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16. ABSTRACT

This project provided an early, objective assessment of selected efforts to develop Washington State Advanced Traveler Information Systems (ATISs). To accomplish this goal, the study team developed a taxonomy of current ATISs nationwide; this taxonomy was used to develop instruments for the assessment. In addition to the specific assessments done under this project, the taxonomy and assessment tools developed could, with some refinement, be used as a model for iterative, standardized assessment of ATIS projects nationwide. Using these assessment tools, some of the study team's conclusions were as follow: (1) FLOW's system goals are appropriate to the audience but cannot be fully achieved in the location at which it was assessed, and an interactive interface would be more appropriate for the delivery of FLOW's information; (2) Traffic Reporter has a high degree of user acceptance, but it is hindered in achieving its implicit goals because of location; (3) the proposed Canadian Border Crossing ATIS would not achieve its goals with two of the three technologies proposed; and (4) although Bellvue Smart Traveler achieves two of its goals, the other two are not fully achieved, mainly because of an appropriate audience.

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Research Project Agreement T9233, Task 43
Advanced Traveler Info Systems Impacts Assessment

AN ASSESSMENT OF WASHINGTON STATE TRAVELER INFORMATION SYSTEMS BASED ON A GENERAL ATIS TAXONOMY

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DISCLAIMER

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EXECUTIVE SUMMARY

Researchers in many states are currently designing, developing, and implementing Advanced Traveler Information Systems (ATISs) that are intended to affect traveler choices and behavior. As yet, we know very little about how effective the projects have been or even how to measure that effectiveness. This project developed an assessment method and used that method to provide an early, objective assessment of selected efforts to develop Washington State Advanced Traveler Information Systems (ATISs).

Our approach began with the development of a taxonomy, or classification system, of ATISs by surveying planned and completed systems. This taxonomy then was used to guide the assessment of selected Washington State ATISs in meeting system goals and objectives. This approach is unique in that it focused on the "big picture" of ATIS design and development rather than on individual systems. One advantage of this approach is that the taxonomy can be used by any system designer or developer to decide how to assess ATIS effectiveness at any stage.

TAXONOMY DEVELOPMENT

The first step of the study was to review the available literature on selected ATISs in the U.S. In many cases, phone interviews were also conducted. A total of 36 ATISs were analyzed for eight characteristics: (1) the contents of the messages relayed to drivers, (2) whether the messages were based on dynamic or static data, (3) whether the messages included a recommended action or simply information; (4) the technology; (5) the degree of interactivity, (6) the format(s) in which messages were presented to the traveler, (7) the location(s) in which messages were delivered, and (8) the scope of the project in terms of area served.

The content of the messages became the central focus of our investigation and also of the taxonomy. We identified 23 distinct kinds of message content and grouped some of these individual kinds of content into categories of "message type." From message type, we were able to deduce system goals and objectives; in addition, we were able to connect message type to the location of delivery and the technology used for delivery.

The taxonomy essentially identifies systems by the message types they deliver. These message types, in turn, suggest system objectives and, ultimately, system goals. The umbrella for the entire taxonomy is the overall ATIS goal of increased mobility. (Include Table 2 here.)

At this point, it is important to emphasize that we developed our taxonomy from intrinsic characteristics of the systems we studied rather than from the stated goals of system designers. We took this approach because we found that stated goals did not always mesh with the intrinsic goals and objectives that were implied by the system's message types.

Table 2 shows, at the top of the taxonomy, the overall ATIS goal of increased mobility. We identified three sub-goals or system goals that contribute to this mobility: (1) to remove individual drivers from congested roads, (2) to reduce individual drivers' overall use of roadways, and (3) to alter drivers' modes of travel. Below these system goals are five more specific system objectives that are suggested by message type. Finally, message type and the possible locations the message can be delivered are listed for each individual objective. Technology, format of the information, and the degree of interactivity have been omitted from the Table for the sake of simplicity, although these elements are part of the taxonomy.

THE TAXONOMY AND THE ASSESSMENT PROCESS

Once the taxonomy was developed, we were able to fit each system that we reviewed or assessed into the grid. Some systems delivered many different message types and fit under more than one objective and goal, while other systems had only one objective and goal.

The Washington State systems that we studied were FLOW, Canadian Border Crossing, Traffic Reporter, and Bellevue Smart Traveler. FLOW and Canadian Border Crossing fit only under Goal 1 (remove individual drivers from congested roads), while the message types of the other two systems indicated that they fit under all three of the previously mentioned system goals.

The taxonomy guided the assessment of the systems by suggesting general assessment questions for each level of the taxonomy, i.e., questions at the level of objectives, message type, location, delivery technology, message format, and level of interactivity.

ASSESSMENT OF FLOW

FLOW was assessed through the design of questions based on the taxonomy, and these questions were asked in an interview format. Sixty-six interviews were conducted. The assessment team concluded that FLOW's message type supports FLOW's system objectives of influencing drivers to travel less congested routes and at less congested times. However, because the location at the time of the assessment was not an appropriate location for FLOW's information, it prevented FLOW from fully achieving its system goal of removing individual drivers from congested roads. Furthermore, given respondents' stated preferences, an interactive interface would be more appropriate for delivery of FLOW's information than its current read-only interface.

ASSESSMENT OF TRAFFIC REPORTER

Traffic Reporter was assessed through the design of questions based on the taxonomy, and these questions were asked in a survey. A total of 48 surveys were returned. The assessment team concluded that Traffic Reporter's current locations prevent it from fully achieving its system objectives and goals. Three of the intrinsic objectives were appropriate for the two locations at which Traffic Reporter was assessed: (1) to influence drivers to travel less congested routes, (2) to influence drivers to travel at less congested times, and (3) to influence drivers to reduce trip frequency and/or distance. However, these objectives were appropriate only for the audience's trip home, not for both the trip to and trip from the destination. Traffic Reporter's fourth objective of influencing single-occupancy vehicle drivers to switch to high-occupancy modes cannot be realized for short-term switches because single-occupancy drivers who have access to Traffic Reporter have presumably already committed to that mode for the day. Further, given respondents' stated preferences, shopping malls and business areas such as the current locations are not ideal locations for Traffic Reporter's information.

ASSESSMENT OF PROPOSED CANADIAN BORDER CROSSING ATIS

The assessment of the proposed Canadian Border Crossing system was different in that questions could not be asked of users because the system is not implemented. However, the description of the system was used to classify the system and develop possible questions. The team was able to assess the system in terms of its ability to achieve its objectives and goals given the message types, locations, and technologies proposed. The study team concluded that the likely users of the proposed Canadian Border Crossing ATIS are an appropriate audience for information designed to influence drivers to travel less congested routes and to travel at less congested times (two of the objectives in the taxonomy). However, two of the proposed delivery methods are strictly in-vehicle, so they could not support the objective of influencing drivers to travel at less congested times. Only a kiosk placed in a shopping or other business area could encourage drivers to adjust their departure time, thereby supporting the objective of influencing drivers to travel at less congested times, as well as less congested routes.

ASSESSMENT OF BELLEVUE SMART TRAVELER

Bellevue Smart Traveler was assessed by designing questions based on the taxonomy and asking these questions in a survey. A total of 28 surveys were returned. In summary, Bellevue Smart Travelér achieved two of its four objectives: it influenced drivers to travel at less congested times and to use less congested routes. It did not influence drivers to reduce trip frequency, nor did it influence drivers to switch to an HOV mode. These failures were likely attributable to an inappropriate audience.

RECOMMENDATIONS

The study team recommends that any group or project developing an ATIS take the following steps to improve the likelihood of its success: (1) identify and evaluate the ATISs message types, objectives, and goals, (2) determine whether the objectives are appropriate for the travelers who have access to them, (3) evaluate whether the ATISs message types achieve their objectives, (4) identify and evaluate the system's delivery location, (5) identify and evaluate the system's interface technology, message format, and system interactivity, and (6) evaluate the system's usability.

CHAPTER 1. INTRODUCTION

BACKGROUND

Researchers in many states, including California, Illinois, Florida, Minnesota, and Washington, are currently designing , developing, and implementing Advanced Traveler Information Systems (ATISs) that are intended to affect traveler choices and behavior. A considerable amount of time and money has been spent on these efforts. These projects differ widely in their goals, audiences, and delivery methods, and, as yet, we know very little about how effective the projects have been or even how to measure that effectiveness.

PURPOSE AND APPROACH

The goal of this project was to provide an early, objective evaluation of four ATISs designed to influence traveler behavior in Washington State. To accomplish this goal, we created an ATIS taxonomy, or classification system, by selectively surveying completed and planned ATISs. The taxonomy was necessary because systems with different goals, audiences, and delivery methods cannot be assessed in the same way. We needed to group similar systems together so that we could compare among them and assess them accurately. We hoped that this taxonomy could drive not only our assessment, but also other nationwide evaluation efforts.

It is also important to note that we approached this problem as a communication problem rather than a technological problem. This approach will be evident throughout our discussion of our taxonomy, as well as our assessment. Previous evaluations have focused on individual systems and their ability to induce behavioral changes in users, particularly as part of the process between research and development. On the other hand, this assessment focuses on using classes of systems to guide the assessment of ATISs in meeting system goals and objectives. To our knowledge, this is a unique approach which could guide future assessments of ATISs.

SCOPE

The overall goal of Intelligent Vehicle-Highway Systems (IVHS) can be simply stated as increased mobility. Traffic demands are increasing in virtually every city in the United States, and both personal and commercial mobility is increasingly hampered by traffic congestion. One approach to increasing mobility is to increase capacity by constructing additional roadways and facilities. This is a slow, costly, and frequently controversial approach that lies beyond the scope of this study.

Barring increased capacity, increasing mobility means increasing the efficiency with which existing roadways are used. Despite the large variety of IVHS systems often discussed, essentially two possibilities for achieving this end have been implemented in the United States. The Advanced Traffic Management System (ATMS) approach is to regulate traffic flow directly, through ramp metering or by dynamically altering the configuration of roadways (e.g., through express lanes that change direction) to meet daily demands. ATMSs are also beyond the scope of this study.

The other approach to regulating traffic flow is to influence drivers' use of the roadways in such a way that they increase their own mobility and, frequently, the mobility of others as well. This is the approach of Advanced Traveler Information Systems (ATISs). As their name suggests, the key to ATISs is *information*—timely, accurate, and useful—given directly to the drivers themselves. The essence of ATISs is communication of transportation-related information to the roadway's users; this communication effort is the focus of the present study. The rectangular boxes in Figure 1 show the scope of the study.

OVERVIEW OF REPORT

This report begins by reviewing our findings about current and planned ATISs. Then we describe how we classified these systems into a taxonomy. The next chapters present the results of our assessments of four Washington State traveler information efforts. The report ends with a summary of our conclusions and an evaluation of the success of our taxonomy for our own use and for future use by others.

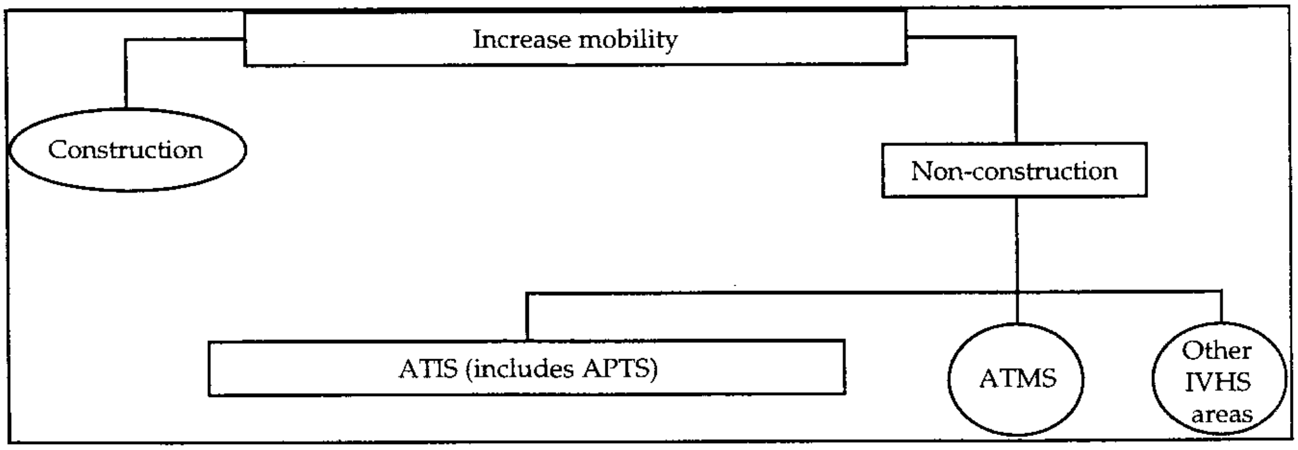


Figure 1. Scope of the Study (The circled items are excluded from the study.)

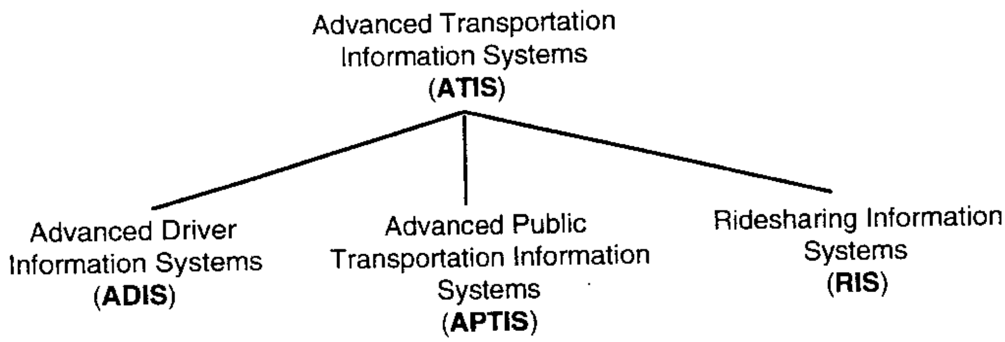
CHAPTER 2. REVIEW OF ATIS

We begin with background and definitions, followed by findings from our 1992 survey of current and planned ATIS.

BACKGROUND AND DEFINITIONS

While ATIS is generally seen as a category separate from Advanced Public Transportation System and as the new, improved name for Advanced Driver Information System, ATIS can more fruitfully be viewed as a general term divisible into three categories: Advanced Driver Information Systems (ADIS), Advanced Public Transportation Information Systems (APTIS), and Ridesharing Information Systems (RIS). [The term Advanced Rural Transportation Systems (ARTS) could also be included here.] ADISs focus on getting individual drivers off congested roadways; a few also provide navigation assistance, mayday services, or encourage drivers to reduce their overall travel. APTISs and RISs focus on getting drivers out of single-occupancy vehicles and into high-occupancy vehicles, the former through more traditional transit services, the latter through less formal paratransit and carpooling.

A few additional comments on these acronyms are in order. First, the acronym *ADIS* has begun to disappear from the transportation literature in the last few years, generally being replaced by the more generic *ATIS*. We are consciously resurrecting the former term (*ADIS*) as a more specific subcategory of the latter (*ATIS*). Second, *APTIS* is generally replaced in the literature by *APTS*, the acronym for Advanced Public Transit Systems. Because this study focuses on the dissemination of information (in the case of APTS, transit information) and not on the transit system itself, we use the term *APTIS*. In addition, this category is generally treated as separate and equal to the *ATIS* category. Without explaining



the historical reasons for this split, we treat *APTIS* as another subcategory of *ATIS*. Finally, *RIS* is not a term derived from current literature or transportation; it was coined specifically for this study to represent a growing, separate class of APTIS and to facilitate discussion.

REVIEW OF SYSTEMS

The first step of the study was to review the available literature on selected ATISs in the United States, including ADISs, APTISs, and RISs. The purpose of this review was to explore the range of existing and planned ATISs in terms of objectives, implementation scopes, technologies (especially user interfaces), and messages delivered to drivers. Because the published material on individual ATISs did not often provide the level of detail needed for our study, we also conducted phone interviews with representatives of most of the ATIS projects mentioned in this report. Note that the purpose of the review was to detail not every ATIS in the United States but rather a sample of ATISs possessing a wide variety of characteristics.

During this review 36 ATISs were analyzed: 15 ADISs, 12 APTISs, seven RISs, and two systems (Bellevue Smart Traveler and Houston Smart Commuter) that have elements of all three. These systems are listed below.

ADVANCE
AIDS
Bellevue Smart Traveler
BusTime
California Smart Traveler
Caltrans
Canadian Border Crossing
CC
Central Ohio Transit Authority
Chart
CRIS
Direct/SCANDI
ESDS
FLOW
Gateway
GoTime
Guidestar
Hillsborouth Transit Authority
Houston Smart Commuter
Incident Management
Inform
Integrated System
Loseff Voice Mail Model
Metro Ridematch
Metro VanPool
Metro Vision
MV of NA
Pathfinder
RSL Fone-Link
Smart Corridor
Traffic Reporter
Transcom
TranStar
Travlink
TravTek
Walker, Rich & Quinn

Preliminary research revealed an interesting trend in the data. Few ATISs in the United States provide drivers combined ADIS, APTIS, and RIS information. Instead, each kind of information—if it is provided at all—is provided by independent agencies with little or no official coordination of effort. In other words, the vast majority of ADISs, APTISs, and RISs are, at least administratively, unrelated operations. As of December 1992, Bellevue Smart Traveler was the only ATIS identified that provided driving, public transit, and ridesharing information in a single system.

For every ATIS project investigated, we analyzed eight key characteristics: (1) the contents of the messages relayed to drivers, (2) whether the messages were based on dynamic or static data, (3) whether the messages included a recommended action or simply information, (4) the technology, (5) the degree of interactivity, (6) the formats in which messages were presented to the traveler, (7) the locations in which messages were delivered, and (8) the scope of the project in terms of area served. The following paragraphs summarize the study team's findings.

Message Content

We discovered that ATISs in the United States are highly diverse in terms of the content of their messages. We identified 23 distinct kinds of message content in our study:

- Volume
- Occupancy
- Traffic and Road Hazards
- Road Closures
- Traffic Speed*
- Route Selection
- Route Guidance
- Ramp Metering
- Freeway and Bridge Tolls
- Transit Fares
- Tourist Information
- Personal Communication
- Traffic Incident Nature
- Road Construction
- Special Events Likely to Impact Traffic
- Estimated Trip Time*
- Route Distance
- Roadside Services and Commerce
- Parking
- Transit Schedules
- Ride Matches
- Public Service Announcements
- Emergency Communication

*For these messages, some systems provide separate HOV and SOV information.

In order to simplify the taxonomy, we later grouped these different messages into categories of message types. For example, "congestion" is a message type. In our formal assessment, we used "congestion" to describe any message intended to give the user a sense of how well the traffic is flowing, independent of the particular source data, algorithms, and display characteristics used to derive and present the message. In the case of Traffic Reporter, for example, congestion is represented in two ways, by a color scheme reflecting speed ranges on freeway sections and by text messages about average speed on a selected route. FLOW uses a similar color scheme, but it is based on volume. For the purpose of our assessment of effectiveness, all three of these messages were treated identically as "congestion."

The study team considered the message type to be the most important characteristic of the ATIS. The type of information the system delivers not only implies the system's goals and objectives, but also determines to a large extent where the message should be delivered and what type of technology should be used to deliver the message. For this reason, the message type became central to the development of the ATIS taxonomy, as will be clear in the next chapter.

Dynamic vs. Static Data

In the area of dynamic vs. static data, there are general differences among the subcategories of ATISs. The vast majority of ADISs provide or rely on dynamic (i.e., real-time) traffic data in developing information for drivers. The only ADIS messages typically formulated from static data concern maps, route distances, roadside services, construction, and public service announcements. In contrast, APTISs use primarily static data for transit schedules and fares, and RISs use static data for participant databases. A few APTISs use dynamic data to inform drivers about current transit schedules.

Since the study team viewed this characteristic as one that is inherently connected with, but subordinate to, the *message type*, we did not rely on this characteristic to build the taxonomy.

Recommended Action vs. Information Only

A few ATIS designers make it a policy never to recommend to drivers specific choices or actions. One project representative indicated that this policy was implemented at least in part to avoid any potential liability for the consequences of traveler's compliance with recommendations. Another noted that if every driver avoided congestion by following, for example, a recommended by-pass, the by-pass itself would quickly become congested. Although some ATISs do not make recommendations, others do, providing either simple information or recommended actions according to the severity of the traffic problem. In some cases, the actual formulation of messages that include a recommendation are left to the discretion of a dispatcher.

Because the choice to recommend or not recommend an action is primarily a policy-decision, we chose not to use this feature as a major classification characteristic in the taxonomy.

Technology

The ATISs investigated in this study used a variety of technologies and information services to deliver messages to drivers. These technologies are listed below:

Computer

- Computer with Communication Link
- Stand-Alone Computer
- Electronic Mail

TV

- Broadcast TV
- Cable TV
- Dedicated Cable TV
- Closed Captioned TV

Radio

- AM/FM Radio
- Highway Advisory Radio
- AM/FM Radio Interrupt
- Radio-RDS

Telephone

- Operator-Assisted Telephone
- Voice-Synthesis Telephone
- Voice Mail

Other

- Variable Message Signs
- Pagers

We were tempted, in our design of the taxonomy, to rely heavily on this category—i.e., to classify systems by technology; however, in the end, we determined that the technology is actually (or at least should be) subordinate to the type of information the system needs to deliver. Thus, although an ATIS cannot provide information on something for which no sensors provide any data, and although the delivery device can limit the type of information that can be displayed (e.g., one can not put a map on a pager), classifying ATISs primarily by technology type would not have facilitated the assessment of the *effectiveness* of the systems. Consequently, technology type, while certainly a part of the taxonomy, became subordinate to message type.

Interactive vs. One-Way Communication

The technology is closely related to an ATIS's potential for interactivity. For example, AM/FM radio and cable TV are broadcast technologies and have little capacity to serve as interactive interfaces; individual listeners or viewers must wait passively for information of value to them to be presented. Likewise, variable message signs present whatever information the dispatcher believes to be of greatest importance; drivers make use of that information or not, according to their own needs. A system that relies on operator-assisted telephone, on the other hand, is necessarily interactive; the traveler requests and receives (with luck) exactly the information needed. A computer can have an interactive interface or not, depending on the communication media available and the programming decisions made.

Most ADISs depend on read-only interfaces, even those that use technology capable of interactivity. APTISs and RISs, on the other hand, tend to use interactive interfaces such as operator-assisted telephone, voice mail, or e-mail.

Because interactivity is related closely to the technology, interactivity became a part of the taxonomy, but only in conjunction with technology.

Message Format

Again, the technology is closely related to the formats in which ATISs can deliver messages. Phone and radio-based systems are limited strictly to speech, while variable message signs tend to be text-only. Only television- and computer-based systems can handle speech, text, and graphics. Nonetheless, speech-only—via telephone and radio—is by far the most common format for ATIS messages, followed by text-only, and then by graphics.

As with interactivity, message format was included with technology in the taxonomy.

Location

Technology likewise impacts the location at which drivers are likely to receive travel-related messages. Computers are increasingly accessible at work and at home, but they are rarely available to the general public. Televisions are most commonly found in private homes. Radio is available in most homes and vehicles. Though businesses sometimes have TVs and VCRs on site, employees are more likely to have access to radios than to TVs. Variable message signs and highway advisory radio are accessible only in-vehicle. Phone systems, on the other hand, are available anywhere there is a phone; given the increasing popularity of cellular and portable phones, in-vehicle phones are becoming more and more common, albeit only among drivers who can afford the installation and monthly fees.

In all, six potential locations were identified. The initial letter of each location is used in later tables.

Home (h)
Work (w)
Vehicle (v)
Kiosk (at transit center, transfer station, business district, etc.) (k)
Bus Stop (b)
Portable (p)

Location, as with interactivity and message format, was linked with interface technology in the taxonomy.

System Scope

System scope—that is, the geographical area and types of roadways served by a given system—varies among ADISs, APTISs, and RISs. ADISs tend to focus on freeways and, to a lesser extent, on supporting arterials. Only two systems, both of which use in-car computers, provide traffic information on virtually all roads within the service area. APTISs naturally confine their information to established transit routes. RISs generally provide information for all roads within a designated service area.

System scope was not used in the taxonomy because it was often a function of system implementation; in addition, a system's potential effectiveness can be assessed even if the system does not currently reach all of its potential audience.

INTERFACE MODULES

Because of the interrelated nature of some of the characteristics discussed in the previous section, particularly those linked with the technology and in order to simplify the taxonomy, we created the notion of *interface modules.* Many ATISs (especially ADISs) relay travel information through a combination of two or more interface technologies. For example, several ADISs provide information via television, radio, and variable message signs. Fewer ADISs rely on a single interface (e.g., an on-board computer or highway advisory radio) to convey information. This finding is significant because a system's interface technology limits the kind of messages that can be delivered to drivers; the format (i.e., graphics, text, or speech) of those messages; the degree to which they can be tailored to individual users (through interactivity); and the location in which users are most likely to receive them (e.g., in-home vs. in-car). Our interface modules each consist of an interface technology, its delivery location(s), its format, and its potential for interactivity. Our study identified 15 interface modules (see Table 1); note that the modules are grouped by interface technology.

Few of the ATISs investigated in this study have been implemented to the fullest potential of their interface technology in terms of location, format, or interactivity. Only the least ambitious have been fully implemented. In other words, few ATISs provide interfaces at all possible locations, make use of all possible formats, and take full advantage of a potentially interactive interface technology. The only systems that do so are those with the most limited interface technologies: automatic-interrupt radio (module IIIB), highway advisory radio (module IIIC), and variable message signs (module V). Note that these systems have a single potential interface location (in-vehicle), a single potential format (either speech or text), and no possibility for interactivity.

Because many ATISs (especially ADISs) make use of multiple modules, we performed a cluster analysis of systems and their modules to determine whether systems grouped by modules are also grouped by objective or message. Unfortunately, the number of ATISs is relatively small, while the variety of module combinations is relatively large; consequently, the statistical analysis produced no meaningful results. Such an approach will become more feasible as more data (from future ATISs) become available.

Table 1. Interface Modules

Module		Interface Technology	Likely Locations	Possible Formats	Interactivity Potential
I	A	Computer - Communication. Link	h,w,v,k,b,p	g,t,s	high
	B	Computer - Stand-Alone	h,w,v,k,b,p	g,t,s	medium
II	A	Television - Broadcast	h,w,p	g,t,s	none
	B	Television - Cable	h,w,k	g,t,s	none
	C	Television - Closed Captioned	h,w,k	g,t,s[1]	none
	D	Television - Interactive Cable	h,w,k	g,t,s	low
III	A	Radio - AM/FM	h,w,v,k,b,p	s	none
	B	Radio - AM/FM Interrupt	v	s	none
	C	Radio - Highway Advisory	v	s	none[2]
	D	Radio - Radio Data Systems	v,p	s	none
IV	A	Phone - Live Operator	h,w,v,k,b,p	s	high[3]
	B	Phone - Voice Synthesis	h,w,v,k,b,p	s	medium
	C	Phone - Voice Mail	h,w,v,k,b,p	s	low
V	A	Variable Message Signs	v	t	none
VI	A	Pagers	h,w,v,b,p	t	none

h=home; w=work; v=vehicle; k=kiosk; b=bus stop; p=portable

g=graphics; t=text; s=speech

[1]Closed captioned television has additional text capacity.

[2]User choice, as opposed to interrupt.

[3]Phone systems listed in descending order of interactivity.

CHAPTER 3. THE TAXONOMY

Having assembled, reviewed, and organized the collected data about current and planned ADISs, APTISs, and RISs, the study team turned directly to the first objective of this study: devising a taxonomy of ATISs and developing guidelines for evaluating ATISs in each of the taxonomy's categories. Because the assessment depended upon the taxonomy and because, as stated earlier, our assessment will focus on the ability of the systems to meet their goals and objectives, the study team opted to develop a taxonomy based on a system's goals and objectives and its potential to achieve them. To do this, we used message type to classify systems. To a large extent, message type determines a system's potential to achieve its goals and objectives on one hand, and it determines technology and location on the other.

At this point, it is important to emphasize that we developed our taxonomy from intrinsic characteristics of the systems we studied rather than from the stated goals of system designers. We took this approach because we found that stated goals did not always mesh with the intrinsic goals that were implied by the system itself.

Although we were working from the bottom up to develop the taxonomy (we were using message type to classify the systems), in many ways it is easier to understand the taxonomy if it is discussed from the top down, so we begin at the top with the overall ATIS goal of increased mobility.

OVERALL ATIS GOAL AND SYSTEM GOALS

Increased mobility is the overall goal of all ATISs. From our review of the current and planned ATISs and the messages that they deliver, we were able to identify three related but distinct *system* goals that contribute to the overall goal of increased mobility.

1. **Remove individual drivers from congested roads.** This goal entails persuading drivers to travel at less congested times or along less congested routes. Removing individual drivers from congested routes also benefits other drivers by reducing overall congestion. This goal addresses the issue of increasing mobility, but it does not directly address the reduction of total travel volume.

2. **Reduce individual drivers' overall use of roadways.** This second goal is to reduce drivers' actual use of the roadways, either by helping them avoid navigation errors or by persuading them to reduce the frequency or distance of their trips. This goal, although related in some ways to goal number 1, is different in that it seeks a bottom line reduction of vehicular travel, with accompanying environmental and infrastructure benefits.

3. **Alter drivers' modes of transportation** (i.e., convert drivers to more efficient modes of travel). This final goal is to reduce the number of SOVs on the road by persuading drivers to make use of public transit or ridesharing (carpools or vanpools). This goal is closely related to goal 2; however, it requires drivers to shift modes (though that mode shift may simply be taking on passengers to change an SOV to an HOV).

SYSTEM GOALS AND RELATED OBJECTIVES

Goals are generally reached by identifying specific objectives. Objectives are outcomes that contribute to achieving a goal. From the message types we identified, we determined objectives that related to each of the three system goals discussed above. Below, the three system goals are listed with their more specific objectives:

Goal 1: Remove individual drivers from congested roads.

Objective: Influence drivers to travel at less congested times.
Objective: Influence drivers to travel less congested routes.

Goal 2: Reduce individual drivers' overall use of roadways.

Objective: Minimize drivers' navigation errors.
Objective: Influence drivers to minimize total travel.

Goal 3: Alter drivers' modes of transportation

Objective : Increase HOV travel.

The figure below shows the upper levels of the taxonomy as it was applied in our assessment scheme; these levels include only goals and objectives.

THE COMPLETE TAXONOMY DEFINED AND DESCRIBED

A description of our complete taxonomy is crucial to understanding our classification of the systems and is also crucial to understanding how the taxonomy could be used to classify current and future ATIS.

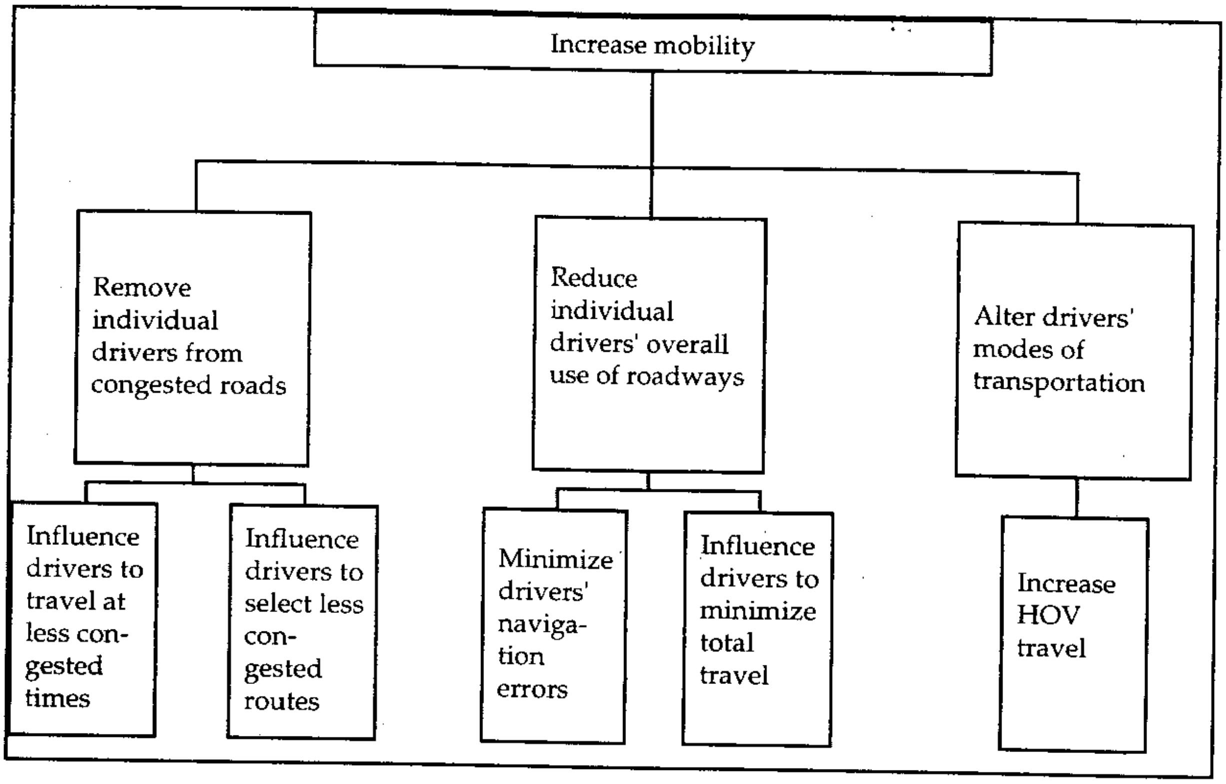


Figure 2. Upper levels of the taxonomy.

The discussion below is organized into five major sections, each focused on a single ATIS objective. Each section outlines the message types that have the potential to further the specific objective and the location in which the messages must be delivered to the traveler to do so. An overview of the taxonomy is presented in Table 2. The first line states the overall goal that all ATISs share: increased mobility. This ATIS goal encompasses three individual *system* goals: (1) remove individual drivers from congested roads, (2) reduce individual drivers' overall use of roadways, and (3) alter drivers' modes (see Table 2). These three system goals encompass the five previously mentioned objectives. Beneath each objective, message type and related locations are listed.

<u>OBJECTIVE 1. Influence Drivers to Travel at Less Congested Times</u>

Systems that influence drivers to travel at less congested times are based on three message types delivered at three locations, as shown in Table 3. These message types are discussed below.

Table 2. Taxonomy Overview

	ATIS GOAL				
	Increased Mobility				
	System Goals for Achieving Increased Mobility				
	Remove Individual Drivers from Congested Roads		Reduce Individual Drivers' Overall Use of Roadways		Alter Drivers' Modes
	System Objectives				
	1. Influence Drivers to Travel at Less Congested Times	2. Influence Drivers to Travel Less Congested Routes	3. Minimize Drivers' Navigation Errors	4. Influence Drivers to Minimize Total Travel	5. Increase HOV Travel
	Messages with the Potential to Achieve System Objectives				
Message Type	Traffic Congestion	Traffic Congestion	Route Selection	Route Distance	Traffic Congestion w/HOV info
Location	h, w,p*	h, w, v,p	h, w, v,p	h, w, v, p	h
Message Type	Traffic Details	Traffic Details	Route Distance	Estimated Trip Time	Estimated Trip Time w/HOV info
Location	h, w,p	h, w, v,p	h, w, v,p	h,w,v,p	h
Message Type	Estimated Trip Time	Estimated Trip Time	Route Guidance	Roadside Services or Commerce	Transit Information
Location	h, w,p	h, w, v,p	v	h, w, v, p	h,w,b,p
Message Type		Route Selection	Roadside Services or Commerce	Freeway or Bridge Tolls	Ridesharing Info
Location		h, w, v,p	h, w, v	h, w, v, p	h,w
Message Type		Freeway or Bridge Tolls			General Benefits of HOV Travel
Location		h, w, v,p			h,w,b,p

*h = home; w = work, v = vehicle, b = bus stop, p = portable

Table 3. Message/Location Summary for Objective 1

MESSAGE TYPE	POTENTIAL LOCATIONS
Traffic Congestion	h, w, p
Traffic Details	h, w, p
Estimated Trip Time	h, w, p

Traffic Congestion

Real-time information about traffic congestion can prompt a driver to travel at less congested times. For this to occur, four conditions must be met: (1) the driver's usual route must, in his or her own estimation, be significantly congested at the intended departure time; (2) the driver's schedule must allow flexibility of departure time; (3) adjustment of departure time must, in the driver's own estimation, offer a significant savings of travel time, or must be necessary to achieve a desired arrival time; and (4) the information is provided before departure. The first three conditions vary according to current traffic conditions, personal schedules, work time flexibility, and driver perceptions. Satisfaction of the last condition is the responsibility of the ATIS: traffic congestion information must be provided prior to trip departure, usually at home or work, but perhaps at other locations as well.

Traffic Details

Drivers may be more willing to alter their travel times if they understand the specific nature of current traffic conditions, especially if those conditions are exceptional. For example, a driver facing congestion caused by a major incident (e.g., a multiple-vehicle pileup, a chemical spill, or a demonstration) might decide more readily to delay departure than a driver facing the "usual" rush-hour congestion. For traffic details to influence travel time selection, four conditions similar to those for traffic congestion must be met: (1) the driver's usual route must, in his or her own estimation, be significantly impacted at the intended departure time; (2) the driver's schedule must allow flexibility of departure time; (3) adjustment of departure time must, in the driver's own estimation, offer a significant savings of travel time, or be necessary to achieve a desired arrival time; and (4) the information must be provided before departure.

Estimated Trip Time

One reason that drivers may hesitate to leave earlier or later is their uncertainty that doing so will actually save time. Providing drivers with the estimated trip time *based on different departure times* could help alleviate this uncertainty. Of course, for an ATIS to provide estimated trip times, it must also be responsive to route and departure time selection. In other words, the ATIS must have a route and time "in mind" before it can estimate trip time. It must also have access both to real-time data to calculate current travel times and to either historical data or a predictive algorithm from which to estimate trip times. Again, four conditions similar to those already discussed must be met for estimated trip time to influence departure time.

OBJECTIVE 2. Influence Drivers to Travel Less Congested Routes

Systems that influence drivers to travel less congested routes are based on five message types delivered at four locations, as shown in Table 4. These message types are further discussed below.

Traffic Congestion

Real-time information about traffic congestion can prompt a driver to take less congested routes. For this to occur, four conditions must be met: (1) the driver's usual route must, in his or her own estimation, be significantly congested; (2) the driver must know of a reasonable alternative route; (3) the alternative route must offer, in the driver's estimation, a significant advantage; and (4) the information is provided before—preferably *at the time that*—the critical route decisions must be made. The first three conditions vary according to current traffic conditions, local roadway systems, and driver perceptions. Satisfaction of the last condition is the responsibility of the ATIS: traffic congestion information must be provided prior to trip departure (usually at home or work, but perhaps at other locations as well) or in-vehicle early in the trip or when the driver needs the information. Timing is clearly critical for successful in-vehicle delivery of information.

Table 4. Message/Location Summary for Objective 2

MESSAGE TYPE	POTENTIAL LOCATIONS
Traffic Congestion	h, w, v, p
Traffic Details	h, w, v, p
Estimated Trip Time	h, w, v, p
Route Selection	h, w, v, p
Freeway or Bridge Tolls	h, w, v, p

Traffic Details

Similarly to departure time changes, drivers may be more willing to alter their routes if they understand the specific nature of current traffic conditions, especially if those conditions are exceptional. For example, a driver facing congestion caused by a major incident might decide more readily to change routes than a driver facing the "usual" rush-hour congestion. For traffic details to influence route selection, four conditions similar to those for traffic congestion must be met. (See the preceding paragraph.)

Estimated Trip Time

One reason that drivers may hesitate to take an alternative route is their uncertainty that the alternative will actually save time. Providing drivers with the estimated trip time along alternative routes could help alleviate this uncertainty. For this to occur, the ATIS must have a start point and destination "in mind" before it can estimate trip times for alternative routes. Again, four conditions must be met for estimated trip time to influence route selection: (1) the driver's usual route must, in his or her own estimation, be significantly congested; (2) the driver must know of a reasonable alternative route; (3) the alternative route must offer, in the driver's estimation, a significant advantage; and (4) the information must be provided before—preferably *at the time that*—the critical route decisions must be made.

Route Selection

Perhaps the most effective way to channel drivers onto less congested routes is to assist in route selection more directly. An ATIS that provides information about traffic congestion, traffic details, or estimated trip time places the burden of decision-making on individual drivers. Provided that the available information is adequate and that drivers have the time, inclination, and skills to make an informed decision, such information may be successful in altering behavior. An ATIS can relieve drivers of the burden of route selection by recommending the best route on the basis of its own analysis of current traffic conditions (although, few ATISs offer recommendations because of liability issues). Drivers can be spared both the effort of decision-making and the penalty for poor judgment. Route selection is probably best completed before departure, e.g., at home, at work, or at other locations. This does, however, increase the chance that conditions will change by the time the congestion point is reached. On the other hand, in-vehicle route selection requires an exchange of information between traveler and ATIS and therefore can be a hazardous distraction without appropriate safeguards (e.g., route selection available only when the vehicle is stopped).

Freeway or Bridge Tolls

Providing information about freeway or bridge tolls prior to trip departure may encourage drivers to select alternative routes; the value of such information depends on the complexity of toll information and the availability of alternative routes. Drivers might alter their behavior on the basis of detailed knowledge of tolls if, for example, tolls varied considerably according to route or time of day. Toll information would have to be available to drivers when they still had route options, preferably before their departure (especially from home or work, sometimes from other locations). Providing this information in-car could also be effective, assuming that drivers received it in time to make the necessary route adjustments.

OBJECTIVE 3. Minimize Drivers' Navigation Errors

Systems that attempt to minimize drivers' navigation errors are based on four message types delivered at four locations, as shown in Table 5 . These message types are discussed below.

Table 5. Message/Location Summary for Objective 3

MESSAGE TYPE	POTENTIAL LOCATIONS
Route Selection	h, w, v, p
Route Distance	h, w, v, p
Route Guidance	v
Roadside Services or Commerce	h, w, v, p

Route Selection

Navigation errors can contribute to overall traffic congestion by causing drivers to remain unnecessarily on freeways or other major arterials. One way to help prevent navigation errors is to assist drivers in selecting a route for their trip. The criteria for selecting a route may be distance, trip time, or ease of navigation. In any case, drivers with an accurate route plan will be better equipped to avoid many of the typical navigation errors that stem from limited knowledge of the planned route (e.g., getting lost, one-way streets, detours caused by construction, turn restrictions). Assistance in route selection must be provided before trip departure or during the trip: either at home, at work, in-vehicle, or at other destinations.

Route Distance

Another kind of information that may help a driver avoid navigation errors is accurate information on a selected route's distance, especially the distance between critical points (e.g., turns or exits) along the route. A driver traveling an unfamiliar route will be better able to avoid or recover from navigation errors if he or she has a clear idea of the distance to be traveled. Information about a route's distance cannot, of course, be given to drivers in the absence of route selection assistance; a route must be selected before its key distance points can be calculated. Information about route distance can be given in any of the locations appropriate for route selection: at home, at work, in-vehicle, or at trip destinations.

Route Guidance

Probably the most effective way to reduce drivers' navigation errors is to provide route guidance, i.e., to help drivers navigate by providing detailed instructions as they travel along their intended routes. Because route guidance occurs in vehicles where a driver must devote most of his or her attention to the task of driving, guidance information must be relatively unobtrusive and cognitively undemanding.

Roadside Services or Commerce

Information about services or businesses may reduce drivers' navigation errors by directing them to destinations along a planned route (e.g., a shoe repair shop along the route to work) or in areas with which they are familiar (e.g., near home or work). This information must be provided prior to trip departure, either at home, at work, in-vehicle, or at other destinations.

OBJECTIVE 4. Influence Drivers to Minimize Total Travel

Systems that influence drivers to minimize total travel (shorter distance and fewer trips) are based on four message types delivered at four locations, as shown in Table 6. These message types are discussed below.

Trip Distance and Estimated Trip Time

Easily accessible information about a specific trip's distance may cause drivers (especially SOV drivers) to reconsider making a special trip or, if the circumstances allow, to select a closer alternative destination. Information about current travel time may influence drivers to avoid taking a particularly arduous trip, especially where an alternative is available (e.g., telecommuting). In either case, information about trip distance or time is most likely to affect a traveler's behavior if it is available prior to trip departure, which most frequently means at home or work. Making this information available at other locations (e.g., public agencies or commercial centers) or in-vehicle may also be useful for excursions involving multiple destinations.

Table 6. Message/Location Summary for Objective 4

MESSAGE TYPE	POTENTIAL LOCATIONS
Trip Distance	h, w, v, p
Estimated Trip Time	h, w, v, p
Roadside Services or Commerce	h, w, v, p
Freeway or Bridge Tolls	h,w,v,p

Roadside Services or Commerce

Another tactic for getting drivers to reduce the frequency or distance of trips would be to provide them with information about services and businesses that may be trip destinations. This information may be organized in two ways: proximity to the trip's point of origin or proximity to a specific route. The first organizational approach may benefit drivers seeking services (e.g., auto repair or photocopying) or products (e.g., hardware or groceries) rather than specific destinations (e.g., Westlake Center or the family doctor's office). The second organizational approach may benefit drivers with a combination of specific destinations and non-specific destinations. A traveler might, for example, want to make photocopies on the way to the post office. Such a traveler might make good use of an information system that indicated the locations of photocopying services along the route to the post office. Obviously, geographic information about services or businesses is most useful prior to trip departure—again, most likely at home or work. This information may be useful at other trip destinations or in-car, especially if the desired service or product is for some reason unavailable at the nearest destination.

Freeway or Bridge Tolls

Providing information about tolls may encourage drivers to take fewer trips to save money, especially where alternatives to travel exist (e.g., telecommuting), or to choose alternative routes with fewer tolls. Drivers might alter their long-term behavior on the basis of detailed knowledge of tolls if, for example, tolls were seen to be a significant expense over a long period of time. Toll information is best be available from home or work, sometimes from other locations.

OBJECTIVE 5. INCREASE HOV TRAVEL

Systems that attempt to increase HOV travel follow two approaches: (1) maintaining and increasing transit ridership and (2) increasing carpooling and ridesharing (paratransit). These two approaches are based on five message types delivered at four locations, as shown in Table 7. These message types are discussed below.

Table 7. Message/Location Summary for Objective 5

MESSAGE TYPE	POTENTIAL LOCATIONS
Traffic Congestion w/HOV information	h
Estimated Trip Time w/HOV information	h
Transit Information	h, w, b, p
Ridesharing Information	h, w
Benefits of HOV Travel	h, w, p

Traffic Congestion with HOV and Estimated Trip Time with HOV

One approach to increasing HOV travel is to appeal to drivers' self-interest: drivers may be more willing to switch to HOV if they perceive an immediate advantage. HOV lanes usually allow qualified drivers to avoid at least some of the traffic congestion that SOV drivers must face and, consequently, to reduce their trip time. Therefore, messages about traffic congestion and estimated trip time may persuade drivers to switch from SOV to HOV. For this to occur, information must distinguish between SOV and HOV travel conditions, and the latter must actually offer a significant advantage. If HOV lanes offer no advantage, then messages about traffic congestion and estimated trip times will be ineffective. Local conditions (e.g., the existence of a seamless HOV system) must be considered in assessing any ATIS that provides these messages.

If the objective of the ATIS is a long-term behavior change from SOV to HOV, then messages about traffic congestion need not be time sensitive and can be disseminated at virtually any location via any interface module, high-tech or not. (Please see the discussion below under "Benefits of HOV Travel.")

On the other hand, if the objective of the ATIS is to persuade drivers *on a particular day* to use HOV instead of SOV transportation, then the message's timing and location become much more important. In such a case, real-time congestion information or estimated trip times must be available to drivers at home before departure. The logic of this requirement is simple: drivers will decide before leaving home whether to commit to HOV for the day; few can be persuaded later in the day to leave their vehicles at work (or any other destination) in favor of transit or ridesharing.

Transit Information

Once a traveler has decided to pursue HOV transportation, he or she has two options: transit or ridesharing. The next few paragraphs addresses transit; ridesharing follows.

A traveler who opts for transit must select the appropriate transit route(s) and departure time(s) and make sure he or she has the necessary fare. An experienced rider may have access to this information through printed bus schedules collected on previous trips. A novice transit user will need—in addition to information about routes, schedules, and fares—detailed instructions about the service, e.g., where to catch the bus, when and how much to pay, and how to make transfers. Drivers who have difficulty obtaining this information—or who anticipate that obtaining it will be difficult—may abandon transit as an option.

Transit information must be available to potential riders before departure. Minimally, they must be able to select a route and time from home and from work. Because a traveler needs information specific to his or her own trip—and because transit information can be extremely detailed—an interactive interface is essential. Experienced transit riders could benefit from scheduling information based on real-time rather than previously printed data; riders informed of delays could avoid long bus-stop waits. Making real-time vehicle location information available at the bus stops themselves, for example through a computerized display, might allow riders to endure long delays elsewhere than at the stop. Making real-time vehicle location information available at home or work might allow riders to better estimate when they had to leave to catch the bus. Making general transit information available from additional locations would allow drivers to more easily use transit for other travel besides commuting to and from work, e.g., running errands or going out to lunch. In all these cases, a reduction in rider stress would be likely, even when time savings were not.

Ridesharing Information

The communication needs of a traveler who pursues ridesharing are unique among ATISs: drivers often give a great deal of information about themselves (name, address, workplace) in addition to obtaining information about the ridesharing system. Most ridesharing systems are static in that agency-assisted ride matching is a one-time (or at least infrequent) event for each traveler. No real-time data are necessary for systems in which carpools are formed once and remain stable, traveling on a regular schedule. Dynamic ridesharing—in which ride matching is done on an ad hoc basis with minimal advance planning—is in its infancy.

Arrangement of static ridesharing is likely to involve a dialog between the traveler and the agency representative, and because this dialog may take time, a traveler is most likely to initiate contact from home or work. Because an exchange of information is typical, an interactive interface is required. Dynamic ridesharing is a much more challenging communications problem. Drivers and riders must be able to make matches quickly and from virtually any location for such a system to work.

Benefits of HOV Travel

As discussed above, SOV drivers may switch to HOV travel out of self-interest, especially to avoid congestion and to reduce trip time. Other benefits not usually addressed by ATISs are relief from the responsibility of driving, the reduction of parking costs, and the increase of parking availability. There are also more altruistic reasons for HOV travel, namely reducing energy consumption and environmental pollution. A few ATISs disseminate a variety of public service announcements, including messages promoting HOV travel. The effectiveness of such messages is uncertain; in any case they are not particularly time-sensitive and, therefore, do not require advanced technology for their dissemination.

Moreover, drivers may avoid using an information service that dedicates significant "air time" to information that they do not perceive as useful. The study team recommends that designers of traveler information systems limit their dissemination of PSAs, especially if they do not directly support the objectives of the system.

CHAPTER 4. CLASSIFICATION OF THE ATISs IN THIS STUDY

As mentioned, 36 ATISs were analyzed during the creation of our proposed taxonomy: 15 ADISs, 12 APTISs, seven RISs, and two hybrid systems. Table 8 indicates the classification of these systems according to the taxonomy developed in this study. The ATISs that were actually assessed in this study are presented in italics. Note that the first ATISs listed have the broadest scope, having all three system goals. Farther down the table, the number of goals served by the systems decreases.

Table 8. ATIS Classification

Goal 1: Remove Individual Drivers from Congested Roads		**Goal 2: Reduce Individual Drivers' Overall Use of Roadways**		**Goal 3: Alter Drivers' Modes of Transportation**
Objective 1: Influence Drivers to Travel at Less Congested Times	**Objective 2: Influence Drivers to Travel Less Congested Routes**	**Objective 3: Minimize Drivers' Navigation Errors**	**Objective 4: Influence Drivers to Minimize Total Travel**	**Objective 5: Influence SOV Drivers to Switch to HOV Modes**
Advanced Driver Information Systems				
Traffic Reporter	*Traffic Reporter*		*Traffic Reporter*	*Traffic Reporter*
Bellevue Smart Traveler	*Bellevue Smart Traveler*		*Bellevue Smart Traveler*	*Bellevue Smart Traveler*
Houston Smart Commuter	Houston Smart Commuter			Houston Smart Commuter
Inform	Inform		Inform	
Integrated System	Integrated System		Integrated System	
	CHART	CHART	CHART	
	ADVANCE	ADVANCE	ADVANCE	
	TravTek	TravTek	TravTek	
Incident Mgmt	Incident Mgmt	Incident Mgmt		
FLOW	*FLOW*			
Direct/SCANDI	Direct/SCANDI			
Santa Monica Smart Corridor	Santa Monica Smart Corridor			
GuideStar	GuideStar			
TransCom	TransCom			
Canadian Border Crossing	*Canadian Border Crossing*			
	Pathfinder			

Table 8. ATIS Classification (continued)

Goal 1: Remove Individual Drivers from Congested Roads		**Goal 2: Reduce Individual Drivers' Overall Use of Roadways**		**Goal 3: Alter Drivers' Modes of Transportation**
Objective 1: Influence Drivers to Travel at Less Congested Times	**Objective 2: Influence Drivers to Travel Less Congested Routes**	**Objective 3: Minimize Drivers' Navigation Errors**	**Objective 4: Influence Drivers to Minimize Total Travel**	**Objective 5: Influence SOV Drivers to Switch to HOV Modes**
Advanced Public Transit Information Systems				
				ESDS
				Metro Vision
				AIDS
				CRIS
				BusTime
				TranStar
				Caltrans
				Hillsborough Transit Authority
				GoTime
				Central Ohio Transit Authority
				Travlink
				Gateway
Ridesharing Information Systems				
				Metro Ridematch
				Metro VanPool
				CC
				Walker, Rich, & Quinn
				RSL Fone-Link
				Loseff Voicemail Model
				California Smart Traveler

System objectives in this chart were primarily inferred from the kinds of messages provided to drivers; objectives thus inferred may or may not coincide with the system designer's stated objectives. Note also that the systems were classified according to the objectives that they have the *potential* to achieve given their messages; the degree to which a system actually achieves its objectives can be determined only by a system-specific assessment study. Finally, some ATISs included in this study were still under development at the time of analysis, and the objectives and messages attributed to them in Table 8 may not reflect their ultimate implementation. (In fact, one of the four systems this study assessed in detail was only in the conceptual stage.)

The ATIS taxonomy developed in the first phase of this study proved extremely useful in the planning of each ATIS's assessment. The taxonomy led to a hierarchy of key characteristics of ATISs (see also Table 2 for a clear view of the hierarchical relationships):

Level One
- System Objective

Level Two
- Message Type

Level Three *(Interface Modules)*
- Location

Level Four *(Interface Modules)*
- Technology
- Format
- Interactivity

This hierarchy was used to develop general assessment questions. Levels Three and Four were separated so that location could be assessed separately from the other three components of an interface module. The study team concluded that the assessment of any ATIS would have to address each level of the hierarchy. The study team also concluded that usability tests should be conducted iteratively during ATIS project development; such tests, however, were beyond the scope of the current project. (For guidance on usability tests of ATISs, see Crosby et al. (1993) and Miller et al (in press).)

We developed the following general assessment questions for all ATISs:

Level One
- Are the system's objectives appropriate for the drivers who have (or will have) access to it?

Level Two
- Do the system's messages achieve their objectives; that is, do they actually (or have the potential to) influence drivers' behavior?

Level Three

- Is the system's delivery location appropriate?

Level Four

- Is the system's technology appropriate?
- Is the message's format appropriate?
- Is the system's level of interactivity appropriate?

Note that these questions are partly hierarchical in nature: if the answer to a higher-level question was "no," then the answer to one or more of the lower-level questions would likely also be "no." For example, if the system's objectives were inappropriate for the drivers who had access to it, it is unlikely that the system's messages would achieve their objectives. On the other hand, an answer of "yes" to a higher-level question does not necessarily mean that "yes" would be the answer to lower-level questions. For example, even if a system's objectives were entirely appropriate for its audience, the format of the system's messages might be less than optimum.

Note also that these questions are communication- and user-oriented; that is, they focus on the system's ability to communicate effectively with drivers. This focus is consistent with the study team's decision to approach this study not as a technological problem but as a technical communication problem. (See the study introduction for further discussion of this decision.) Accordingly, the study team concluded that user input, most likely through interviews or questionnaires, would be necessary for our assessment of ATISs.

CHAPTER 5. ASSESSMENT OF FLOW

The first ATIS to be assessed by the study team was FLOW, a computer-based graphical display of traffic speeds on Seattle's freeways. At the time of assessment, FLOW was the earliest of the systems and was installed in a single public location, namely Westlake Center in downtown Seattle.

FLOW ASSESSMENT METHODS

The first step in assessing FLOW was to identify and characterize its potential audience. In the most general terms, FLOW's potential audience includes everyone who visits Westlake Center. However, more realistically, FLOW's audience is much narrower because its message type is limited to traffic congestion on Seattle freeways. Thus the audience is limited to drivers who use Seattle freeways to reach Westlake Center, encounter traffic congestion on the freeways, and are willing to change their routes and/or departure times. Because FLOW's audience is such a small subset of the Westlake Center population, and because that population would not be strongly motivated to participate in the assessment of FLOW, the study team opted for interviews rather than questionnaire instruments. The first section of the interview was designed to include questions that would distinguish members of FLOW's audience from other visitors to Westlake Center: place of residence, origin and purpose of trip, frequency of visits, and usual route and transportation mode. (A copy of the interview instrument is included in Appendix A.)

The second section of the interview instrument concerned the traveler's prior knowledge and use of FLOW. The study team was interested in determining the portion of FLOW's intended audience that was even aware of its existence and, among them, the portion that used it, either occasionally or regularly. This information was needed to distinguish between the effects of publicity and the effects of system design. Failure in either area might prevent the system from reaching its intended audience, but remedial measures would, of course, be very different.

Section three of the interview instrument focused on the actual assessment of FLOW itself. Questions in this section were organized according to the levels of the taxonomy. The first two were directed at the message's ability to achieve its objectives: is information about traffic congestion likely to influence drivers to change their routes or departure times? The next two investigated the usefulness of traffic congestion information and other potential message types. Questions five and six concerned the convenience of Westlake Center and other locations for receiving traffic congestion information. Questions seven and eight focused on the computer and other technologies that could be used to deliver traffic congestion information. The next pair of questions concerned the format in which the information is presented. (FLOW is a schematic map with text labels.) The next two addressed the issue of interactivity. (FLOW is non-interactive.) Note that questions three through twelve were paired: the first question asked participants to rate the success of a specific characteristic of FLOW; the second question asked them to rank optional characteristics that could be used by ATISs in general. The last question asked for additional comments or suggestions about FLOW.

FLOW ASSESSMENT RESULTS

Two graduate-student research assistants completed 66 interviews at Westlake Center between March 29 and April 3, 1993. The earliest interview started at 11:04 a.m., the latest at 6:30 p.m. These hours reflected the peak usage of Westlake Center; the Center has very few visitors outside this time frame.

Chi-squares were used to test for significant differences (at an alpha-level of .05) in the number of responses in each category or ranking scale. In other words, the statistical test ensured (with 95 percent certainty) that trends evident in the responses were genuine and not merely random variation. Reported p values of .05 or less suggest significant; p values greater than .05 are not reported. Statistical analyses were limited to questions with an adequate number of responses for meaningful results.

Part I. Audience Profile

All respondents answered the questions in the audience profile section.

When asked "What brings you to downtown Seattle today?" 42 (64 percent) of the respondents reported that "work" was their primary reason for being in downtown Seattle on the day they were interviewed. Eleven cited "shopping" as their primary task; seven cited "other business;" one cited "tourism" (showing visiting parents around the city); five cited miscellaneous tasks (dropping a friend off at work, bringing a car in for repairs). Statistical analysis revealed a significant difference in the number of responses in each category (χ^2 = 82.49, df = 4, critical = 9.49, $p < .05$, n = 66).

The research team recognized that visitors to the Puget Sound area were unlikely users of FLOW, given limited knowledge of Seattle's usual traffic levels, typical trip times, or alternative routes. Therefore, only respondents who reported that they lived in the Puget Sound area were interviewed. The majority of respondents (64.6 percent) lived in Seattle. Table 9 summarizes the respondents' places of residence.

Table 9. FLOW Respondents' Place of Residence

Area	Count	% of Respondents
City of Seattle	42	64.6
North of Seattle	7	10.8
South of Seattle	10	15.4
East of Seattle	5	7.7
West of Seattle	1	1.5
Totals	65	100.0

(χ^2 = 84.15, df = 4, critical = 9.49, $p < .05$, n = 65)

The research team assumed that most respondents would have come to downtown from their place of residence but decided to ask for confirmation of this point. Of the 66 respondents, only six reported that they had come to Westlake Center from some place other than their residence, most from their place of work.

The research team was interested in how often respondents visit Westlake Center because they wanted to evaluate the accessibility of FLOW in its current location. Respondents were asked how frequently they came to Westlake Center. Respondents answered in terms of frequency per week, month, or year; for chi-square analysis, the research team converted all responses to frequency per year. A majority of respondents visited Westlake Center either once a week or once a month. Table 10 summarizes the data.

Because the research team had already identified drivers as the primary audience for FLOW, respondents were asked how they usually traveled to Westlake Center. Nearly 26 percent of respondents rode the bus to get to Westlake Center; 18.3 percent bused and walked; and 15.2 percent drove alone. Table 11 summarizes their responses.

Table 12 collapses Table 11 into fewer categories—summarizing respondents' usual mode of transportation with multiple modes collapsed into those that involve driving and those that do not.

Table 10. FLOW Respondents' Frequency of Visits to Westlake Center

Number of Visits	Count	% of Respondents
Up to:		
1 visit per year	5	7.6
1 visit per month	24	36.4
1 visit per week	19	28.8
2 visits per week	4	6.1
3 visits per week	3	4.5
4 visits per week	2	3.0
5 or more visits per week	9	13.6
Totals	66	100.0

(χ^2 = 47.70 df = 6, critical = 12.59, $p < .05$, range = 1 to 312 visits per year, mean = 67.32, n = 66)

Only 12 of 66 respondents indicated that they had not used their usual mode of transportation to reach downtown Seattle on the day of their interview. By far, the majority of respondents used their usual mode of transportation.

Table 11. FLOW Respondents' Usual Mode of Transportation to Westlake Center (full set)

Usual Mode	Count	% of Respondents
Single occupancy vehicle	10	15.2
Carpool	7	10.6
Bus	17	25.8
Walk	6	9.1
Single occupancy vehicle and bus	1	1.5
Single occupancy vehicle and walk	3	4.5
Carpool and bus	1	1.5
Carpool and walk	3	4.5
Carpool and monorail	1	1.5
Bus and walk	12	18.3
Single occupancy vehicle and bus and bicycle	1	1.5
Single occupancy vehicle and bus and walk	3	4.5
Carpool and bus and bicycle	1	1.5
Totals	66	100.0

($\chi^2 = 62.03$, df = 12, critical = 21.03, $p < .05$, n = 66)

Table 12. FLOW Respondents' Usual Mode of Transportation to Westlake Center (collapsed set)

Usual Mode	Count	% of Respondents
Single occupancy vehicle	10	15.2
Carpool	7	10.6
Bus	17	25.8
Walk	6	9.1
Multiple mode involving driving	13	19.7
Multiple mode not involving driving	13	19.7
Totals	66	100.0

($\chi^2 = 7.82$, df = 5, critical = 11.07, n = 66, total involving driving/non-driving: 30/36)

Because FLOW's traffic congestion information is limited to major freeways (I-5, I-90, SR-520, and SR-405), only travelers who reached downtown via these routes would benefit from using the system in its current location. The research team therefore asked interviewees, "How frequently do you take a freeway to get here?" Forty-four percent reported *always* taking a freeway to reach Westlake Center. Table 13 summarizes their responses.

The research team anticipated that travelers who rarely or never encountered traffic congestion on the freeways might not find FLOW's information particularly useful. Therefore, a follow-up to the above question was, "How frequently do you encounter traffic congestion on the freeway?" Nearly a third reported that they always encountered traffic congestion on the freeways, and only 12 percent reported that they never encountered traffic congestion. Their responses are summarized in Table 14 .

Table 13. FLOW Respondents' Frequency of Travel to Downtown Seattle via Freeways

Rated Frequency	Count	% of Respondents
Never	20	30.3
Rarely	9	13.6
Half the time	3	4.5
Usually	5	7.6
Always	29	44.0
Totals	66	100.0

($\chi^2 = 36.73$, df = 4, critical = 9.49, $p < .05$)

Table 14. FLOW Respondents' Frequency of Traffic Congestion Encounters on Freeways

Rated Frequency	Count	% of Respondents
Never	7	12.1
Rarely	11	19.0
Half the time	11	19.0
Usually	10	17.2
Always	19	32.7
Totals	58*	100.0

($\chi^2 = 6.83$, df = 4, critical = 9.49, n = 58)

*The total number of responses is 58 instead of 66 because one interviewer assumed incorrectly that this question did not apply to people who indicated in the preceding question that they "never" traveled on the freeways to reach downtown Seattle.

Part II. Knowledge and Use of FLOW

Two sets of questions were developed for this section: the first for respondents recruited randomly from visitors to Westlake Center and the second for respondents whom the interviewers had observed using FLOW on their own initiative.

Set 1: Random Sample of Mall Occupants

Fifty-six of the interview instruments' respondents were recruited randomly among people who passed by the Information Desk where FLOW is installed. The following eight questions pertained only to this group.

Awareness and Use of FLOW. Respondents were asked whether they were aware that current traffic information is available at the information desk through a computer display called FLOW. Of the 56 randomly selected respondents, 50 were unaware that traffic information was available through FLOW.

Of the six respondents familiar with FLOW, one had been told about it by a relative who had seen it at Westlake Center. One had seen it at a transportation fair. The remaining four had noticed it earlier in Westlake Center. However, of the six respondents who knew of FLOW, four had never used it. Of these four, two said they had never used FLOW because they never drive to downtown Seattle. One said s/he never drove to or from Westlake Center. The other one said s/he was not really bothered by traffic congestion.

Of the six respondents familiar with FLOW, only two (the same two who had used FLOW before) said they were likely to use FLOW on the day of the interview. The same four who had never used FLOW offered the same reasons for not being likely to use it on the day of the interview.

Usefulness of FLOW's Information on Day of Interview. Respondents were asked whether they would find FLOW's information useful on the day of the interview. Of the 56 respondents, 27 said no; 29 said yes. Those who reported that traffic congestion information would not be useful on the day of the interview were asked for a reason. Of the 27 respondents who said that FLOW's information would not be useful, 12 were bus riders who noted that the bus schedules are not much affected by traffic congestion. Four said that they were not planning to drive from Westlake Center. Three said they were unlikely to encounter traffic congestion. Three said that they had not driven to downtown and did not plan to drive home. The remaining five offered unique reasons: inflexible driving plans; disregard for traffic congestion; belief that the on-line data were not current; belief that the on-line data was not reliable; or dislike of computers.

Set 2: Observed Users of FLOW

Ten of the 66 interview instrument respondents were recruited by an interviewer who had observed them using FLOW on their own. This section pertains only to this group.

Awareness and Use of FLOW. Seven of the ten people observed using FLOW said they had stopped at the information desk specifically to use FLOW. The other three had come to the information desk for another reason but decided to stop and look at FLOW while they were there.

Of the ten people observed using FLOW, five had stopped to use FLOW because they saw the interviewers' sign and became curious about the program. Three (two of whom worked at Westlake Center) had noticed it earlier when passing by. Another had been told about it by a friend. One claimed to "know the person who came up with the idea" but declined to elaborate.

Usefulness of FLOW's Information on Day of Interview. Four of the ten people who had used FLOW reported that they had found the information useful. The remaining six were asked why they had not found it useful. Of the six people who had not found FLOW's information useful, two explained that they did not use the freeways, one had no car, one respondent's bus route was not affected by congestion, one was not bothered by traffic congestion, and are believed that the information was not current enough and did not cover enough areas.

Part III. Assessment of FLOW

All respondents were asked the questions in Part III.

Likely Changes in Route and/or Departure Time

Respondents were asked whether they would be likely to change route and/or departure time if FLOW indicated that their planned route was congested. Of the 66 respondents, 38 percent said they would change either their departure time or their route; only 9 percent said they would not change either. Table 15 summarizes the responses.

Congestion Level Needed to Affect Route or Departure Time

Respondents were asked how congested their route would have to be before they would change their travel plans (i.e., route and departure time). In response, nearly 73 percent said their route would have to be severely congested; only 3 percent said they would not change their travel plans under any circumstances. See Table 16 .

Table 15. Likely Changes in Route and/or Departure Time based on FLOW's Information

Would change:	Count	% of Respondents
Departure time	23	34.8
Route	12	18.2
Either time or route	25	37.9
Neither time nor route	6	9.1
Totals	66	100.0

(χ^2 = 14.85, df = 3, critical = 7.81, $p < .05$)

Table 16. Congestion Level Required before FLOW Respondents Would Change Travel Plans

Would change if:	Count	% of Respondents
Stopped completely	12	18.2
Severe	48	72.7
Moderate	4	6.1
Would not change plans under any circumstances	2	3.0
Totals	66	100.0

(χ^2 = 83.58, df = 3, critical = 7.81 $p < .05$)

The remaining questions were organized in pairs. The first question in each pair related to FLOW specifically; the second related to traffic information systems in general. Each pair of questions addressed a slightly different issue. These issues were: usefulness of FLOW's information, convenience of FLOW's location, helpfulness of FLOW's technology, understandability of FLOW's format, and preference for an automatic or user-specified display.

Usefulness of FLOW's Information

First, respondents were asked to rate the usefulness of FLOW's information on a scale of 1 to 5. The most common rating was 4. A chi-square test revealed a significant difference in the number of responses on each point of the rating scale (see Table 17).

Respondents were then asked to choose which of the information types in Table 9 they would find most useful, second most useful, and third most useful. As their first choice, between 18 and 21 percent of the respondents selected either real-time data about bus schedules and bus locations, traffic congestion for SOV lanes, or help selecting the quickest route to their destination. As their second choice, between 12 and 18 percent chose help selecting the quickest route to their destination, trip-specific bus information, or real-time data about bus schedules and bus locations. For their third choice, between 10 and 15 percent chose help selecting the quickest route to their destination, general bus information, detailed traffic information, or detailed directions for finding their destination (see Table 18).

Table 17. Rated Usefulness of FLOW's Information

Scale	Count	% of Respondents
1 Not very useful	5	7.58
2	11	16.67
3	12	18.18
4	21	31.82
5 Very useful	17	25.76
Totals	66	100.00

($\chi^2 = 11.27$, df = 4, critical = 9.49)

Convenience of F LOW's Location

In the second paired set of questions, respondents rated (on a scale of 1 to 5) Westlake Center's convenience as a location for getting traffic information from FLOW. The most common rating was 1: least convenient. A chi-square test revealed a significant difference in the number of responses on each point of the rating scale (see Table 19).

Table 18. FLOW Respondents' Ranking of Information Types by Usefulness

Information Type	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Traffic congestion for HOV lanes	3	4.5	2	3.0	3	4.5
Traffic congestion for SOV lanes	12	18.2	4	6.1	6	9.1
Detailed traffic information (why traffic is congested, what's being done about it, etc.)	9	13.6	6	9.1	7	10.6
Estimation of travel time for a particular trip	8	12.1	6	9.1	3	4.5
Help selecting the quickest route to destination	12	18.2	12	18.2	10	15.2
Help selecting the most direct route to destination	0	0.0	1	1.5	3	4.5
Detailed directions for finding destination	0	0.0	4	6.1	7	10.6
Information about business or services on route	1	1.5	3	4.5	4	6.1
General bus information (route, schedule, fare)	3	4.5	5	7.6	8	12.1
Trip-specific bus information (route, schedule, fare)	2	3.0	9	13.6	6	9.1
Real-time ("live") data about bus schedules and bus locations	14	21.2	8	12.1	2	3.0
Carpooling or vanpooling information	1	1.5	2	3.0	2	3.0
Information about one-time, on-demand carpooling	1	1.5	4	6.1	5	7.6
Totals	66	100.0	66	100.0	66	100.0

1st choice: ($\chi^2 = 43$, df = 12, critical = 18.31, $p < .05$)

2nd choice: ($\chi^2 = 23.03$, df = 12, critical = 21.03, $p < .05$)

3rd choice: ($\chi^2 = 14.76$, df = 12, critical = 21.03)

Respondents were then asked to rank the top three most convenient possible locations for FLOW from the list in Table 20. Nearly 46 percent chose home as their first choice, followed by 35 percent who chose in-car as their first choice. The next most popular first choice (10.6 percent of respondents) was work. As their second choice, 48.5 percent of respondents selected work, 16.7 selected in-car, and 15.2 percent selected home. For their third choice, 25.8 percent selected home, 19.7 percent selected in-car, 18.2 percent selected work and 18.2 percent selected malls and other commercial areas. As Table 20 reveals, malls and other commercial areas and portable devices were not popular as first and second choices for possible locations for FLOW.

Helpfulness of FLOW's Technology

Respondents rated the helpfulness of a computer like FLOW as a means for providing traffic information. The most common response was 5: very helpful. Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale (see Table 21).

Respondents were then asked to rank the top three most helpful technologies from the list in Table 22. Approximately 24 percent of respondents chose AM or FM radio as their first choice; the next most popular first choice was interruption of AM or FM stations for traffic information about their routes—16.7 percent of respondents chose it; the third most popular first choice (15.2 percent of respondents) was computer. As for their second choice of technology, 27.3 percent of respondents chose AM or FM radio, 22.7 percent chose changeable highway message signs, and 12.1 percent chose interruption of AM or FM stations for traffic information about their routes. For their third choice, 13.6 percent of respondents chose computer, 13.6 chose regular TV, 13.6 percent chose short-distance highway advisory radio, and 13.6 percent chose phone with a touch-tone menu and synthesized voice.

Table 19. Rated Convenience of FLOW's Location

Scale	Count	% of Respondents
1 Not very convenient	27	40.91
2	6	9.09
3	6	9.09
4	6	9.09
5 Very convenient	21	31.82
Totals	66	100.00

($\chi^2 = 30.82$, df = 4, critical = 9.49, $p < .05$)

Table 20. FLOW Respondents' Choice of Possible Locations for FLOW

Possible Locations for FLOW	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Home	30	45.5	10	15.2	17	25.8
Work	7	10.6	32	48.5	12	18.2
In-car	23	34.8	11	16.7	13	19.7
Malls and other commercial areas	1	1.5	7	10.6	12	18.2
Portable device (like a pager)	5	7.6	6	9.1	11	16.7
Totals	66	100.0	66	100.0	65	100.0

1st choice: ($\chi^2 = 47.94$, df = 4, critical = 9.49, $p < .05$)
2nd choice: ($\chi^2 = 34.76$, df = 4, critical = 9.49, $p < .05$)
3rd choice: ($\chi^2 = 1.69$, df = 4, critical = 9.49)

Table 21. Rated Helpfulness of FLOW's Technology

Scale	Count	% of Respondents
1 Not very helpful	6	9.23
2	3	4.62
3	8	12.31
4	18	27.69
5 Very helpful	30	46.15
Totals	65	100.00

($\chi^2 = 27.54$, df = 4, critical = 9.49, $p < .05$)

Respondents were then asked to rank the top three most helpful technologies from the list in Table 22. Approximately 24 percent of respondents chose AM or FM radio as their first choice; the next most popular first choice was interruption of AM or FM stations for traffic information about their routes—16.7 percent of respondents chose it; the third most popular first choice (15.2 percent of respondents) was computer. As for their second choice of technology, 27.3 percent of respondents chose AM or FM radio, 22.7 percent chose changeable highway message signs, and 12.1 percent chose interruption of AM or FM stations for traffic information about their routes. For their third choice, 13.6 percent of respondents chose computer, 13.6 chose regular TV, 13.6 percent chose short-distance highway advisory radio, and 13.6 percent chose phone with a touch-tone menu and synthesized voice.

Table 22. FLOW Respondents' Ranking of Various Technologies by Helpfulness

Technology	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Computer	10	15.2	6	9.1	9	13.6
Regular TV	8	12.1	3	4.5	9	13.6
Cable TV	3	4.5	6	9.1	3	4.5
AM or FM radio	16	24.2	18	27.3	8	12.1
Short-distance highway advisory radio	3	4.5	3	4.5	9	13.6
Interruption of AM or FM stations for traffic information about your route	11	16.7	8	12.1	6	9.1
Phone—live operator	0	0.0	1	1.5		0.0
Phone—touch-tone menu with synthesized voice	7	10.6	3	4.5	9	13.6
Changeable highway message signs	4	6.1	15	22.7	8	12.1
Portable device (like a pager)	4	6.1	3	4.5	5	7.6
Totals	66	100.0	66	100.0	66	100.0

1st choice: ($\chi^2 = 21.27$, df = 9, critical = 15.51, $p < .05$)

2nd choice: ($\chi^2 = 43.39$, df = 9, critical = 16.92, $p < .05$)

3rd choice: ($\chi^2 = 5.18$, df = 9, critical = 15.51)

Understandability of FLOW's Format

Respondents were asked to rate the understandability of FLOW's format on a scale of 1 to 5. The most common response was 5: easiest to understand. Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale (see Table 23).

Interviewers then asked respondents to rank various delivery formats for traffic information by their understandability. The most popular format—and presumably the one respondents found easiest to understand—was maps (68.2 percent). The second most popular first choice was speech (22.7 percent). Second and third choices for format were more mixed. The most popular second choice was speech (40 percent), and the most popular third choice was text (37.5 percent) (see Table 24).

Table 23. Rated Understandability of FLOW's Format

Scale	Count	% of Respondents
1 Not very easy to understand	0	0.00
2	2	3.03
3	18	27.27
4	20	30.30
5 Very easy to understand	26	39.39
Totals	66	100.00

($\chi^2 = 40.36$, df = 4, critical = 9.49, n = 66, $p < .05$)

Table 24. FLOW Respondents' Ranking of Formats for Traffic Information by Understandability

Format	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Maps	45	68.2	10	15.4	8	12.5
Charts and graphs	3	4.5	19	29.2	16	25.0
Text	3	4.5	10	15.4	24	37.5
Speech	15	22.7	26	40.0	16	25.0
Totals	66	100.0	65	100.0	64	100.0

1st choice: ($\chi^2 = 71.46$, df = 3, critical = 7.81, $p < .05$)

2nd choice: ($\chi^2 = 11.12$ df = 3, critical = 7.81, $p < .05$)

3rd choice: ($\chi^2 = 8$, df = 3, critical = 7.81, $p < .05$)

Rating of FLOW's Read-Only Interface

Respondents rated their satisfaction on a scale of 1 to 5 with the way FLOW displayed information automatically. The most common response was 3, the center of the scale (see Table 25).

Preference for Read-Only or Interactive Interface

Next, respondents stated the kind of interface they preferred: read-only or interactive. Although they were fairly satisfied with FLOW's read-only interface, when given a choice respondents overwhelmingly preferred an interactive interface (89 percent) to a read-only one (11 percent) ($\chi^2 = 40.97$, df = 1, critical = 3.84, n = 66, $p < .05$).

FLOW ASSESSMENT DISCUSSION

To finish our assessment of FLOW, we must return to the taxonomy. Below is a discussion of the data in terms of each level of the taxonomy and the general questions set forth on page 35.

Levels One and Two. Are the system's objectives appropriate for the travelers who have access to it? Do the system's messages achieve their objectives?

The only objectives supported by FLOW's message type (traffic congestion for Seattle-area freeways) are to influence drivers to travel less congested routes and to influence drivers to travel at less congested times. Accordingly, for the system to achieve its objectives, it must communicate successfully with a very specific audience, drivers who (1)

Table 25. Rated Satisfaction with FLOW's Read-Only Interface

Scale	Count	% of Respondents
1 Not very satisfied	4	6.15
2	12	18.46
3	21	32.31
4	15	23.08
5 Very satisfied	13	20.00
Totals	65	100.00

($\chi^2 = 11.54$, df = 4, critical = 9.49, n = 65, $p < .05$)

use Seattle's freeways on their way to and from Westlake Center, (2) encounter significant traffic congestion along the way, and (3) are flexible regarding routes or departure times. Part I of the interview instrument determined that 51.6 percent of respondents *always* or *usually* took a freeway to get to Westlake Center and that 49.9 percent *always* or *usually* encountered traffic congestion (see Tables 13 and 14), which the study team concluded satisfied conditions 1 and 2. Of the respondents who said they *always* or *usually* took a freeway <u>and</u> said they *always* or *usually* encountered traffic congestion (23 of the 66 respondents), 86.96 percent (20 respondents) said they would change time, route, or both on the basis of FLOW's information, thus meeting condition 3. Given these results, the study team concluded that FLOW's objectives are appropriate for the travelers who have access to it and that FLOW's message type achieves these objectives.

<u>Level Three. Is the system's delivery location appropriate?</u>

When respondents were asked to rate the convenience of FLOW's location, the study team received a mixed response (see Table 19). The most common response was 1 (least convenient); yet the second most common response was 5 (most convenient). Further, when asked to rank possible locations for FLOW, malls and other commercial areas (such as Westlake Center) were ranked low—only 1.5 percent of respondents chose them as their first choice for location (see Table 20). An important fact is that 64 percent of respondents reported that "work" was their primary reason for being in downtown Seattle on the day they were interviewed; however, none of these respondents was employed at Westlake Center. To benefit from FLOW's information, these respondents would have to go to Westlake Center from their workplace before driving home, an inconvenient task. Further, Westlake Center as a location for FLOW can only partially help FLOW achieve its system goals because it can influence drivers to travel less congested routes and/or at less congested times only for their trip home but has no influence on their trip to downtown. Thus, the study team concluded that Westlake Center was not an appropriate delivery location for FLOW's information.

Level Four. Is the system's technology appropriate?
Is the message's format appropriate?
Is the system's level of interactivity appropriate?

Respondents rated the helpfulness of a computer like FLOW as a means for providing traffic information fairly high (the mean was 3.97). When respondents were asked to rank the top three most helpful technologies, a computer was the third most popular first choice (15.2 percent chose it); however, it did not appear among the top three for respondents' second or third choices. Different forms of radio delivery seemed to be the most popular (see Table 22). Although a computer has as many or more potential interface locations as various forms of radio, significantly more people are likely to have access to radios than to computers.

As for its message format, FLOW was rated as very easy to understand. Further, when respondents were asked to rank formats for traffic information by understandability, maps—such as FLOW's—were by far the first choice of format (see Table 24).

Respondents seemed generally satisfied with the way FLOW displays information automatically; however, when given a choice, they decidedly preferred an interactive interface.

SUMMARY OF FLOW ASSESSMENT

In conclusion, FLOW's message type supports FLOW's system objectives of influencing drivers to travel less congested routes and influencing drivers to travel at less congested times. However, because Westlake Center is an inappropriate location for FLOW's information, it prevents FLOW from fully achieving its system goal. Further, given respondents' stated preferences, an interactive interface would be more appropriate for delivery of FLOW's information than its current read-only interface.

CHAPTER 6. ASSESSMENT OF TRAFFIC REPORTER

The second ATIS to be assessed by the study team was Traffic Reporter, which—like FLOW—is a computer-based graphical display of real-time information on Seattle's freeways. Unlike FLOW, Traffic Reporter is interactive; a user can select his or her origin and destination, and Traffic Reporter provides information on several possible routes between the user's origin and destination beginning with the most time efficient route. Traffic Reporter gives the estimated trip time, average speeds, and distance for each route and estimates the travel time users would save for each route if they traveled in the HOV lanes.

At the time of assessment, Traffic Reporter was installed in two public locations: Westlake Center in downtown Seattle and Bellevue Place in downtown Bellevue.

TRAFFIC REPORTER ASSESSMENT METHODS

The study team first classified Traffic Reporter according to the objectives inherent in its message types. The study team identified six message types delivered by Traffic Reporter: (1) traffic congestion; (2) estimated trip time; (3) route selection; (4) trip distance; (5) traffic congestion on HOV lanes; and (6) estimated trip time using HOV lanes. Traffic congestion in Traffic Reporter is represented by speeds. Given these message types, Traffic Reporter supports four objectives: to influence drivers to travel at less congested times, to influence drivers to travel less congested routes, to influence drivers to reduce trip frequency or distance, and to influence SOV drivers to switch to HOV modes (see Table 26).

The study team identified one module employed to deliver all of Traffic Reporter's message types: a computer with a communication link. The potential locations for this module include the traveler's home, work, and vehicle, as well as a kiosk placed in a shopping or business area or a portable device. This module also has the potential for interactivity. However, the current implementation of Traffic Reporter does not take full advantage of its potential; although it is interactive, it is currently accessible from only one of the locations mentioned: a kiosk placed in a shopping/business area.

The next step in assessing Traffic Reporter was to identify and characterize its potential audience. Like FLOW, Traffic Reporter's audience is fairly narrow because its message types are limited to information on the greater Seattle-area freeways. Thus the audience is limited to drivers who use these freeways to reach Westlake Center or Bellevue Place, encounter traffic congestion on the freeways, and are willing to change their modes, routes, and/or departure times. The assessment of Traffic Reporter began during the Christmas holiday season. During this time, the activity in Westlake Center reached peak volume. Because of the crowded conditions, the study team was unable to conduct in-person interviews. Instead, the study team placed surveys next to Traffic Reporter at the Westlake Center information desk. As an incentive, the study team advertised a drawing that would be held for survey participants for a $30 gift certificate redeemable at any Westlake Center store. Westlake Center respondents could return their surveys by handing them to the information desk attendant or by mailing them directly to the Department of Technical Communication at the University of Washington. Because Traffic Reporter was also installed at Bellevue Place, the study team decided to assess Traffic Reporter at its Bellevue Place location as well. To keep the administrative methods consistent, the study team opted to set out surveys at Bellevue Place (rather than doing in-person interviews). As an incentive, Bellevue Place respondents were given the option of entering a drawing for a $30 gift certificate redeemable at Bellevue Place. The Bellevue Place respondents returned their surveys by mail.

The study team began collecting Westlake Center surveys in mid-December 1993 and concluded collection in mid-February 1994. Collection of Bellevue Place surveys began in mid-February 1994 and ran through March 1994. The surveys for both locations were identical except for location names; that is, "Bellevue" and "Bellevue Place" replaced "Seattle" and "Westlake Center" in the Bellevue Place surveys. The study team received 33 surveys from Westlake Center respondents and 15 from Bellevue Place. The response rate may have been relatively low because of technical problems that Traffic Reporter experienced at both locations during the survey period. These technical problems, related to source data access, led Westlake Center personnel to remove Traffic Reporter for approximately ten days during the holiday season and Bellevue Place personnel to remove Traffic Reporter for a two-week period. (Both FLOW and Traffic Reporter rely on the same data.)

Similarly to the FLOW interviews, the first section of the Traffic Reporter survey included questions that distinguished members of Traffic Reporter's audience from other visitors to Westlake Center and Bellevue Place: section one questions concerned place of residence, origin and purpose of trip, frequency of visits, and usual route and transportation mode. The second section of the survey concerned the traveler's prior knowledge and use of Traffic Reporter. As in the FLOW assessment, the study team was interested in finding out the portion of Traffic Reporter's intended audience that was even aware of the program's existence and, among them, the portion that used it, either occasionally or regularly.

Table 26. Classification of Traffic Reporter

Strategies	Remove Individual Drivers from Congested Roads		Reduce Individual Drivers' Overall Use of Roadways	Alter Travelers' Modes of Transportation
I. System Goals	Influence Drivers to Travel at Less Congested Times	Influence Drivers to Travel Less Congested Routes	Influence Drivers to Reduce Trip Frequency or Distance	Influence SOV Drivers to Switch to HOV Modes
II. Message Type	(1) Traffic Congestion (2) Estimated Trip Time	(1) Traffic Congestion (2) Estimated Trip Time (3) Route Selection	(1) Trip Distance (2) Estimated Trip Time	(1) Traffic Congestion w/HOV Information (2) Estimated Trip Time w/HOV Information
III. Location	Kiosk	Kiosk	Kiosk	Kiosk
IV. Interface Technology	Computer	Computer	Computer	Computer
Format	Text, Graphics	Text, Graphics	Text, Graphics	Text, Graphics
Interactivity	Yes	Yes	Yes	Yes

Section three of the survey focused on the actual assessment of Traffic Reporter. Again, like the FLOW assessment questionnaire, questions in this section was organized according to the levels of the taxonomy. The first two was directed at the message's ability to achieve its objectives: Was information about traffic congestion likely to influence drivers to change their routes or departure times? Was information about traffic congestion with HOV information likely to influence SOV drivers to change to HOV modes? The next two questions investigated the usefulness of traffic congestion information and other potential message types. Questions five and six concerned the convenience of Westlake Center and Bellevue Place and other locations for receiving traffic congestion information. Questions seven and eight focused on the computer and other interface technologies that could be used to deliver traffic congestion information. The next pair of questions concerned the format in which the information is presented. (Traffic Reporter is a schematic map with text labels.) The next two addressed the issue of interactivity. Like the FLOW questionnaire, questions three through twelve in section three were paired: the first question asked participants to rate the success of a specific characteristic of Traffic Reporter; the second question asked them to rank optional characteristics that could be used by ATISs in general. The last question asked for additional comments or suggestions about Traffic Reporter. A copy of the entire survey is included in Appendix B.

TRAFFIC REPORTER ASSESSMENT RESULTS

The study team first determined whether there were any significant differences between Bellevue Place and Westlake Center respondents. Chi-squares were used to compare nominal data, and Mann-Whitney *U* tests were used to compare ordinal data. Significant differences were noted at an alpha level of .05. The author chose to report the responses of the two groups separately when one of the following conditions existed: (1) the two groups differed significantly in their responses, or (2) the two different locations required separate analysis. Significant differences were found only in the responses to the first section of the survey, Audience Profile. Chi-squares were used to test for significant differences (at an alpha level of .05) in the number of responses in each category or ranking scale. In other words, the statistical test ensured (with 95% certainty) that trends evident in the responses were genuine and not merely random variation. Reported p values of .05 or less suggest significance; p values greater than .05 are not reported. Statistical analyses were limited to questions with an adequate number of responses for meaningful results.

Part I. Audience Profile

When asked, "What brings you to downtown Seattle/Bellevue today?", approximately 44 percent of the respondents reported that "work" was their primary reason for being in downtown Seattle/Bellevue on the day they used Traffic Reporter. An additional 27 percent cited "shopping" as their primary task; 21 percent cited "other business"; 2 percent cited "tourism"; 6 percent reported other tasks or circumstances. Statistical analysis revealed a significant difference in the number of responses in each category ($\chi^2 = 27$, df = 4, critical = 9.49, $p < .05$, n = 48).

Nearly all of the respondents lived in the Puget Sound area. The most common place of residence for both Westlake Center respondents and Bellevue Place respondents was Seattle. The two groups of respondents did not differ significantly by place of residence. Tables 27 and 28 summarize the respondents' places of residence. The abbreviations WLC and BP are used to refer to Westlake Center and Bellevue Place, respectively, in table titles.

Table 27. Traffic Reporter (WLC) Respondents' Place of Residence

Area	Count	% of Respondents
City of Seattle	21	65.63
North of Seattle	2	6.25
South of Seattle	3	9.38
East of Seattle	6	18.75
West of Seattle	0	0.00
Totals	32	100.00

($\chi^2 = 44.56$, df = 4, critical = 9.49, $p < .05$)

To evaluate the accessibility of Traffic Reporter in its current locations, respondents were asked to rate how frequently they visited Westlake Center/Bellevue Place. The responses were fairly evenly distributed across the scale for both groups of respondents. There were no significant differences between the Westlake Center and Bellevue Place respondents in their rated frequency of visits; however, the results are reported separately as a matter of interest. The number of responses within each group did not differ significantly, either. Table 29 summarizes the data.

Table 28. Traffic Reporter (BP) Respondents' Place of Residence

Area	Count	% of Respondents
City of Bellevue	2	14.29
North of Bellevue	4	28.57
South of Bellevue	3	21.43
East of Bellevue	0	0.00
West of Bellevue (Seattle)	5	35.71
Totals	14	100.00

($\chi^2 = 5.29$, df = 4, critical = 9.49)

Table 29. Traffic Reporter Respondents' Rated Frequency of Visits to Westlake Center/Bellevue Place

Scale	Westlake Center		Bellevue Place	
	Count	% of Respondents	Count	% of Respondents
1 Very infrequently	5	15.625	2	13.33
2	8	25.00	4	26.67
3	6	18.75	3	20.00
4	4	12.50	2	13.33
5 Very frequently	9	28.13	4	26.67
Totals	32	100.00	15	100.00

(Westlake Center: $\chi^2 = 2.69$, df = 4, critical = 9.49)

(Bellevue Place: $\chi^2 = 1.33$, df = 4, critical = 9.49)

($\chi^2 = 18.401$, df = 8, $p < .05$)

Respondents indicated the modes usually used to travel to Westlake Center or Bellevue Place. A chi-square test revealed a significant difference between the usual modes of Westlake Center respondents and Bellevue Place respondents. Nearly half (40.63 percent) of the Westlake Center respondents reported usually riding the bus to reach downtown Seattle, while nearly 67 percent of the Bellevue Place respondents reported driving alone to downtown Bellevue and none reported riding the bus (see Table 30).

Only nine of the Westlake Center respondents and one of the Bellevue Place respondents indicated that they had not used their usual mode of transportation to reach downtown Seattle/Bellevue on the day that they used Traffic Reporter. The majority of respondents had used their usual mode of transportation.

Because Traffic Reporter's traffic congestion information is limited only to major freeways (I-5, I-90, SR-520, and SR-405), only travelers who reach either downtown Seattle or downtown Bellevue using these routes would benefit from the system. Approximately 44 percent of the Westlake Center respondents reported *always* or *usually* using a freeway to reach downtown Seattle, and 80 percent of Bellevue Place respondents reported *always* or *usually* using a freeway to reach downtown Bellevue. Table 31 summarizes their responses.

Table 30. Traffic Reporter Respondents' Usual Mode of Transportation to WLC/BP

	Westlake Center Respondents		Bellevue Place Respondents	
Usual Mode	Count	% of Respondents	Count	% of Respondents
Single occupancy vehicle	6	18.75	10	66.67
Carpool	6	18.75	5	33.33
Vanpool	0	0.00	0	0.00
Bus	13	40.63	0	0.00
Motorcycle/moped	1	3.12	0	0.00
Walk	3	9.38	0	0.00
Bicycle	0	0.00	0	0.00
Drive alone <u>and</u> bus	1	3.12	0	0.00
Motorcycle <u>and</u> bus	1	3.12	0	0.00
Bus <u>and</u> walk	1	3.12	0	0.00
Totals	32	100.00	15	100.00

The research team anticipated that travelers who rarely or never encountered traffic congestion on the freeways might not find Traffic Reporter's information particularly useful. Therefore, a follow-up to the above question, was, "How frequently do you encounter traffic congestion on the freeway?" Approximately 55 percent of the Westlake Center respondents reported encountering freeway traffic congestion *always* or *usually*, and approximately 67 percent of the Bellevue Place respondents reported encountering traffic congestion *always* or *usually*. Their responses are summarized in Table 32.

Table 31. Traffic Reporter Respondents' Frequency of Travel to Downtown Seattle/Bellevue via Freeways

Rated Frequency	Westlake Center Respondents		Bellevue Place Respondents	
	Count	% of Respondents	Count	% of Respondents
Never	4	12.50	0	0.00
Rarely	4	12.50	1	6.67
Sometimes	10	31.25	2	13.33
Usually	0	0.00	4	26.67
Always	14	43.75	8	53.33
Totals	32	100.00	15	100.00

(Westlake Center: $\chi^2 = 19.25$, df = 4, critical = 9.49, $p < .05$)

(Bellevue Place: $\chi^2 = 13.33$, df = 4, critical = 9.49, $p < .05$)

Table 32. Traffic Reporter Respondents' Frequency of Traffic Congestion Encounters on Freeways

Rated Frequency	Westlake Center Respondents		Bellevue Place Respondents	
	Count	% of Respondents	Count	% of Respondents
Never	1	3.45	0	0.00
Rarely	1	3.45	0	0.00
Sometimes	11	37.93	5	33.33
Usually	14	48.28	8	53.33
Always	2	6.89	2	13.33
Totals	29	100.00	15	100.00

(Westlake Center: $\chi^2 = 26.69$ df = 4, critical = 9.49, $p < .05$)

(Bellevue Place: $\chi^2 = 16$, df = 4, critical = 9.49, $p < .05$)

Part II. Knowledge and Use of Traffic Reporter

The study team did not find any significant differences between Westlake Center and Bellevue Place respondents in this section of the survey; therefore, the responses for the two groups have been combined.

Awareness and Use of Traffic Reporter

Half of the respondents reported stopping specifically to use Traffic Reporter. The remainder were nearby for some other reason but had decided to stop and look at Traffic Reporter while they were there. Fifty-nine percent of respondents reported using Traffic Reporter for the first time; 13 percent reported that they had used Traffic Reporter 2 to 3 times before; 15 percent had already used it 4 to 7 times; and 13 percent had used Traffic Reporter over 7 times.

When asked how they had learned about Traffic Reporter, 70 percent of respondents said they had happened to see it while walking by; 14 percent said they had heard about it from friends; 7 percent said they had heard about it from DOT personnel; 4.5 percent had heard about it from employees working at the desk where Traffic Reporter was located; and 4.5 percent had heard about it through their workplace.

Usefulness of Traffic Reporter's Information

Sixty-five percent of respondents reported that Traffic Reporter's information was useful on the day they used Traffic Reporter. Those who did not find Traffic Reporter's information useful gave various reasons. The most frequent reason given (seven respondents) was that Traffic Reporter had shown "insufficient data" at the time that they had tried to use it. (Traffic Reporter displays a message stating that is has insufficient data when it is unable to connect to its source data.) The next most frequent reason was that Traffic Reporter's data were inappropriate to the users' needs: one person said that s/he could not get information on the Eastside, which was his or her primary interest; one reported that s/he was interested in Kent and West Seattle information; and one said s/he was interested in information for South King County (i.e., Federal Way), which was not available on Traffic Reporter. Two respondents reported that the data were old (Traffic Reporter displays a message indicating the time of the last received new data): one wrote that the data were 130 minutes old at the time s/he used Traffic Reporter, and the other simply wrote that the data were not current. Two respondents reported that Traffic Reporter's information was not useful because they did not plan to use the freeway that day, and two respondents reported that the information was not useful because it would not change their driving plans.

Part III. Assessment of Traffic Reporter

The study team found no significant differences between the Bellevue Place and Westlake Center respondents in this section of the survey. For this reason, the study team analyzed responses from both Bellevue Place and Westlake Center together.

Likely Changes in Route, Departure Time, Mode, and/or Trip Frequency

Respondents were asked whether they would be likely to change their mode of transportation (from an SOV to an HOV mode), their departure time, their route, or cancel their trip if Traffic Reporter indicated that their planned route was congested. Approximately 85 percent said they would change their route, and 72 percent said they would change their departure time. Forty percent said they would change their mode, and 17 percent said they would cancel their trip.

If respondents indicated that they could not change any aspect of their trip or cancel it, they were asked why. Respondents could check as many reasons as they felt applied to them and were also provided with an "other" category in which they could write in a response. Reasons given for not changing to an HOV mode were: a lack of carpool partners (15 respondents); the inconvenience of bus/carpooling (11 respondents); and no bus service to the respondent's destination (nine respondents). Six respondents indicated that they could not change their departure time, and four respondents reported that changing their departure time was too inconvenient. Four respondents indicated that they could not change their route, and eight respondents reported that changing their route was too inconvenient. Twenty-two respondents indicated that canceling their trip was not an option. The most frequently occurring "other" reason provided by respondents was a reluctance to let traffic congestion dictate their travel plans.

Congestion Level Needed to Affect Travel Plans

Respondents were asked how congested their route would have to be before they would change their travel plans (i.e., route, departure time, or mode). In response, nearly 73 percent said their route would have to be severely congested; only 3 percent said they would not change their travel plans under any circumstances (see Table 33).

Following the same format as the FLOW interviews, the remaining survey questions were organized in pairs. The first question in each pair related to Traffic Reporter specifically; the second related to traffic information systems in general. Each pair of questions addressed a slightly different issue. These issues were: the usefulness of Traffic Reporter's information, convenience of Traffic Reporter's location, helpfulness of Traffic Reporter's technology, understandability of Traffic Reporter's format, and preference for an automatic or user-specified display.

Table 33. Congestion Level Required before Traffic Reporter Respondents Would Change Travel Plans

Would change if:	Count	% of Respondents
Stopped completely	18	38.30
Severe	26	55.32
Moderate	2	4.25
Would not change plans under any circumstances	1	2.13
Totals	47	100.00

($\chi^2 = 38.53$, df = 3, critical = 7.81, $p < .05$)

Usefulness of Traffic Reporter's Information

First, respondents were asked to rate the usefulness of Traffic Reporter's information on a scale of 1 to 5. Table 34 illustrates their responses. The most common rating was 4. A chi-square test did not reveal a significant difference in the number of responses on each point of the rating scale.

Table 34. Rated Usefulness of Traffic Reporter's Information

Scale	Count	% of Respondents
1 Not very useful	4	8.51
2	5	10.64
3	13	27.66
4	14	29.79
5 Very useful	11	23.40
Totals	47	100.00

($\chi^2 = 9.06$, df = 4, critical = 9.49)

Respondents then chose which of the information types in Table 35 they would find most useful, second most useful, and third most useful. As their first choice, 36 percent of respondents selected traffic congestion for SOV lanes or help selecting the quickest route to their destination. Detailed traffic information and help selecting the quickest route to their destination were the second most popular first choices, with 15.9 of respondents selecting each of them. As their second choice, 18.6 percent chose estimation of travel time for a particular trip, and 16.3 percent chose help selecting the quickest route to their destination. For their third choice, 25.6 percent chose help selecting the quickest route to their destination, and 14 percent selected detailed traffic information. Chi-square test results revealed significant differences in the number of responses for first, second, and third choices (see Table 35).

Convenience of Traffic Reporter's Location

In the second paired set of questions, respondents rated (on a scale of 1 to 5) Westlake Center's and Bellevue Place's convenience as a location for getting traffic information from Traffic Reporter. The most common rating for Westlake Center was 5 (very convenient); however, the most common rating for Bellevue Place was 1 (not at all convenient). Chi-square tests did not reveal any significant differences within each group (see Table 36).

Table 35. Traffic Reporter Respondents' Ranking of Information Types by Usefulness

Information Type	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Traffic congestion for HOV lanes	2	4.5	4	9.3	1	2.3
Traffic congestion for SOV lanes	16	36.4	3	7.0	5	11.6
Detailed traffic information (why traffic is congested, what's being done about it, etc.)	7	15.9	5	11.6	6	14.0
Estimation of travel time for a particular trip	6	13.6	8	18.6	4	9.3
Help selecting the quickest route to destination	7	15.9	7	16.3	11	25.6
Help selecting the most direct route to destination	1	2.3	4	9.3	3	7.0
Detailed directions for finding destination	0	0.0	4	9.3	2	4.7
Information about business or services on route	1	2.3	0	0.0	0	0.0
General bus information (route, schedule, fare)	0	0.0	1	2.3	1	2.3
Trip-specific bus information (route, schedule, fare)	1	2.3	2	4.7	4	9.3
Real-time ("live") data about bus schedules and bus locations	3	6.8	4	9.3	5	11.6
Carpooling or vanpooling information	0	0.0	1	2.3	0	0.0
Information about one-time, on-demand carpooling	0	0.0	0	0.0	1	2.3
Totals	44	100.0	43	100.0	43	100.0

1st choice: ($\chi^2 = 75.96$, df = 12, critical = 21.03, $p < .05$)

2nd choice: ($\chi^2 = 22.61$, df = 12, critical = 21.03, $p < .05$)

3rd choice: ($\chi^2 = 34.09$, df = 12, critical = 21.03, $p < .05$)

Table 36. Rated Convenience of Westlake Center/Bellevue Place as a Location for Traffic Reporter

Scale	Westlake Center		Bellevue Place	
	Count	% of Respondents	Count	% of Respondents
1 - Not at all convenient	6	19.36	6	40.00
2	4	12.90	2	13.33
3	6	19.36	3	20.00
4	5	16.13	2	13.33
5 - Very convenient	10	32.25	2	13.33
Totals	31	100.00	15	100.00

(Westlake Center: $\chi^2 = 3.36$, df = 4, critical = 9.49)

(Bellevue Place: $\chi^2 = 4$, df = 4, critical = 9.49)

Respondents were then asked to rank the top three most convenient possible locations for Traffic Reporter from the list in Table 37. Forty-five percent chose home as their first choice, followed by 25 percent who chose in-car as their first choice. The next most popular first choice (16 percent of respondents) was portable device. As their second choice, 36.6 percent of respondents selected work; 29.3 selected home; and 24.4 percent selected in-car. For their third choice, 24.4 percent selected work, in-car, and malls and other commercial areas. As Table 37 reveals, malls and other commercial areas and portable devices were not popular as first and second choices for possible locations for Traffic Reporter. The number of responses between possible locations differed significantly for first and second choices, but not for respondents' third choices.

Helpfulness of Traffic Reporter's Technology

Respondents rated the helpfulness of a computer like Traffic Reporter as a means for providing traffic information. The most common response was 5 (very helpful). Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale (see Table 38).

Table 37. Respondents' Choice of Possible Locations for Traffic Reporter

Possible Locations for Traffic Reporter	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Home	20	45.46	12	29.27	7	17.07
Work	6	13.63	15	36.58	10	24.39
In-car	11	25.00	10	24.39	10	24.39
Malls and other commercial areas	0	0.00	2	4.88	10	24.39
Portable device (like a pager)	7	15.91	2	4.88	4	9.76
Totals	44	100.00	41	100.00	41	100.00

1st choice: ($\chi^2 = 24.86$, df = 4, critical = 9.49, $p < .05$)

2nd choice: ($\chi^2 = 17.17$, df = 4, critical = 9.49, $p < .05$)

3rd choice: ($\chi^2 = 3.51$, df = 4, critical = 9.49)

Table 38. Rated Helpfulness of Traffic Reporter's Technology

Scale	Count	% of Respondents
1 - Not at all helpful	0	0.00
2	2	4.44
3	12	26.67
4	12	26.67
5 - Very helpful	19	42.22
Totals	45	100.00

($\chi^2 = 27.56$, df = 4, critical = 9.49, $p < .05$)

Respondents were then asked to rank the top three most helpful technologies from the list in Table 39. Approximately 39 percent of respondents selected computer as their first choice; the next most popular first choices were AM or FM radio (17.39 percent chose it) and portable device (17.39 percent chose it). Computer was also the most popular second choice (22.22 percent chose it). The next most popular second choice was cable TV (17.78 percent), followed by highway advisory radio (13.33 percent). For their third choice, 25.58 percent chose variable message signs; 16.28 percent chose phone with live operator; and 13.95 percent chose phone with a touch-tone menu with a synthesized voice. Chi-square results revealed significant differences in respondents' selections for first, second, and third choices.

Understandability of Traffic Reporter's Format

Respondents rated the understandability of Traffic Reporter's format on a scale of 1 to 5. The most common response was 5 (very easy to understand). Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale (see Table 40).

Table 39. Traffic Reporter Respondents' Ranking of Various Technologies by Helpfulness

Technology	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Computer	18	39.13	10	22.22	5	11.63
Regular TV	3	6.52	2	4.44	2	4.65
Cable TV	3	6.52	8	17.78	0	0.00
AM or FM radio	8	17.39	5	11.11	6	13.95
Short-distance highway advisory radio	3	6.52	6	13.33	2	4.65
Interruption of AM or FM stations for traffic information about your route	0	0.00	3	6.67	3	6.98
Phone—live operator	0	0.00	2	4.44	7	16.28
Phone—touch-tone menu with synthesized voice	3	6.52	4	8.89	6	13.95
Variable message signs	0	0.00	0	0.00	11	25.58
Portable device (like a pager)	8	17.39	5	11.11	1	2.33
Totals	46	100.00	45	100.00	43	100.00

1st choice: ($\chi^2 = 60.09$, df = 9, critical = 16.92, $p < .05$)

2nd choice: ($\chi^2 = 17.89$, df = 9, critical = 16.92, $p < .05$)

3rd choice: ($\chi^2 = 23.28$, df = 9, critical = 16.92, $p < .05$)

Table 40. Rated Understandability of Traffic Reporter's Format

Scale	Count	% of Respondents
1 Not at all easy to understand	0	0.00
2	1	2.13
3	4	8.51
4	14	29.79
5 Very easy to understand	28	59.57
Totals	47	100.00

($\chi^2 = 59.06$, df = 4, critical = 9.49, $p < .05$)

Respondents then ranked various delivery formats for traffic information by their understandability (see Table 41). The most popular format was maps (68.09 percent), which is consistent with the results of the FLOW questionnaire. The second most popular first choice was text (14.89 percent). The most popular second choice was charts and graphs (40 percent) and the most popular third choice was text (40.48 percent). Chi-square tests revealed significant differences in respondents' selections for their first and third choices of format.

Rating of Traffic Reporter's Read-Only Interface

Respondents rated their satisfaction with the way Traffic Reporter displayed information automatically on a scale of 1 to 5. The most common response was 4. Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale (see Table 42).

Preference for Read-Only or Interactive Interface

Next, respondents indicated whether they preferred a read-only or interactive interface. Seventy-nine percent preferred an interactive interface (χ^2 = 16.33, df = 1, critical = 3.84, $p < .05$, n = 48).

Table 41. Traffic Reporter Respondents' Ranking of Formats for Traffic Information by Understandability

Format	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Maps	32	68.09	7	15.56	3	7.14
Charts and graphs	4	8.51	18	40.00	7	16.67
Text	7	14.89	12	26.67	17	40.48
Speech	4	8.51	8	17.78	15	35.71
Totals	47	100.00	45	100.00	42	100.00

1st choice: (χ^2 = 47.04, df = 3, critical = 7.81, $p < .05$)

2nd choice: (χ^2 = 6.64, df = 3, critical = 7.81)

3rd choice: (χ^2 = 12.48, df = 3, critical = 7.81, $p < .05$)

took a freeway <u>and</u> *always* or *usually* encountered traffic congestion (17 of the 48 respondents), 82.35 percent (14 respondents) said they would change route, and 70.59 percent said they would change departure time on the basis of Traffic Reporter's information. Given these results, the study team concluded that Traffic Reporter's objectives of influencing drivers to travel less congested routes and influencing drivers to travel at less congested times are appropriate for the travelers who have access to it.

In regard to the objective of influencing drivers to reduce trip frequency, 23.53 percent of the drivers who *always* or *usually* took a freeway <u>and</u> *always* or *usually* encountered traffic congestion reported a willingness to cancel their trip on the basis of Traffic Reporter's information. While this result is intriguing, we must note that it is based on a very small number of respondents.

We must also point out here that, for some of the Bellevue Place respondents, Traffic Reporter's information appeared to be very Seattle-centric. Traffic Reporter has the ability to modify its display to accommodate its location, and the display employed at Bellevue Place focused more on the Eastside than the display used at Westlake Center. Nevertheless, it could not extend farther into some of the areas that Bellevue Place's respondents were interested in because loop sensors are not in place (for example, it could not track I-90 into Issaquah).

Traffic Reporter's fourth objective—influencing SOV drivers to switch to HOV modes—requires further discussion. The HOV message types—traffic congestion with HOV information and estimated trip time with HOV information—could only prompt drivers to make an immediate change to an HOV mode if the following conditions were met: (1) the information distinguished between SOV and HOV conditions, and the latter offered a significant advantage (note that SOV lanes would have to be heavily congested for the HOV lanes to provide a significant advantage); and (2) the information was provided to travelers at home, before departure (a long-term, future change to HOV, of course, would not require this condition). Therefore, the study team determined that the target audience for Traffic

Reporter's HOV message types would include drivers who satisfied the same audience criteria as described for Traffic Reporter's goals listed above and were SOV drivers.

Of all respondents who reported usually driving alone to reach downtown Seattle or downtown Bellevue (16 respondents), only nine of them reported *always* and *usually* taking the freeway and *always* and *usually* encountering traffic congestion. These nine respondents represented the target audience for the goal of influencing SOV drivers to switch to HOV modes. Of these nine, only 1 respondent said s/he would be willing to change to an HOV mode on the basis of Traffic Reporter's information. The apparent reluctance to switch to an HOV mode may have stemmed from Traffic Reporter's current failure to meet the second condition: that the information be provided to travelers at home, before departure. SOV drivers who had access to Traffic Reporter's HOV information at Westlake Center or Bellevue Place had already committed to an SOV mode for the day and were not in a position to act on Traffic Reporter's HOV information.

When asked why they would not change to an HOV mode, respondents most frequently cited a lack of carpooling partners. However, when asked to rank information types by usefulness, carpooling/vanpooling information and information about one-time, on-demand carpooling were unpopular as first choices (no one selected them) and were also unpopular as second and third choices (see Table 35). Traffic congestion information for HOV lanes was slightly more popular; however, only two respondents selected it as a first choice. As a result, the study team concluded that the objective of influencing SOV drivers to make an immediate switch to HOV modes as an option for that day's travel is not appropriate for the travelers who have access to Traffic Reporter at its current locations.

Level Three. Is the system's delivery location appropriate?

When respondents were asked to rate the convenience of Traffic Reporter's location, 40 percent of Bellevue Place respondents rated it *not at all convenient*; however, 32.25 percent of Westlake Center's respondents rated Westlake Center as a *very convenient* location (see Table 36). Interestingly, when asked to rank possible locations for Traffic

Reporter, no respondents chose malls and other commercial areas (which include Westlake Center and Bellevue Place) as their first choice, and only 5 percent selected malls and commercial areas as their second choice (see Table 37). The two current locations can only partially help Traffic Reporter achieve its system goals because the program can influence drivers to travel less congested routes and/or at less congested times only for their trips home; it has no influence on their trips to downtown Seattle or downtown Bellevue. For many respondents, any benefit from Traffic Reporter's information at Westlake Center, which is primarily a shopping area, would require the inconvenience of going to Westlake Center from their workplace before going home. Further, as already discussed, Traffic Reporter's current locations prevent Traffic Reporter from realizing its goal of influencing SOV drivers to make an immediate switch to HOV modes, which requires that travelers receive the information at home before departure. In fact, as Table 37 reveals, home was by far the most popular first choice for receiving Traffic Reporter's information. Thus, the study team concluded that neither Westlake Center nor Bellevue Place are ideal delivery locations for Traffic Reporter's information.

Note that, in the survey's comments section, many respondents asked whether they could dial in to Traffic Reporter's information via modem, presumably so they could access the information from home or work.

**Level Four. Is the system's interface technology appropriate?
Is the message's format appropriate?
Is the system's interactivity (or lack thereof) appropriate?**

Respondents rated the helpfulness of a computer like Traffic Reporter as a means for providing traffic information fairly high (42.22 percent chose *very helpful*). Also, when asked to rank the top three most helpful technologies, a computer was the most popular first choice (39.13 percent chose it); it was also the most popular second choice (22.22 percent).

As for its message format, Traffic Reporter was rated as very easy to understand. Further, the majority of respondents ranked maps as their first choice of format (see Table 41).

Respondents seemed generally satisfied with Traffic Reporter's interactive display, and when asked to indicate which type of interface they preferred, interactive or read-only, 79 percent chose interactive.

SUMMARY OF TRAFFIC REPORTER ASSESSMENT

In conclusion, Traffic Reporter's current locations prevent Traffic Reporter from fully achieving its system goals. As discussed, Traffic Reporter's first three objectives (1) to influence drivers to travel less congested routes, (2) to influence drivers to travel at less congested times, and (3) to influence drivers to reduce trip frequency and/or distance, are appropriate for Traffic Reporter's audience at Westlake Center and Bellevue Place. However, Traffic Reporter can only partially achieve these objectives in its current locations because the information provided can only influence drivers' decisions for the trip home. Traffic Reporter's fourth objective of influencing SOV drivers to switch to HOV modes cannot be realized for short term switches because SOV drivers who currently have access to Traffic Reporter have presumably already committed to an SOV mode for the day. Further, given respondents' stated preferences, shopping malls and business areas such as Westlake Center and Bellevue Place are not ideal locations for Traffic Reporter's information.

CHAPTER 7. PROPOSED CANADIAN BORDER ATIS ASSESSMENT

The third ATIS to be assessed was the proposed Canadian border crossing ATIS (hereafter referred to as CBC ATIS). This "system" differs from FLOW and Traffic Reporter in that it is only in the proposal, rather than prototype, stage. The proposed CBC ATIS will estimate border-crossing delay times and relay this information to travelers so they can select less-congested border crossing sites and/or choose to cross at a later time. The proposal describes an ATIS that will include detectors to estimate queue length, software to predict delay by using a statistical model, and methods of disseminating delay information to the public, including highway advisory radio (HAR), variable message signs (VMS), and computer terminals. The formats for these technologies include speech for HAR, text for the VMS, and a combination of text and graphics for the computer terminals.

CBC ASSESSMENT METHODS

Even though the CBC ATIS was only the in the proposal stage, our taxonomy proved useful for an early assessment. We were able to classify the CBC ATIS according to the objectives inherent in its message types. The study team could then evaluate it in terms of its ability to achieve its objectives given the modules that have been proposed.

The strategy for achieving increased mobility that the CBC ATIS will employ is to remove individual drivers from congested streams. To realize this strategy, the proposed CBC ATIS has two objectives: (1) to influence drivers to travel at less congested times, and (2) to influence drivers to travel less congested routes. To achieve these objectives, the CBC ATIS will provide two message types to travelers: estimated trip time (in this case, queue time) and route selection (see Table 43).

Table 43. Classification of the Proposed CBC ATIS

Strategy: Remove Individual Drivers from Congested Roads			
I. System Goals	Influence Drivers to Travel at Less Congested Times	Influence Drivers to Travel Less Congested Routes	
II. Message Type	Estimated Trip Time	(1) Estimated Trip Time (2) Route Selection	
III. Location	Kiosk, home, work, vehicle	In-vehicle	In-vehicle
IV. Interface Technology	Computer	VMS	HAR
Format	Text, Graphics	Text	Speech
Interactivity Potential	Yes	No	No

The study team identified three modules that the proposed CBC ATIS will employ to deliver the two message types: (1) variable message signs (VMS), which deliver information using text; (2) highway advisory radio (HAR), which uses speech; and (3) computers, which use both text and graphic formats. The potential location of the first two modules is the traveler's vehicle. The potential locations of the third module (computer) include the traveler's home, work, and vehicle, as well as a kiosk placed in a shopping area or business district. Only the third module (computer) has the potential for interactivity.

CBC ASSESSMENT DISCUSSION

Because no system existed, users could not be surveyed. Instead, the study team used the proposal to answer the same general assessment questions that were developed for assessing FLOW and Traffic Reporter. These questions followed the taxonomy and, as a result, were hierarchical in nature; that is, if the answer to a higher-level question was "no," then answers to lower-level questions were also likely to be "no." Again, the questions the study team chose to ask were communication- and user-oriented. In the case of the proposed CBC ATIS, the questions focused on the *potential* of the proposed system to communicate its message types effectively to travelers.

Level One. Are the system's objectives appropriate for the travelers who have access to it?

The objectives supported by the proposed CBC ATIS's message types—route selection and estimated trip time—are (1) to influence drivers to travel less congested routes and (2) to influence drivers to travel at less congested times. If all three modules are used, the travelers who will have access to the system will consist of all people traveling near Bellingham. However, for the system to achieve its objectives, it must communicate successfully with a much narrower audience: drivers who (1) are traveling northbound into Canada, (2) encounter significant congestion at the border, and (3) are flexible regarding routes or departure times. The study team concluded that drivers with the first two characteristics would have access to the CBC ATIS; however, drivers' flexibility regarding routes or departure times requires further analysis. If drivers are primarily in the United States for a shopping excursion rather than for work or other business, it seems likely that they will be flexible regarding their departure times. As for their flexibility regarding routes, drivers' perceptions of travel time savings offered by a particular route will involve more than border-delay time. Drivers will also consider the directness to their destination that a particular route will provide. If drivers perceive that a suggested alternative route will take them enough out of their way to offset any time savings at the border, drivers will not perceive that route as a viable alternative. For example, a returning resident of the Delta district, which is west of the Blaine crossing, might not view the Sumas crossing, which is over 25 miles east of the Blaine crossing, as a viable alternative. Conversely, a returning resident of the Abbotsford district might not view the Blaine crossing as a viable alternative. Of course, these are extremes; however, they illustrate the point that drivers will weigh border delay time against direct access to their destination. The study team concluded that the objectives of influencing drivers to travel at less congested times and influencing drivers to travel less congested routes are both appropriate for the travelers who will have access to the CBC ATIS; however, the objective of influencing drivers to travel less congested routes may not be as easily achieved as influencing them to travel at less congested times.

Level Two. Do the system's messages achieve their objectives?

The two message types that the CBC ATIS will deliver are estimated trip time and route selection. The CBC ATIS's approach to each of these message types is discussed below.

Estimated Trip Time

We previously determined that for information about estimated trip time to influence travelers' behavior, four conditions must be met: (1) the driver's usual route is, in his or her own estimation, significantly congested at the intended departure time; (2) the driver's schedule allows flexibility of departure time; (3) adjustment of departure time will, in the driver's own estimation, offer a significant travel time savings or enable the driver to meet a deadline; and (4) the information is provided before departure. Two of the modules, VMS and HAR, are strictly in-vehicle so they cannot meet the fourth condition, that the information be provided before departure; consequently, they do not support the objective of influencing drivers to travel at less congested times.

Route Selection

In order for information about route selection to influence people to travel less congested routes, four conditions must be met: (1) the driver's usual route is, in his or her own estimation, significantly congested at the intended departure time; (2) the driver knows of a reasonable alternative route; (3) the alternative route offers, in the driver's estimation, a significant advantage; and (4) the information is provided before critical route decisions must be made. The first and second conditions involve not only current traffic conditions but also driver perceptions. The responsibility of the ATIS is to meet the fourth condition and, if feasible, to aid the driver in the second condition. The proposed CBC ATIS will do both (see the discussion of Level Three below).

Level Three. Is the system's delivery location appropriate?

The CBC ATIS proposal states that 80 percent of the crossing traffic is Canadian. The proposal also states that nearly 60 percent of the retail sales at Bellis Fair Mall are generated by Canadians and that approximately 40 percent of merchandise trade in Whatcom County is generated by Canadians. Because the audience will consist primarily of Canadians returning to Canada after shopping in the United States, "home" and "work" are unlikely locations for travelers to seek information regarding Canadian border delay times. Therefore, the most effective locations are likely to be in-vehicle and kiosk (most likely placed in a shopping center).

Variable Message Signs (VMS)

The proposal placing the VMSs at three locations: near Bellingham, south of SR 543 on I-5, and south of Lynden on SR 539. Each of these locations is considered a decision point; that is, travelers must decide to continue on the route they are on or change to an alternative route once they have passed the VMS. The VMS near Bellingham will provide information about all four border crossing sites. The VMS south of SR 543 will provide information about the SR 543 and I-5 crossings, and the third VMS, south of Lynden, will provide information about the Lynden and Sumas crossings. Because the proposed VMSs will provide information before critical route decisions must be made, they will be able to influence drivers to travel less congested routes. However, as mentioned earlier, the VMSs will not achieve the objective of influencing drivers to travel at less congested times, which requires delivery of the information before departure.

Highway Advisory Radio (HAR)

HAR has the potential to reach a wider audience than VMSs and can provide information before critical route decisions must be made, thereby supporting the objective of influencing drivers to travel less congested routes. However, because HAR's delivery location is primarily in-vehicle, HAR—like VMSs—fails to support the objective of influencing drivers to travel at less congested times.

Kiosk

The proposal also suggests delivering the information via computer network. According to the proposal, companies and other groups, such as shopping malls, could subscribe to the network and display the information to their employees and customers. Because the audience for the CBC ATIS largely consists of Canadians returning to Canada after shopping in the United States, a kiosk placed in a shopping area, such as Bellis Fair, would allow drivers to make decisions before departure, thereby supporting the objective of influencing drivers to travel at less congested times, as well as the of influencing drivers to travel less congested routes.

Level Four Is the system's interface technology appropriate?
Is the message's format appropriate?
Is the system's interactivity (or lack thereof) appropriate?

Because the CBC ATIS currently exists only in concept, the study team was not able to directly assess the impact of the proposed interface technology, message format, or system interactivity on a user population.

SUMMARY OF CBC ASSESSMENT

In conclusion, likely users of the proposed CBC ATIS are an appropriate audience for information designed to influence drivers to travel less congested routes and to travel at less congested times. However, two of the proposed modules, VMS and HAR, are strictly in-vehicle, so they cannot support the objective of influencing drivers to travel at less congested times. Only the third module, a kiosk placed in a shopping or other business area, could encourage drivers to adjust their departure time, thereby supporting the objective of influencing drivers to travel at less congested times, as well as less congested routes.

CHAPTER 8. BELLEVUE SMART TRAVELER ASSESSMENT

The fourth and final ATIS to be assessed by the study team was Bellevue Smart Traveler (BST), an ATIS that was developed not only to provide travelers with traffic congestion information, but, more importantly, to enable travelers to offer and look for dynamic ride matches. BST took advantage of three technologies to deliver its information: computers, touch-tone telephones, and pagers. Using a touch-tone phone and following voice prompts, participants in the BST demonstration project could offer and look for ridematches, get traffic congestion information, and get transit schedule information. Rides that were offered via the phone system also appeared on participants' pagers, as did traffic congestion information for major Puget Sound-area corridors. News and other non-transportation related information were also available on the pagers. A demonstration of BST ran from November 1993 through mid-April 1994.

BST ASSESSMENT METHODS

First, the study team classified BST according to the objectives inherent in its message types. The study team identified five message types delivered by BST: (1) estimated trip time, (2) route selection, (3) HOV traffic information, (4) ridesharing information, and (5) transit information. Given these message types, BST support four objectives: to influence drivers to travel at less congested times; to influence drivers to travel less congested routes; to influence drivers to reduce trip frequency or distance; and to influence SOV drivers to switch to HOV modes. Three of the five message types address the SOV vs. HOV issue (see Table 44).

BST employs two modules to deliver all of its message types: (1) a telephone system with synthesized voice and (2) a pager. (To encourage its use, the pager delivered non-transportation related information in addition to traffic congestion and ridematching information. Our discussion covers only the use and influence of the transportation-related information that the pagers provided.) The potential locations for these modules include the traveler's home, work place, vehicle—virtually anywhere the traveler has access to a phone or can carry a pager. However, of these two modules, only the telephone currently has the potential for interactivity, potential that the BST phone system utilizes.

Next, the study team identified and characterized BST's potential audience. Because BST's traffic congestion information is limited to Seattle-area freeways—including freeways running to and from downtown Bellevue—the study team determined that a potential audience for BST should be travelers who (1) use these freeways to reach downtown Bellevue, (2) encounter significant traffic congestion on the freeways, and (3) are willing to change their modes, routes, and/or departure times.

To assess BST, the study team developed a questionnaire specific to BST's system objectives and message types. This questionnaire was then combined with the BST researchers' own assessment survey, which was sent to BST participants in mid-April 1994 at the end of the BST project. The first section of the joint survey included questions designed to develop an audience profile of BST's participants. The second section of the survey concerned the participants' use of the BST system. Section three of the survey focused specifically on the BST participants' ridesharing activities. Like the FLOW and Traffic Reporter assessment questionnaires, questions in section four of the survey closely followed the taxonomy. The initial questions were directed at the ability of BST's message types to achieve their objectives: Did information about trip time influence drivers to change their routes, departure times, or modes? did information about HOV traffic and ridesharing influence SOV drivers to change to HOV modes? The remaining questions investigated the usefulness of BST's information, the convenience of the locations for using BST's, the helpfulness of BST's technologies, and the usability of BST's formats. Participants were also asked to rate the usefulness of other types of information, the convenience of other locations, the helpfulness of other technologies, and the usability of other formats. The final section of the survey asked participants for demographic information. A copy of the survey is included in Appendix C.

BST ASSESSMENT RESULTS

Twenty-eight BST participants responded to the survey. Repeated *p* values of .05 or less suggest significance, *p* values greater then .05 are not reported.

Part I. Audience Profile

When asked, "Why did you register for the BST program?" approximately 61 percent of the respondents reported that they had wanted to find an occasional carpool partner. Fifty-seven percent cited curiosity; 36 percent cited saving time by using the HOV lanes; 36 percent cited saving money by carpooling; 21 percent cited an interest in traffic congestion information; 11 percent reported that they had wanted a regular carpool partner; 11 percent had wanted use of a pager; 11 percent cited an interest in the transit information; and 3.5 percent (one participant) reported an interest in the weather, sports, and news information available on the pager. Seven participants wrote in other reasons for registering: three participants said they had were vanpool drivers looking for riders; two participants said they had wanted to save energy (one wrote that s/he had wanted to save energy and the other simply wrote, "conservation"); one wrote that s/he had wanted to help reduce congestion; and one wrote that it was "socially responsible."

Unlike the FLOW and Traffic Reporter surveys, there was no need to ask respondents for their place of residence or their frequency of travel to downtown Bellevue because this information was already known to the BST project team, who then provided it for this assessment. Of the 28 participants who responded to this survey, ten lived north of Seattle, seven lived in Issaquah, one lived in Seattle, and ten lived south of Seattle. All participants worked in downtown Bellevue.

Respondents indicated whether they had rideshared before participating in the BST program. Fifty percent of them said yes. Of those who said yes, 21 percent had carpooled less than once per week, 21 percent one to three times per week, 36 percent four to six times per week, and 21 percent had carpooled over six times per week.

Respondents then indicated how they usually commuted to downtown Bellevue. The majority of them (46.43 percent) usually drove alone (see Table 45).

Only two of the respondents indicated that they had not used their usual mode of transportation to reach downtown Bellevue on the day they filled out the survey. The majority of respondents had used their usual mode of transportation.

Because BST's traffic congestion information is limited to major freeways (I-5, I-90, SR-520, and SR-405), only travelers who reach downtown Bellevue using these routes would benefit from the system. Approximately 89 percent of the respondents reported *always* or *usually* using a freeway to reach downtown Bellevue. Table 46 summarizes their responses.

Table 44. Classification of Bellevue Smart Traveler

Strategies	Remove Individual Drivers from Congested Roads		Reduce Overall Use of Roadways	Alter Travelers' Modes of Transportation
I. System Goals	Influence Drivers to Travel at Less Congested Times	Influence Drivers to Travel Less Congested Routes	Influence Drivers to Reduce Trip Frequency or Distance	Influence SOV Drivers to Switch to HOV Modes
II. Message Type	(1) Estimated Trip Time	(1) Estimated Trip Time (2) Route Selection	(1) Estimated Trip Time	(1) Traffic Congestion w/HOV Information (2) Ridesharing Information (3) Transit Information
III. Location	Home, Work, Vehicle, Etc.	Home, Work, Vehicle, Etc.	Home, Work, Vehicle, Etc.	Home, Work, Vehicle, Etc.
IV. Interface Technology	Telephone/Pager	Telephone/Pager	Telephone/Pager	Telephone/Pager
Format	Speech/Text	Speech/Text	Speech/Text	Speech/Text
Interactivity	Yes/No	Yes/No	Yes/No	Yes/No

Table 45. BST Respondents' Usual Mode of Transportation to Downtown Bellevue

Usual Mode	Count	% of Respondents
Single occupancy vehicle	13	46.43
Carpool	6	21.43
Vanpool	4	14.29
Bus	5	17.86
Totals	28	100.00

Table 46. BST Respondents' Frequency of Travel to Downtown Bellevue via Freeways

Rated Frequency	Count	% of Respondents
Never	1	3.57
Rarely	1	3.57
Sometimes	1	3.57
Usually	1	3.57
Always	24	85.71
Totals	28	100.00

(χ^2 = 19.14, df = 4, critical = 9.49, n = 28, $p < .05$)

The research team anticipated that travelers who rarely or never encountered traffic congestion on the freeways might not find all of BST's information particularly useful. Therefore, a follow-up to the above question was, "How frequently do you encounter traffic congestion on the freeway?" Approximately 75 percent of the respondents reported encountering freeway traffic congestion *always* or *usually*. Their responses are summarized in Table 47.

<u>Part II. System Usage</u>

Respondents were asked how many times they had used the BST phone system to participate in ridesharing (either to look for a ride or to offer a ride), get traffic information, or get transit information. Forty-eight percent of respondents having reported never looked for a ride; nearly 26 percent had looked for a ride less than once per week; and 22 percent reported having looked for a ride one to three times per week. However, respondents reported offering rides more frequently: 50 percent reported having offered rides one to three times per week; 25 percent had never offered rides; and 21 percent had offered rides less than once per week. As for the other information available through the BST phone system, 50 percent of respondents reported having called at least once to get traffic congestion information; however, only 22 percent had called to get transit information (see Table 48).

Table 47. BST Respondents' Frequency of Traffic Congestion Encounters on Freeways

Rated Frequency	Count	% of Respondents
Never	0	0.00
Rarely	3	10.71
Sometimes	4	14.29
Usually	15	53.57
Always	6	21.43
Totals	28	100.00

($\chi^2 = 23.07$ df = 4, critical = 9.49, n = 28, $p < .05$)

Table 48. BST *Phone System* Usage Reported by Participants

No. of times/week participants called the BST phone system to:	Look for a ride		Offer a ride		Get traffic congestion information		Get transit information	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
None	13	48.15	7	25.00	14	50.00	21	77.78
Less than 1	7	25.93	6	21.43	3	10.71	0	0.00
1 - 3	6	22.22	14	50.00	3	10.71	2	7.41
4 - 6	1	3.70	1	3.57	7	25.00	3	11.11
Over 6	0	0.00	0	0.00	1	3.57	1	3.70
Totals	27	100.00	28	100.00	28	100.00	27	100.00

(Look for a ride: $\chi^2 = 20.22$, df = 4, critical = 9.49, $p < .05$)

(Offer a ride: $\chi^2 = 22.36$, df = 4, critical = 9.49, $p < .05$)

(Get traffic congestion information: $\chi^2 = 19.14$, df = 4, critical = 9.49, $p < .05$)

(Get transit information: $\chi^2 = 23.07$ df = 4, critical = 9.49, $p < .05$)

Respondents were also asked how many times they had referred to their BST pagers to look for a ride or to get traffic congestion information (these were the two types of transportation-related information available on the pager). Respondents appeared to have used the pager more frequently than the phone system for looking for rides and for getting traffic congestion information. Seventy-seven percent had referred to their pagers to look for a ride at least once (compared to the 52 percent who reported having used the phone system for the same task). Of this 77 percent, nearly 30 percent reported using their pagers to look for a ride one to three times per week. Seventy-one percent of respondents had referred to their pagers to get traffic congestion information at least once; of this 71 percent, approximately 29 percent reported having referred to their pagers one to three times per week to get traffic congestion information. Table 49 summarizes the results.

Table 49. BST *Pager* Usage Reported by Participants

No. of times/week participants referred to their pagers to:	Look for a ride		Get traffic congestion information	
	Count	Percent	Count	Percent
None	9	33.33	8	28.57
Less than 1	3	11.11	3	10.71
1 - 3	8	29.63	8	28.57
4 - 6	3	11.11	5	17.86
Over 6	4	14.82	4	14.29
Totals	27	100.00	28	100.00

(Look for a ride: $\chi^2 = 6.15$, df = 4, critical = 9.49)

(Get traffic congestion information: $\chi^2 = 3.79$, df = 4, critical = 9.49)

Part III. Ridesharing

In Part III, respondents answered specific questions about their ridesharing activities throughout the life of the BST project. First, respondents indicated how many times they had looked for a ride (using either the phone or pager) during the project. Seventeen respondents (61 percent) reported having looked for a ride at least once. Of those 17, eight had found a potential ride. Of the eight respondents who had found a potential ride, five of them had called the driver offering the ride. As for offering rides, 23 out of the 28 respondents had offered at least one ride. Out of the 23 respondents who had offered rides, only one had received a call from an interested rider. Table 50 summarizes the results.

Respondents were then asked how many times they had actually carpooled during the project. Of the 28 respondents, seven reported having formed carpools during the project. Each of these seven had carpooled only one to five times throughout the life of the BST demonstration. (Two of the 28 respondents had already been members of a vanpool and had vanpooled regularly before and while participating in the BST project. The study team determined that they were not influenced by BST to use an HOV mode because they had already been using an HOV mode when they started participating in the BST project; therefore, the study team did not include their responses.)

Part IV. Assessment

Part IV's questions followed the levels of the taxonomy discussed previously.

Changes in Route, Departure Time, Mode, and/or Trip Frequency

Respondents were asked how many times per week they had changed their mode of transportation (from an SOV to an HOV mode), their departure time, their route, or canceled their trip on the basis of the traffic congestion information provided by BST. Only 8 percent of respondents reported having changed to an HOV mode on the basis of BST's traffic congestion information. However, 37 percent had changed their departure time, and 44 percent had changed their route. As for canceling their trip, approximately 7 percent (two respondents) said they had done so on the basis of the traffic congestion information available on BST (see Table 51).

If respondents indicated that they had never changed any aspect of a trip or had canceled it, they were asked why. Respondents could check as many reasons as they felt applied to them and were also provided with an "other" category in which they could write in a response. Reasons given for not changing to an HOV mode were no bus service to the respondent's destination (three respondents); inability to find any rides (five respondents); and the inconvenience of bus/carpooling (two respondents). Six respondents indicated that they could not have changed their departure time, and two respondents reported that changing their departure time had been too inconvenient. Two respondents indicated that they could not have changed their route, and one respondent reported that changing his/her route had been too inconvenient. Nine respondents indicated that they could not have canceled their trips.

Congestion Level Needed to Affect Travel Plans

Respondents were asked how congested their route would have to be before they would change their travel plans (i.e., route, departure time, or mode). In response, 40 percent said their route would have to be severely congested, and only 15 percent said they would not change their travel plans under any circumstances (see Table 52).

Following the taxonomy, the next set of questions related to the usefulness of BST's information, the convenience of BST's locations, the helpfulness of BST's technology, the understandability of BST's format, and preference for an automatic or user-specified display.

Usefulness of BST's Information

Respondents were asked to rate the usefulness of the information available through the BST *phone system* on a scale of 1 to 5. First, respondents rated the usefulness of its ridesharing information. The most common rating was 2; however, the responses were fairly evenly spread across the scale (a chi-square test did not reveal a significant difference in the number of responses on each point of the rating scale). Next, respondents rated the usefulness of transit information available through the BST phone system. The most common response was 1: not very useful. A chi-square revealed a significant difference in the number of responses on each point of the rating scale. Respondents then rated the usefulness of the traffic congestion information available on the phone system. Here the most common responses were 1 or 2 (nine respondents selected 1 and nine selected 2). Chi-square results also revealed a significant difference in the number of responses on each point of the rating scale for traffic congestion information. Table 53 summarizes the data.

Table 50. BST Respondents' Self-reported Ridesharing Activity

Ridesharing Activity	None	1 - 5	6 - 10	10 - 20	Over 20
No. of times participants looked for a ride	11	5	2	5	5
Of the above, no. of times participants found a potential ride	9	7	1	0	0
Of the above, no. of times participants called the driver offering the ride	3	5	0	0	0
No. of times participants offered a ride	5	7	4	5	7
Of the above, no. of times participants received a call from an interested rider	22	1	0	0	0

Table 51. Times/Week Participants Changed Driving Behavior on the Basis of BST Information

No. of times/week participants:	Changed to an HOV mode		Changed departure time		Changed route		Canceled a trip	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
None	23	92.00	17	62.96	15	55.56	25	92.59
Less than 1	1	4.00	5	18.52	7	25.93	2	7.41
1 - 3	1	4.00	3	11.11	4	14.82	0	0.00
4 - 6	0	0.00	2	7.41	1	3.70	0	0.00
Over 6	0	0.00	0	0.00	0	0.00	0	0.00
Totals	25	100.00	27	100.00	27	100.00	27	100.00

(Changed to an HOV mode: $\chi^2 = 81.20$, df = 4, critical = 9.49, n = 25, $p < .05$)

(Changed departure time: $\chi^2 = 33.56$, df = 4, critical = 9.49, n = 27, $p < .05$)

(Changed route: $\chi^2 = 26.89$, df = 4, critical = 9.49, n = 27, $p < .05$)

(Canceled a trip: $\chi^2 = 89.48$ df = 4, critical = 9.49, n = 27, $p < .05$)

Table 52. Congestion Level Required before BST Respondents Would Change Travel Plans

Would change if:	Count	% of Respondents
Stopped completely	8	29.63
Severe	11	40.74
Moderate	4	14.81
Would not change plans under any circumstances	4	14.81
Totals	27	100.00

($\chi^2 = 5.15$. df = 3, critical = 7.81)

Next, respondents rated the usefulness of the information available through the BST *pager* on a scale of 1 to 5. The most common rating for the ridesharing information available on the pager was 4; however, the responses were fairly evenly spread across the scale (a chi-square test did not reveal a significant difference in the number of responses on each point of the rating scale). Respondents then rated the usefulness of the pager's traffic congestion information. The most common response was 1: not very useful. A chi-square test did not reveal a significant difference in the number of responses on each point of the rating scale for traffic congestion (see Table 54).

Respondents then chose which of the information types in Table 55 they would find most useful, second most useful, and third most useful. As their first choice, 22 percent of respondents selected detailed traffic congestion information. Traffic congestion for HOV lanes; traffic congestion for SOV lanes; information about one-time, on-demand carpooling; and information about carpooling or vanpooling were the second most popular first choices, with 14.82 percent of respondents selecting each of them. As their second choice, 22 percent chose detailed traffic congestion information; 14.82 percent chose traffic congestion for SOV lanes; and 14.82 percent chose carpooling or vanpooling information. For their third choice, 19.23 percent chose traffic congestion for SOV lanes. Chi-square test results revealed significant differences in the number of responses for first and second choices (see Table 55).

Table 55. BST Respondents' Ranking of Information Types by Usefulness

Information Type	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Traffic congestion for HOV lanes	4	14.82	2	7.41	3	11.54
Traffic congestion for SOV lanes	4	14.82	4	14.82	5	19.23
Detailed traffic information (why traffic is congested, what's being done about it, etc.)	6	22.22	6	22.22	1	3.85
Estimation of travel time for a particular trip	1	3.70	3	11.11	3	11.54
Help selecting the quickest route to destination	3	11.11	3	11.11	3	11.54
Help selecting the most direct route to destination	0	0.00	0	0.00	0	0.00
Detailed directions for finding destination	0	0.00	0	0.00	0	0.00
Information about business or services on route	1	3.70	0	0.00	1	3.85
General bus information (route, schedule, fare)	0	0.00	1	3.70	2	7.69
Trip-specific bus information (route, schedule, fare)	0	0.00	0	0.00	2	7.69
Real-time ("live") data about bus schedules and bus locations	0	0.00	1	3.70	2	7.69
Carpooling or vanpooling information	4	14.82	4	14.82	2	7.69
Information about one-time, on-demand carpooling	4	14.82	3	11.11	2	7.69
Totals	27	100.00	27	100.00	26	100.0

1st choice: ($\chi^2 = 26.44$, df = 12, critical = 21.03, $p < .05$)

2nd choice: ($\chi^2 = 21.63$, df = 12, critical = 21.03, $p < .05$)

3rd choice: ($\chi^2 = 11.00$, df = 12, critical = 21.03)

Convenience of BST's Location(s)

In both the FLOW and Traffic Reporter assessments, the study team asked respondents to rate the locations of FLOW and Traffic Reporter for their convenience. Because BST's information is available from virtually anywhere a telephone can be found or anywhere the participant chooses to take a pager, the study team opted not to ask respondents to rate BST's "locations." Instead, respondents simply ranked the top three most convenient locations for receiving each of the types of information offered by BST. First, respondents ranked their top three choices for receiving ridesharing information (Table 56). Work and portable device (e.g., pager) were the top two first choices for location, with 32 percent of respondents selecting each of them. (Obviously, a portable device is not a location; however, "portable device" implies that the information can be accessed wherever the user is.) As for their second choice, 56 percent of respondents selected "work." For their third choice, 32 percent of respondents selected home, and the same percentage chose portable device. Malls and other commercial areas were ranked quite low; no one selected them as either a first or second choice for receiving ridesharing information. The number of responses between location preferences for receiving ridesharing information differed significantly for first and second choices, but not for respondents' third choices.

Table 56. BST Respondents' Choice of Locations for Receiving *Ridesharing* Information

Locations	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Home	7	28.00	9	36.00	8	32.00
Work	8	32.00	14	56.00	2	8.00
In-car	2	8.00	0	0.00	5	20.00
Malls and other commercial areas	0	0.00	0	0.00	2	8.00
Portable device (like a pager)	8	32.00	2	8.00	8	32.00
Totals	25	100.00	25	100.00	25	100.00

1st choice: ($\chi^2 = 11.2$, df = 4, critical = 9.49, $p < .05$)

2nd choice: ($\chi^2 = 31.2$, df = 4, critical = 9.49, $p < .05$)

3rd choice: ($\chi^2 = 7.2$, df = 4, critical = 9.49)

As for their choices of locations for receiving transit information, 43.48 percent chose work as their first choice. The next most popular first choice of location for receiving transit information was home (30.44 percent). Work and home were the most popular second choices as well, with 34.78 percent of respondents choosing each. For their third choice, 26.09 percent chose in-car and 21.74 percent chose home. Chi-square tests revealed a significant difference in the number of responses on each point of the rating scale for respondents' first and second choices (see Table 57).

As for their choices of locations for receiving traffic congestion information, 50.00 percent chose home as their first choice, followed by 23.08 percent who chose home as their first choice. Work was the most popular second choice (50.00 percent), followed by portable device (26.92 percent). For their third choice, 30.77 percent chose home and 26.92 percent chose work. Chi-square tests revealed a significant difference in the number of responses on each point of the rating scale for respondents' first and second choices (see Table 58).

Helpfulness of BST's Technology

Respondents rated the helpfulness of the technologies BST employs as a means for providing ridesharing, traffic congestion, and transit information. Respondents first rated the BST phone system. The most common rating of the phone system's helpfulness for delivering ridesharing information was 3; for delivering transit information, the most common rating was 4; and for delivering traffic congestion information, the most common rating was 1 (*not very helpful*). Chi-square test results did not reveal a significant difference in the number of responses on each point of the rating scale for any of the information types (see Table 59).

As for the pager, the most common rating for its helpfulness as a means for delivering ridesharing information was 5: *very helpful*. Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale for the pager's delivery of ridesharing information. For its delivery of traffic congestion information, the most common rating was 4. Chi-square test results did not reveal a significant difference in the number of responses on each point of the rating scale for any of the traffic congestion information (see Table 60).

Respondents were then asked to rank the top three most helpful technologies for delivering ridesharing, transit, and traffic congestion information. For the delivery of *ridesharing* information, 36 percent of respondents selected portable device as their first choice; the next most popular first choice was computer (32 percent chose it). Computer was the most popular second choice (28 percent chose it). The next most popular second choice was phone with a touch-tone menu and synthesized voice (24 percent). For their third choice, 32 percent chose phone with live operator, and 28 percent chose phone with a touch-tone menu and synthesized voice. Chi-square results revealed significant differences in respondents' selections for first, second, and third choices (see Table 61).

For the delivery of *transit* information, 34.78 of respondents who answered this question chose computer as their first choice. The next most popular first choices were portable device and phone with a touch-tone menu and synthesized voice, with 21.74 percent selecting each. For their second choice, 34.78 percent of respondents selected phone with touch-tone menu and synthesized voice, and 26.09 percent chose computer. The most popular third choices were AM or FM radio and phone with live operator (21.74 percent selected each). Chi-square results revealed significant differences in respondents' selections for first and second choices (see Table 62).

Table 57. BST Respondents' Choice of Locations for Receiving *Transit* Information

Locations	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Home	7	30.44	8	34.78	5	21.74
Work	10	43.48	8	34.78	4	17.39
In-car	1	4.35	0	0.00	6	26.09
Malls and other commercial areas	1	4.35	2	8.70	4	17.39
Portable device (like a pager)	4	17.39	5	21.74	4	17.39
Totals	23	100.00	23	100.00	23	100.00

1st rank: (χ^2 = 13.30, df = 4, critical = 9.49, $p < .05$)

2nd rank: (χ^2 = 11.13, df = 4, critical = 9.49, $p < .05$)

3rd rank: (χ^2 = .70, df = 4, critical = 9.49)

Table 58. BST Respondents' Choice of Locations for Receiving *Traffic Congestion* Information

Locations	1st Choice Count	1st Choice Percent	2nd Choice Count	2nd Choice Percent	3rd Choice Count	3rd Choice Percent
Home	6	23.08	4	15.39	8	30.77
Work	3	11.54	13	50.00	7	26.92
In-car	13	50.00	2	7.69	6	23.08
Malls and other commercial areas	0	0.00	0	0.00	1	3.85
Portable device (like a pager)	4	15.39	7	26.92	4	15.39
Totals	26	100.00	26	100.00	26	100.00

1st rank: (χ^2 = 18.23, df = 4, critical = 9.49, $p < .05$)

2nd rank: (χ^2 = 19.77, df = 4, critical = 9.49, $p < .05$)

3rd rank: (χ^2 = 5.92, df = 4, critical = 9.49)

Table 59. Rated Helpfulness of BST's *Phone System*

Scale	BST Phone System Information					
	Ridesharing		Transit		Traffic Congestion	
	Count	Percent	Count	Percent	Count	Percent
1 Not very helpful	2	7.69	3	11.54	7	26.92
2	5	19.23	6	23.08	6	23.08
3	6	23.08	5	19.23	5	19.23
4	8	30.77	9	34.62	6	23.08
5 Very helpful	5	19.23	3	11.54	2	7.69
Totals	26	100.00	26	100.00	26	100.00

(Ridesharing information: χ^2 = 3.62, df = 4, critical = 9.49)

(Transit information: χ^2 = 4.77, df = 4, critical = 9.49)

(Traffic congestion information: χ^2 = 2.85, df = 4, critical = 9.49)

Table 60. Rated Helpfulness of BST's *Pager*

Scale	BST Pager Information			
	Ridesharing		Traffic Congestion	
	Count	Percent	Count	Percent
1 Not very helpful	1	3.85	1	3.85
2	3	11.54	7	26.92
3	4	15.39	3	11.54
4	8	30.77	8	30.77
5 Very helpful	10	38.46	1	26.92
Totals	26	100.00	26	100.00

(Ridesharing information: χ^2 = 10.54, df = 4, critical = 9.49, $p < .05$)

(Traffic congestion information: χ^2 = 7.08, df = 4, critical = 9.49)

Table 61. BST Respondents' Ranking of Various Technologies by Helpfulness for Delivery of *Ridesharing* Information

Technology	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Computer	8	32.00	7	28.00	2	8.00
Regular TV	1	4.00	1	4.00	2	8.00
Cable TV	0	0.00	2	8.00	0	0.00
AM or FM radio	4	16.00	1	4.00	2	8.00
Short-distance highway advisory radio	0	0.00	2	8.00	0	0.00
Interruption of AM or FM stations for traffic information about your route	0	0.00	0	0.00	1	4.00
Phone—live operator	0	0.00	1	4.00	8	32.00
Phone—touch-tone menu with synthesized voice	3	12.00	6	24.00	7	28.00
Variable message signs	0	0.00	0	0.00	2	8.00
Portable device (like a pager)	9	36.00	5	20.00	1	4.00
Totals	25	100.00	25	100.00	25	100.00

1st choice: (χ^2 = 43.4, df = 9, critical = 16.92, $p < .05$)

2nd choice: (χ^2 = 23.4, df = 9, critical = 16.92, $p < .05$)

3rd choice: (χ^2 = 27.4, df = 9, critical = 16.92, $p < .05$)

Table 62. Respondents' Ranking of Various Technologies by Helpfulness for Delivery of *Transit* Information

Technology	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Computer	8	34.78	6	26.09	1	4.35
Regular TV	0	0.00	1	4.35	2	8.70
Cable TV	0	0.00	3	13.04	1	4.35
AM or FM radio	3	13.04	0	0.00	5	21.74
Short-distance highway advisory radio	0	0.00	0	0.00	1	4.35
Interruption of AM or FM stations for traffic information about your route	0	0.00	1	4.35	1	4.35
Phone—live operator	2	8.70	2	8.70	5	21.74
Phone—touch-tone menu with synthesized voice	5	21.74	8	34.78	3	13.04
Variable message signs	0	0.00	0	0.00	0	0.00
Portable device (like a pager)	5	21.74	2	8.70	4	17.39
Totals	23	100.00	23	100.00	23	100.00

1st choice: (χ^2 = 32.22, df = 9, critical = 16.92, $p < .05$)

2nd choice: (χ^2 = 28.74, df = 9, critical = 16.92, $p < .05$)

3rd choice: (χ^2 = 13.09 df = 9, critical = 16.92)

Respondents then ranked various technologies by helpfulness for delivery of traffic congestion information. For their first choice, 38.46 percent selected portable device, and 23.08 percent selected AM or FM radio. The most popular second choices were AM or FM radio (26.92 percent selected it) and portable device (15.39 percent selected it). The most popular third choices were computer (19.23 percent) and AM or FM radio (15.39 percent selected each). Chi-square results revealed significant differences in respondents' selections for their first choice only. Interestingly, only two people selected a form of telephone delivery as their first choice (see Table 63).

Understandability of BST's Format

Respondents rated the understandability of BST's phone system delivery of ridesharing, transit, and traffic congestion information on a scale of 1 to 5. The most common response for ridesharing information was 4, for transit information was 3, and for traffic congestion information was 4. Chi-square test results did not reveal significant differences in the number of responses on each point of the rating scale for any of the information types (see Table 64).

Next, respondents rated the understandability of BST's pager delivery of ridesharing and traffic congestion information on a scale of 1 to 5. The most common response for ridesharing information was 4; for traffic congestion information the most common response was 1 (not very useful). Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale for ridesharing but not for traffic congestion information (see Table 65).

Respondents then ranked various delivery formats for ridesharing, transit, and traffic congestion information by their understandability. The most popular format for delivery of ridesharing information was text (52 percent chose it). The second most popular first choice was speech (36 percent chose it). The most popular second choice was speech (50 percent), and the second most popular second choice was text (37.5 percent). The most popular third choice was maps (66.67 percent), followed by charts or graphs (23.81 percent). Chi-square tests revealed a significant differences in respondents' selections for their first, second, and third choices of format (see Table 66).

As for transit information, 56.52 percent of respondents chose maps as their first delivery choice, followed by text (26.09 percent). For their second choice, 31.82 percent chose text, followed by 27.27 percent who chose speech. The most popular third choices were speech and text, as 27.27 percent chose each. A chi-square test revealed a significant difference in the number of responses on each point of the rating scale for respondents' first choices (see Table 67).

Respondents then ranked formats for the delivery of traffic congestion information. Forty-four percent chose speech as their first choice, and 40 percent chose maps. Maps and speech were the most popular second choices also; 29.17 percent chose maps and 29.17 percent chose speech. The most popular third choice was text, chosen by 45.83 percent. A chi-square test revealed a significant difference in the number of responses on each point of the rating scale for respondents' first and third choices (see Table 68).

Table 63. Respondents' Ranking of Various Technologies by Helpfulness for Delivery of *Traffic Congestion* Information

Technology	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Computer	0	0.00	3	11.54	5	19.23
Regular TV	1	3.85	1	3.85	2	7.70
Cable TV	1	3.85	2	7.70	0	0.00
AM or FM radio	6	23.08	7	26.92	4	15.39
Short-distance highway advisory radio	3	11.54	1	3.85	1	3.85
Interruption of AM or FM stations for traffic information about your route	1	3.85	4	15.39	3	11.54
Phone—live operator	1	3.85	0	0.00	2	7.70
Phone—touch-tone menu with synthesized voice	1	3.85	2	7.70	2	7.70
Variable message signs	2	7.70	2	7.70	4	15.39
Portable device (like a pager)	10	38.46	4	15.39	3	11.54
Totals	26	100.00	26	100.00	26	100.00

1st choice: (χ^2 = 33.23, df = 9, critical = 16.92, $p < .05$)

2nd choice: (χ^2 = 14.00, df = 9, critical = 16.92)

3rd choice: (χ^2 = 7.85, df = 9, critical = 16.92)

Table 64. Rated Understandability of BST *Phone System*'s Delivery of Information

Scale	BST Phone System Information					
	Ridesharing		Transit		Traffic Congestion	
	Count	Percent	Count	Percent	Count	Percent
1 Not very useful	1	4.00	2	9.09	0	0.00
2	3	12.00	2	9.09	4	16.67
3	5	20.00	7	31.82	5	20.83
4	9	36.00	6	27.27	8	33.33
5 Very useful	7	28.00	5	22.73	7	29.17
Totals	25	100.00	22	100.00	24	100.00

(Ridesharing information: χ^2 = 8.0, df = 4, critical = 9.49)

(Transit information: χ^2 = 4.82, df = 4, critical = 9.49)

(Traffic congestion information: χ^2 = 8.08, df = 4, critical = 9.49)

Table 65. Rated Usefulness of BST's *Pager*'s Delivery of Information

Scale	BST Pager Information			
	Ridesharing		Traffic Congestion	
	Count	Percent	Count	Percent
1 Not very useful	5	19.23	9	34.62
2	4	15.39	3	11.54
3	5	19.23	6	23.08
4	9	34.62	5	19.23
5 Very useful	3	11.54	3	11.54
Totals	26	100.00	26	100.00

(Ridesharing information: χ^2 = 15.04, df = 4, critical = 9.49, $p < .05$)

(Traffic congestion information: χ^2 = 9.39, df = 4, critical = 9.49)

Table 66. BST Respondents' Choice of Formats for Delivery of *Ridesharing* Information

Locations	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Maps	3	0.00	1	4.17	14	66.67
Charts or graphs	0	12.00	2	8.33	5	23.81
Text (printed words)	13	52.00	9	37.50	1	7.76
Speech (spoken words)	9	36.00	12	50.00	1	4.76
Totals	25	100.00	24	100.00	21	100.00

1st choice: (χ^2 = 16.44, df = 4, critical = 9.49, $p < .05$)

2nd choice: (χ^2 = 14.33, df = 4, critical = 9.49, $p < .05$)

3rd choice: (χ^2 = 21.48, df = 4, critical = 9.49, $p < .05$)

Table 67. BST Respondents' Choice of Formats for Delivery of *Transit* Information

Locations	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Maps	13	56.52	4	18.18	5	22.73
Charts or graphs	1	4.35	5	22.73	5	22.73
Text (printed words)	6	26.09	7	31.82	6	27.27
Speech (spoken words)	3	13.04	6	27.27	6	27.27
Totals	23	100.00	22	100.00	22	100.00

1st choice: (χ^2 = 14.39, df = 4, critical = 9.49, $p < .05$)

2nd choice: (χ^2 = .91, df = 4, critical = 9.49)

3rd choice: (χ^2 = .182, df = 4, critical = 9.49)

Table 68. BST Respondents' Choice of Formats for Delivery of *Traffic Congestion* Information

Locations	1st Choice		2nd Choice		3rd Choice	
	Count	Percent	Count	Percent	Count	Percent
Maps	10	40.00	7	29.17	5	20.83
Charts or graphs	1	4.00	6	25.00	4	16.67
Text (printed words)	3	12.00	4	16.67	11	45.83
Speech (spoken words)	11	44.00	7	29.17	4	16.67
Totals	25	100.00	24	100.00	24	100.00

1st choice: (χ^2 = 11.96, df = 4, critical = 9.49, $p < .05$)

2nd choice: (χ^2 = 1.00, df = 4, critical = 9.49)

3rd choice: (χ^2 = 14.39, df = 4, critical = 9.49, $p < .05$)

Rating of BST's Phone System Interface

Respondents rated their satisfaction with the way the BST phone system responded to their input on a scale of 1 to 5. The most common response was 4. Chi-square test results revealed a significant difference in the number of responses on each point of the rating scale (see Table 69).

Preference for Read-Only or Interactive Interface

Next, respondents indicated whether they preferred a read-only or interactive interface for the delivery of ridesharing, transit, and traffic congestion information. Ninetytwo percent preferred an interactive interface for the delivery of ridesharing information ($\chi^2 = 18.62$, df = 1, critical = 3.84, $p < .05$). For the delivery of transit information, approximately 88 percent preferred an interactive interface ($\chi^2 = 15.39$, df = 1, critical = 3.84, $p < .05$), and nearly 77 percent preferred an interactive interface for the delivery of traffic congestion information ($\chi^2 = 7.54$, df = 1, critical = 3.84, $p < .05$).

DISCUSSION OF BST ASSESSMENT

Below is a discussion of the data in terms of each level of the taxonomy and the general questions set forth previously.

Levels One and Two. Are the system's objectives appropriate for the travelers who have access to it? Do the system's messages achieve their objectives?

The objectives inherent in BST's message types are (1) to influence drivers to travel at less congested times, (2) to influence drivers to travel less congested routes, (3) to influence drivers to reduce trip frequency or distance, and (4) to influence SOV drivers to switch to HOV modes (three of the five message types). For the BST system to achieve these objectives, it must communicate successfully with a very specific audience: drivers who (1) use freeways to and from Bellevue, (2) encounter significant traffic congestion along the way, and (3) are flexible regarding modes, routes, or departure times. Part I of the BST survey determined that 89 percent of the respondents reported *always* or *usually* taking a freeway to downtown Bellevue and that approximately 75 percent reported *always* or *usually* encountering traffic congestion. Of the respondents who said that they *always* or *usually* took a freeway and that they *always* or *usually* encountered traffic congestion (18 of the 28 respondents), 44.45 percent reported having changed their departure time at least once during the demonstration period on the basis of the traffic congestion information provided by BST, and 55.56 percent reported having changed their route at least once. Given these results, the study team concluded that the audience was appropriate for BST's first two objectives of influencing drivers to travel at less congested times and influencing drivers to travel less congested routes.

Table 69. Rated Satisfaction with BST's Phone System Interface

Scale		Count	% of Respondents
Not at all satisfied	1	2	8.00
	2	1	4.00
	3	5	20.00
	4	9	36.00
Very satisfied	5	8	32.00
Totals		25	100.00

($\chi^2 = 10.00$, critical = 9.49, $p < .05$)

As for the third objective of influencing drivers to reduce trip frequency, only 5.56 percent of respondents who *always* or *usually* took a freeway <u>and</u> *always* or *usually* encountered traffic congestion reported having canceled a trip during the demonstration period. From this data, the study team concluded that (1) the audience of the BST ATIS was unwilling to or could not reduce trip frequency; therefore, the system's objective was not appropriate to its audience. Consequently, (2) the BST ATIS did not achieve its goal of influencing drivers to reduce trip frequency.

In regard to the fourth objective of influencing drivers to use HOV modes, of the respondents who *always* or *usually* took a freeway <u>and</u> *always* or *usually* encountered traffic congestion, *none* reported having changed to an HOV mode on the basis of BST's traffic congestion information. More importantly, people clearly had reasons not related to information for not accepting rides, such as rides that were offered at inconvenient times or unease with getting in another's car. These hindrances seem supported by the fact that five of 28 participants looked for 10 to 20 rides and another five looked for more than 20 rides, yet none made any ride matches. Because, users also reported the interface to be appropriate and clear (level four), the study team concluded that BST's audience was *unwilling* or *unable* to switch to an HOV mode on the basis of available information. Therefore, BST failed to achieve its fourth objective.

Level Three. Is the system's delivery location appropriate?

Respondents ranked their top three choices of delivery locations for ridesharing, transit, and traffic congestion information. Respondents' first choices of location for delivering ridesharing information were work and in-car; their first choice for delivery of transit information was work; and their first choice for delivery of traffic congestion information was in-car. BST's technologies (both the telephone system and the pager) provide participants with access to BST's information at all of these locations; therefore, the study team concluded that the locations afforded by BST's technologies were appropriate.

Level Four. Is the system's interface technology appropriate?
Is the message's format appropriate?
Is the system's interactivity (or lack thereof) appropriate?

Respondents rated the helpfulness of each of BST's technologies, the telephone system and the pager, as a means for providing ridesharing, transit, and traffic congestion information. Respondents rated the helpfulness of a telephone as a means for delivering ridesharing and transit information fairly high: 50 percent of respondents chose 4 or 5 for ridesharing information, and 46 percent chose 4 or 5 for transit information (5 being *very helpful*). Given these results, the study team concluded that the telephone system is an appropriate interface for the delivery of ridesharing and transit information. However, respondents did not rate the telephone system high as a means for delivering traffic congestion information: only 31 percent chose 4 or 5, while 27 percent chose 1 (*not very helpful*). To further determine the helpfulness of the telephone system as a means for delivering traffic congestion information, the study team turned to the participants' reported usage of the telephone system for obtaining traffic congestion information: 14 respondents (half of the total) reported never using the telephone system to get traffic congestion information. This led the study team to question the appropriateness of the telephone system as a means for the delivery of traffic congestion information.

As for the pager helpfulness, 69 percent rated its helpfulness for the delivery of ridesharing information a 4 or 5, and 57 percent rated its helpfulness for the delivery of traffic congestion information a 4 or 5. From this information, the study team concluded that the pager was an appropriate interface for the delivery of both ridesharing and traffic congestion information.

Regarding the understandability of format, respondents rated the phone system for the delivery of transit information as fairly easy to understand (although only six of the 28 respondents reported using the telephone to get transit information). For the delivery of ridesharing information, respondents rated both the pager and the telephone system's formats to be fairly easy to understand. For the delivery of traffic congestion information, respondents rated the understandability of the phone system's format higher than the understandability of the pager's format, despite the fact that, as mentioned above, they reported the pager to be more helpful.

As for system interactivity, respondents preferred an interactive interface for the delivery of all three types of information. BST's telephone system provided them with an interactive interface; however, the pager did not.

SUMMARY OF BST ASSESSMENT

In conclusion, the BST ATIS achieved two of its four objectives: it influenced drivers to travel at less congested times and to use less congested routes. It did not influence drivers to reduce trip frequency, nor did it influence drivers to switch to an HOV mode. These failures were likely attributable to an inappropriate audience.

CHAPTER 9 CONCLUSIONS AND RECOMMENDATIONS

These conclusions and recommendations center on the assessment of the four systems and on the taxonomy and its ability to be guide assessment projects.

REVIEW OF SYSTEM ASSESSMENTS

Flow

FLOW's message type indicates system objectives of influencing drivers to travel less congested routes and influencing drivers to travel at less congested times. However, Westlake Center is an inappropriate location for FLOW's information, preventing FLOW from fully achieving its system objectives and system goals. Further, given respondents' stated preferences, an interactive interface would be more appropriate for delivery of FLOW's information than its current read-only interface.

Traffic Reporter

Traffic Reporter's message types indicate four objectives of (1) influencing drivers to travel less congested routes, (2) influencing drivers to travel at less congested times, (3) influencing drivers to reduce trip frequency and/or distance, and (4) influencing drivers to switch to an HOV mode. The first three objectives are appropriate for Traffic Reporter's audience at Westlake Center and Bellevue Place. However, Traffic Reporter can only partially achieve these objectives in its current locations because the information provided can only influence drivers' decisions for the trip home. Traffic Reporter's fourth objective of influencing SOV drivers to switch to HOV modes *cannot* be realized and is inappropriate at its current locations. For drivers to make a decision to switch to an HOV on the basis of Traffic Reporter's HOV information, they must receive the information at home, before departure. Currently, because Traffic Reporter is in public locations, SOV drivers who currently have access to Traffic Reporter have presumably already committed to an SOV mode for the day. Further, given respondents' general preferences, shopping malls and business areas, such as Westlake Center and Bellevue Place, are not ideal locations for Traffic Reporter's information.

Canadian Border Crossing ATIS

The CBC ATIS's message types indicate objectives of influencing drivers to travel less congested routes and influencing drivers to travel at less congested times; these objectives are appropriate for travelers who will have access to the CBC ATIS. However, two of the technologies likely to be employed by the CBC ATIS, VMS and HAR, are strictly in-vehicle, so they cannot support the objective of influencing drivers to travel at less congested times. Only the third module, a kiosk placed in a shopping or other business area, could allow drivers to make decisions before departure, thereby supporting the objective of influencing drivers to travel at less congested times, as well as less on congested routes.

Bellevue Smart Traveler

BST's message types indicate four objectives: (1) to influence drivers to travel at less congested times, (2) to influence drivers to use less congested routes, (3) to influence drivers to reduce trip frequency, and (4) to influence drivers to switch to an HOV mode. The first two of these objectives were achieved; the third and fourth objectives were not. The failure to influence drivers to switch to an HOV mode was likely due to an inappropriate audience and the failure to provide convenient ride choices for them.

Given that these four assessments were guided by the taxonomy, it is helpful to reexamine the application of the taxonomy to assessment procedures.

THE TAXONOMY AND ITS POTENTIAL FOR USE IN ASSESSMENT

The study team recommends that any group or project developing an ATIS take the following steps to improve the likelihood of its success (these steps follow the taxonomy described in Chapter 4):

(1) identify and evaluate the ATIS's message types, objectives and system objectives

(2) determine whether the system objectives are appropriate for the travelers who have access to them

(3) evaluate whether the ATIS's message types achieve their objectives

(4) identify and evaluate the system's delivery location

(5) identify and evaluate the system's interface technology, message format, and system interactivity;

(6) evaluate the system's usability.

Identify and evaluate the ATIS's system objectives

Depending on the system's message types, the ATIS will have one or more of the following system goals: (1) to influence drivers to travel at less congested times, (2) to influence drivers to travel less congested routes, (3) to minimize drivers' navigation errors, (4) to influence drivers to reduce trip frequency or distance, and/or (5) to influence SOV drivers to switch to HOV modes.

Determine whether system objectives are appropriate

The ATIS developers must then ask, "Are the system's objectives appropriate for the travelers who have access to the system?" For example, the study team determined that given their message types, Flow and Traffic Reporter had to communicate with a specific audience to achieve their objectives (influencing drivers to travel on less congested times or to travel less congested routes). This audience comprised people who used Seattle-area freeways, encountered significant traffic congestion along the way, and were flexible regarding departure time and routes. By surveying the people who had access to FLOW and Traffic Reporter and determining whether they had these characteristics, the study team was able to determine whether the system objectives were indeed appropriate for FLOW and Traffic Reporter's audience.

Evaluate whether the ATIS's message types achieve their objectives

The ATIS developer should ask, "Do the system's messages achieve their objectives; that is, do/will they actually influence travelers' behavior?" In the case of FLOW and Traffic Reporter, the study team asked potential users how they would respond to the information provided: would they change their route, departure time, or cancel a trip on the basis of the information provided? If the answers to the questions are primarily "no," then the system's messages have failed to achieve their objectives. In the case of the BST ATIS, the study team was able to ask the question in the past tense: did the participants change their routes, departure times, cancel trips, or switch to an HOV mode on the basis of the information provided? Here, the study team found that the HOV message type did not achieve its objective, that of altering travelers' modes.

Identify and evaluate the system's delivery location

The ATIS developer should next ask whether the user of the ATIS is able to respond to the information at its delivery location. For example, both FLOW and Traffic Reporter were located at Westlake Center, a downtown shopping mall. Thus, these two ATISs could only affect travelers' trips in one direction--from downtown. Further, the majority of potential users did not work in Westlake Center and had to make a special trip there to benefit from FLOW or Traffic Reporter's information for the trip home. Therefore, the study team concluded that Westlake Center was an inappropriate location if these two ATISs were to fully realize their system objectives and goals. The case of the CBC ATIS was similar: two of its delivery modules could not achieve the objective of influencing drivers to travel at less congested times because neither VMSs nor HAR provide information to travelers before departure, a necessity if travelers are expected to make decisions about their departure times.

Identify and evaluate the system's interface technology, message format, and system interactivity

The ATIS developer must also determine the preferences of potential ATIS users. For example, the study team asked potential users of the various systems which, among a variety of technologies, they would find the most helpful (for an example, see Table 22). The study team then asked potential users to select their top choices among possible delivery formats (i.e., text, speech, maps). The study team also asked potential users about their preferences for an interactive or read-only interface.

Evaluate the system's usability

Very early in the design of an ATIS, the developer should begin to test the system's interface for ease of use. The sooner potential usability problems are caught, the sooner they can be corrected (and usually with the least expense).

We believe the protocol provided here can be generalized to the assessment of all ATISs.

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