nearest your home? ___________________________________

2.2 How familiar are you with the following features of Park & Ride bus service?

	Very Familiar	Somewhat Familiar	Not At All Familiar
a. Schedule	‘ 1	‘ 2	‘ 3
b. Bus stop locations	‘ 1	‘ 2	‘ 3
c. Cost	‘ 1	‘ 2	‘ 3

3. What are your work hours and schedule? (Check all that apply, indicate hours, and circle a.m. or p.m.) If you work full-time or part-time, circle which days of the week you work.

	HOURS	**SCHEDULE (Circle all that apply)**
‘ 1	Full-time. Hours are from __:__ a.m./p.m. to __:_ a.m./p.m. (Circle One)	Mon. Tues. Wed. Thur. Fri. Sat. Su (Circle One)
‘ 2	Full-time. Hours are irregular.	
‘ 3	Part-time. Hours are from ___:__ a.m./p.m. to ___:__ a.m./p.m. (Circle One)	Mon. Tues. Wed. Thur. Fri. Sat. Sun. (Circle One)
‘ 4	Part-time. Hours are irregular.	
‘ 5	Student. Attend school (*Circle One*): Full-time or Part-time	
‘ 6	Other (*Specify*): ______________________________________	

4. On an average workday, how many minutes do you spend commuting one-way? ________

5. How many miles, one-way, is it from your home to work location? _________

6. Which of the following would influence your commuting habits? (*Check all that apply*)

Bus Service

‘ 1 More information regarding bus routes
‘ 2 Late evening bus service
‘ 3 None, I already ride the bus on a regular basis
‘ 4 Your employer paying a portion of your bus pass
‘ 5 None, nothing would influence me to ride a bus

Carpool-Vanpool

‘ 1 Free matching with other convenient car/vanpoolers
‘ 2 Vehicles at work available for midday business trips
‘ 3 Employer paying a portion of your vanpool seat (vans only)
‘ 4 None, I already car/vanpool on a regular basis
‘ 5 Preferential parking at work
‘ 6 Access to HOV Lanes
‘ 7 None, nothing would influence me to car/vanpool

General

‘ 1 Guaranteed ride home for emergencies/overtime
‘ 2 Increased parking costs which I would have to pay
‘ 3 Variable/flexible work hours
‘ 4 Midday shuttle service to restaurants/shopping
‘ 5 Other: ______________________________

7. If you drive alone to work, what are the two most important reasons you do so? (*Check 2*)

- ₁ Can't find anyone to ride with
- ₂ Need car for work during day
- ₃ Need car before/after work for errands
- ₄ Enjoy my privacy, do not care to share a ride
- ₅ Need car to take/pickup child to/from child care
- ₆ Work schedule doesn't permit sharing a ride
- ₇ Need car in case of emergencies
- ₈ Other: ___________________________

8. How many passenger vehicles does your household own or have available for use? ____

9. How many individuals, including yourself, are 16 years old or older in your household? ____

10. For your trip to/from work, do you regularly seek out traffic or transit information from the following? (*Check all that apply*)
    - 1 Radio
    - 2 Television
    - 3 Newspaper
    - 4 Internet
    - 5 Do not seek out traffic or transit information

    10a. When do you normally seek out this information? (*Check all that apply*)
    - 1 Before leaving for work
    - 2 On my way to work
    - 3 At work before leaving to go home

    10b. How important is availability of traffic information in your choice of a radio station or television station?
    - 1 Very Important
    - 2 Somewhat Important
    - 3 Somewhat Unimportant
    - 4 Not Important At All

11. Does your employer provide any of the following commuting benefits? (*Check all that apply*)
    - 1 Free parking
    - 2 Subsidizes bus passes at $_______ per month
    - 3 Subsidizes vanpool seat at $_______ per month
    - 4 On-site bus pass sales
    - 5 Guaranteed emergency ride home
    - 6 Other: ___________________________

The last few questions are for statistical purposes only to ensure a representative sample of survey participants.

12. What is the highest level of education that you have completed?
    - 1 Some high school
    - 2 High school graduate
    - 3 Technical/Vocational school
    - 4 Some college
    - 5 College graduate
    - 6 Post graduate studies

13. What is your total annual household income (*range*) before taxes?
    - 1 Under $20,000
    - 2 $20,000 to $34,999
    - 3 $35,000 to $49,999
    - 4 $50,000 to $74,999
    - 5 $75,000 to $99,999
    - 6 $100,000 or more

14. What is your gender?
    - 1 Male
    - 2 Female

15. Please check the appropriate age (*range*):

'1 Under 21 '2 21-34 '3 35-44 '4 45-54 '5 55-64
'6 65 or older

16. What is your race/ethnicity?
'1 White '2 African American '3 Hispanic '4 Asian
'5 Other ______________________

If you would be willing to complete another survey in 1997, please provide your name and address below.

Name	
Home Address	
City	**Home Zip Code**

Thank you for your assistance in completing this survey. We would also like you to record your trips to and from work for the week of **Monday, November 18 thru Friday, November 22, 1996**. Please complete the attached travel diaries for this time period.

APPENDIX D. AFTER TRAVEL SURVEY—TEST PARTICIPANTS

HOUSTON SMART COMMUTER PARTICIPANT SURVEY

Thank you for participating in the Smart Commuter project. Your assistance is requested in completing this short questionnaire to help evaluate the project and plan future efforts.

1. In general, how frequently did you use the Magic Link™ device to obtain traffic and transit information?
   - ☐ Daily (___ morning ___ afternoon)
   - ☐ Once or twice a week
   - ☐ Once or twice a month
   - ☐ Almost never

2. In general, how frequently did you use the other features of the Magic Link™ device?
   - ☐ Daily (___ morning ___ afternoon)
   - ☐ Once or twice a week
   - ☐ Once or twice a month
   - ☐ Almost never

3. What other features did you use most often (check all that apply)?
   - ☐ Address Book ☐ Calendar ☐ Games ☐ Modem for e-mail
   - ☐ Other ________________

4. In general, how frequently did you use the telephone system to obtain traffic information?
   - ☐ Daily (___ morning ___ afternoon)
   - ☐ One or twice a week
   - ☐ One or twice a month
   - ☐ Almost never

5. Please rate the Magic Link™, telephone system, and other methods on the following criteria.

	Very Good	**Good**	**Unsure**	**Poor**	**Very Poor**
Magic Link™					
Ease of Use	☐	☐	☐	☐	☐
Reliability of Information	☐	☐	☐	☐	☐
Accuracy of Information	☐	☐	☐	☐	☐
Timeliness of Information	☐	☐	☐	☐	☐
Usefulness of Information	☐	☐	☐	☐	☐
Telephone System					
Ease of Use	☐	☐	☐	☐	☐
Reliability of Information	☐	☐	☐	☐	☐
Accuracy of Information	☐	☐	☐	☐	☐
Timeliness of Information	☐	☐	☐	☐	☐
Usefulness of Information	☐	☐	☐	☐	☐

	Very Good	Good	Unsure	Poor	Very Poor
Radio					
Ease of Use	☐	☐	☐	☐	☐
Reliability of Information	☐	☐	☐	☐	☐
Accuracy of Information	☐	☐	☐	☐	☐
Timeliness of Information	☐	☐	☐	☐	☐
Usefulness of Information	☐	☐	☐	☐	☐
Television					
Ease of Use	☐	☐	☐	☐	☐
Reliability of Information	☐	☐	☐	☐	☐
Accuracy of Information	☐	☐	☐	☐	☐
Timeliness of Information	☐	☐	☐	☐	☐
Usefulness of Information	☐	☐	☐	☐	☐
Newspaper					
Ease of Use	☐	☐	☐	☐	☐
Reliability of Information	☐	☐	☐	☐	☐
Timeliness of Information	☐	☐	☐	☐	☐
Accuracy of Information	☐	☐	☐	☐	☐
Usefulness of Information	☐	☐	☐	☐	☐
Internet					
Ease of Use	☐	☐	☐	☐	☐
Reliability of Information	☐	☐	☐	☐	☐
Accuracy of Information	☐	☐	☐	☐	☐
Timeliness of Information	☐	☐	☐	☐	☐
Usefulness of Information	☐	☐	☐	☐	☐

6. What methods do you currently use to obtain traffic information (check all that apply)?

☐ Radio ☐ Television ☐ Newspaper ☐ Telephone System
☐ Internet ☐ Magic Link™ ☐ None ☐ Other ____________________

7. How important is obtaining traffic information to you?

☐ Very important ☐ Somewhat important ☐ Somewhat unimportant

‘ Not important

8. Over the past year have you changed the way you obtain traffic information?

‘ Seek traffic information less now ‘ Seek traffic information more now ‘ No Change

If you seek traffic information more now, which sources are you relying on?

‘ Radio ‘ Television ‘ Newspaper ‘ Internet ‘ Other ______________

‘ Magic Link™ ‘ Telephone System

9. What other methods would you like to use to obtain traffic information?

‘ Cellular telephone ‘ Pager ‘ E-mail ‘ Handheld/Palmtop Computer

‘ None ‘ Other ______________________

10. Would you consider subscribing to a service providing current traffic information at a reasonable cost?

‘ Yes ‘ No

If yes, how would you prefer to pay?

‘ Fixed rate per month ‘ Flat rate per call/page

How much would you be willing to pay for this service?

$_________ per month $_________ per call/page

11. How often do you use the following modes of transportation for commuting to or from work?

	Always or Almost Always	**Occasionally**	**Never**
Drive alone	‘	‘	‘
Carpool/Vanpool	‘	‘	‘
Ride the Bus	‘	‘	‘
Other (Specify)	‘	‘	‘

12. Has your general commute behavior changed during your participation in this project?

‘ Yes ‘ No

If yes, how has your travel changed?

‘ Change mode more frequently

‘ Carpool more

‘ Take bus more

‘ Change route more frequently

‘ Change time of travel more frequently

‘ Other _______________________

13. Did you ever change your travel behavior as a result of the specific information provided by the Magic Link™ or telephone system?

‘ Yes, frequently ‘ Yes, infrequently ‘ No

14. What change did you make based on this information (check all that apply)?

‘ Mode ‘ Route ‘ Time of travel ‘ Did not make trip

- Other __

____

15. What has been your normal experience when you made a change (check all that apply)?
    - Save ____ minutes in travel time
    - More comfortable trip
    - Less stressful trip
    - More stressful trip
    - Other ________________________

    Based on your experience, would you make the same change in the future?
    - Yes
    - No
    - Undecided

16. For what types of trips are you most likely to change your travel behavior based on traffic information?
    - Commute to/from work
    - Work related travel
    - Errands/personal business
    - Recreation/Social activities
    - Other

17. Please provide any comments on the information devices or the project.

    ____

Thank you for your participation in the Smart Commuter project and your assistance completing this survey!

APPENDIX E. AFTER TRAVEL SURVEY—CONTROL GROUP MEMBERS

I-45 NORTH FREEWAY CORRIDOR
COMMUTER SURVEY

Thank you for participating in the I-45 North Freeway Corridor travel survey over the past two years. Your assistance is greatly appreciated. Please complete this short questionnaire as part of the final survey period.

1. What methods do you currently use to obtain traffic information (check all that apply)?
   ‘ Radio ‘ Television ‘ Newspaper ‘ Internet ‘ None
   ‘ Other ____________________

2. How would you rate the ease of use, reliability, and accuracy of these sources?

	Very Good	Good	Unsure	Poor	Very Poor
Radio					
Ease of Use	‘	‘	‘	‘	‘
Reliability of Information	‘	‘	‘	‘	‘
Accuracy of Information	‘	‘	‘	‘	‘
Timeliness of Information	‘	‘	‘	‘	‘
Usefulness of Information	‘	‘	‘	‘	‘
Television					
Ease of Use	‘	‘	‘	‘	‘
Reliability of Information	‘	‘	‘	‘	‘
Accuracy of Information	‘	‘	‘	‘	‘
Timeliness of Information	‘	‘	‘	‘	‘
Usefulness of Information	‘	‘	‘	‘	‘
Newspaper					
Ease of Use	‘	‘	‘	‘	‘
Reliability of Information	‘	‘	‘	‘	‘
Accuracy of Information	‘	‘	‘	‘	‘
Timeliness of Information	‘	‘	‘	‘	‘
Usefulness of Information	‘	‘	‘	‘	‘

	Very Good	**Good**	**Unsure**	**Poor**	**Very Poor**
Internet					
Ease of Use	‘	‘	‘	‘	‘
Reliability of Information	‘	‘	‘	‘	‘
Accuracy of Information	‘	‘	‘	‘	‘
Timeliness of Information	‘	‘	‘	‘	‘
Usefulness of Information	‘	‘	‘	‘	‘

3. How important is obtaining traffic information to you?
   ‘ Very important ‘ Somewhat important ‘ Somewhat unimportant ‘ Not important

4. Over the past year, have you changed the way you obtain traffic information?
   ‘ Seek traffic information less now ‘ Seek traffic information more now ‘ No change

   If you seek traffic information more now, which sources are you relying on?
   ‘ Radio ‘ Television ‘ Newspaper ‘ Internet ‘ Other _______________

5. What other methods would you like to use to obtain traffic information?
   ‘ Telephone ‘ Cellular telephone ‘ Pager ‘ E-mail ‘ Handheld/Palmtop Computer
   ‘ None ‘ Other _____________________

6. Would you consider subscribing to a service providing current traffic information at a reasonable cost?
   ‘ Yes ‘ No

   If yes, how would you prefer to pay?
   ‘ Fixed rate per month ‘ Flat rate per call/page

   How much would you be willing to pay for this service?
   $________ per month $________ per call/page

7. How often do you use the following modes of transportation for commuting to and from work?

	Always or Almost Always	**Occasionally**	**Never**
Drive Alone	‘	‘	‘
Carpool/Vanpool	‘	‘	‘
Ride the Bus	‘	‘	‘
Other (Specify)	‘	‘	‘

8. Do you ever change your travel behavior based on specific traffic information?

- Yes, frequently
- Yes, infrequently
- No

9. What changes do you normally make based on this information (check all that apply)?

- Mode
- Route
- Time of travel
- Did not make trip
- Other ___________

10. What has been your normal experience when you made a change (check all that apply)?

- Save ____ minutes in travel time
- More comfortable trip
- Less stressful trip
- More stressful trip
- Other ________________________

Based on your experience, would you make the same change in the future?

- Yes
- No
- Undecided

11. For what types of trips are you most likely to change your travel behavior based on traffic information?

- Commute to/from work
- Work related travel
- Errands/personal business
- Recreation/Social activities
- Other

12. Please provide any comments on other ways you may wish to receive traffic and transit information.

____

Thank you for your assistance in completing this survey!