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Real-Time Motorist Information for Reducing Urban Freeway Congestion: Commuter Behavior, Data Conversion and Display, and Transportation Policy

Final Report
June 1992

WA-RD 240.2
TNW 91-04



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Motorist Information Real-Time**

**REAL-TIME MOTORIST INFORMATION FOR
REDUCING URBAN FREEWAY CONGESTION:
COMMUTER BEHAVIOR, DATA CONVERSION
AND DISPLAY, AND TRANSPORTATION POLICY**

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EXECUTIVE SUMMARY

Background

We have completed Phase 2 of a project to design and develop a real-time, PC-based, interactive, advanced traveler information system (ATIS) for the Puget Sound area. For an ATIS to be effective, its design must be based on an understanding of commuter behavior and information needs. Therefore during Phase 1, we conducted an extensive on-road survey (Survey 1) of motorists traveling south on I-5 into downtown Seattle. Survey 1 identified four types of commuters according to their willingness to change various aspects of their commute in response to traveler information: (1) Pre-trip Changers, (2) Route & Time Changers, (3) Route Changers, and (4) Non-changers.

Commuter Surveys

In Phase 2 of this project, we conducted another extensive on-road survey (Survey 2), this time of commuters traveling north on I-5 into downtown Seattle. We also extracted data on commuters traveling east and west as part of their commute. The most important finding from Survey 2 was that the four commuter types identified in Survey 1 were consistent throughout the Puget Sound population and did not vary significantly by geographical location. Thus, the major conclusions from our survey of southbound (Survey 1) commuters held true for northbound and east/west commuters (Survey 2) as well.

Also in Phase 2, we conducted a non-response survey to determine if non-respondents constituted a subgroup of commuters with markedly different commuting patterns and behaviors. We concluded from this survey that most non-respondents were actually non-commuters who realized that the survey was not intended for them. Therefore, non-respondents did not constitute an additional subgroup of commuters.

Traffic Reporter

The majority of effort in Phase 2 was spent using our knowledge about Seattle commuters to develop a prototype ATIS called *Traffic Reporter*. This prototype can help

travelers make intelligent decisions about use of various commuting alternatives. *Traffic Reporter* converts traffic data collected from freeway sensors into up-to-the-minute information that can be delivered directly to commuters. This information is shown on *Traffic Reporter's* interactive graphical display. The central feature of the screen is a graphical representation of a northern corridor of I-5. All north and south entry and exit ramps in that freeway corridor are active elements of the display. Segments of the freeway are color-coded according to one of four speed ranges. The current time and date, as well as the time the displayed information was gathered, are also shown. The screen is updated every minute. These elements allow users to interactively explore traffic conditions and alternatives, such as average mph at a particular location instead of broad speed ranges, average travel time and speed for a specific trip, and the "best" exit or entry ramp for a specific trip.

In addition to providing traffic information to commuters, *Traffic Reporter* provides information that is of interest to traffic engineers and TV or radio traffic reporters. For example, *Traffic Reporter* can store and play back commute data, show congestion patterns, create a historical record of freeway activity, indicate a malfunctioning station, and display up-to-the-minute data on volume and occupancy.

Currently, the *Traffic Reporter* prototype resides in the Department of Technical Communication at the University of Washington. Direct delivery of traveler information to commuters will be accomplished in Phase 3 of this project.

Usability Tests

Once the *Traffic Reporter* prototype was implemented, we conducted usability tests to ensure its effectiveness and ease of use. All commuters who evaluated the system stated they would be willing to change their departure time, route, and occasionally even transportation mode, given the right kind of information. However, commuters also said they would like *Traffic Reporter* to include information on arterials and alternative routes, as well as explanations of traffic delays. Commuters also need to be convinced that the system

information is both timely and accurate. Therefore, future versions of *Traffic Reporter* should include:

- Graphical arterial information.
- Graphical incident information.
- A feedback mechanism.

In addition, special effort should be made to measure and improve the accuracy of information.

Most subjects thought the type of information presented in dialog boxes was useful, but they would probably go to information dialog boxes only if the main screen showed a problem. Moreover, subjects want to know when traffic is completely stopped versus when traffic is just moving slowly. Therefore, a flashing color or other distinct marking should be added to the main screen to let commuters know where traffic is stopped.

Subjects liked the choice of colors used to indicate speeds, except for the color purple. Therefore, an alternative to the color purple should be used to represent speeds between those represented by red and yellow.

Subjects were confused by arrows next to six of the exits. (Those arrows were designed to indicate ramps that are exit only or entrance only.) Therefore, the ramp arrows should be deleted and another method found to represent one-way ramps.

All subjects said they would use *Traffic Reporter* if it were readily available. They commented that choice of delivery medium would depend on where they were when they needed traffic information: if they were in their cars, they would prefer to hear the information on the radio; if they were either at home or work before departing, they would prefer the information on a screen.

Although the majority of subjects expressed a desire to view and manipulate the system themselves, current cost and hardware constraints mean this may not always be feasible. Therefore, we are investigating delivery not only by PCs and touch-screen kiosks, but also by TV and radio reporters, as well as audio phone delivery.

Based on the above results, we should do the following:

- Develop a version of *Traffic Reporter* for the use of radio and TV media.
- Explore an audio version of *Traffic Reporter* for dedicated radio or phone delivery.
- Develop a PC-based system geared toward commuters who use a touch-screen kiosk, or be willing to pay for additional information via home services, such as CompuServe.
- Expose the public to computer-based traveler information kiosks via TV delivery and, perhaps, a museum exhibit of *Traffic Reporter*.

Testing and evaluation must continue as system expansion occurs. The needs of commuters must periodically be confirmed, as they are the ones who will ultimately be making decisions based on the information.

BACKGROUND

Following a previous two-year study of real-time traveler information systems and Puget Sound commuting behaviors, we reported on the results of an on-road survey of commuters traveling on I-5 south into downtown Seattle. The results of that survey identified four types of commuters, which we named Pre-trip Changers, Route & Time Changers, Route Changers, and Non-changers. We also reported on in-person interviews to clarify points from this initial survey and to gather information for screen design of a computer-based, traveler information system. (See *Improving Motorist Information Systems: Towards a User-Based Motorist Information System for the Puget Sound Area*, Washington State Department of Transportation Final Technical Report WA-RD 187.1, April 1990.)

The work reported here builds on these past efforts and takes a number of additional major steps toward the development of a PC-based, interactive, real-time traveler information system (now called *Traffic Reporter*). Specifically, the Phase 2 objectives were as follows:

- (a) To further enhance our fundamental knowledge of Puget Sound commuter behavior and decision-making.
- (b) To apply that knowledge to the design and development of a *Traffic Reporter* prototype.
- (c) To develop a personal computer front/end interface for *Traffic Reporter* capable of (1) receiving existing real-time traffic data; (2) converting that data into information designed to impact commuter choice of route, transportation mode, and departure time of commute; and (3) displaying that information through a user interface designed to meet the needs of individual drivers, TV and radio traffic reporters, and traffic engineers.
- (d) To perform usability tests on *Traffic Reporter*.

To accomplish these objectives, we began by conducting another on-road survey of commuters traveling north on I-5 into downtown Seattle. Next, based on results from surveys and interviews in both phases of this project, we began the design and implementation of *Traffic Reporter*. Currently, *Traffic Reporter* is in the prototype stage and resides in the Department of Technical Communication at the University of Washington. Once the prototype

was implemented, we conducted usability tests to confirm *Traffic Reporter's* usefulness and effectiveness.

IMPLEMENTATION OF *TRAFFIC REPORTER*

Traffic Reporter currently exists in a prototype version covering I-5 traffic from the northern King-Snohomish County line to downtown Seattle. In the prototype version, all lanes are aggregated. The actual system, currently under development, will geographically be expanded to cover the entire Puget Sound area, and will break out HOV and express lane information. The expanded system will also have additional features beyond those described here and will include a touch-screen mode.

The first step in implementing *Traffic Reporter* was to import freeway data into the PC environment. Then, a graphical, interactive display was designed and coded that uses those data to provide real-time traveler information. These steps are described below.

Freeway Data Conversion

The procedure for accumulating traffic data and converting those data on a PC screen to be used for later display is summarized here. Traffic data are accumulated from freeway stations positioned about every half mile along I-5 between Dearborn Street and the King-Snohomish County line. Each station consists of loop detectors (one for each lane) embedded in the pavement, a microprocessor, and a modem. The loops detect vehicles 60 times per second. These data are processed at the station, and then one-second summaries of the output, consisting of volume (number of vehicles passing over a loop) and occupancy (fraction of total time a vehicle occupies a loop), are sent to the Traffic Systems Management Center (TSMC).

At the TSMC, a Perkin-Elmer mainframe computer (soon to be replaced by a VAX) converts these data into one-minute summaries. These summaries are transferred to the PC each minute over a 9600 baud modem. The summaries are converted to speed and travel time on the PC. The volume/occupancy to speed and travel time conversion algorithm is detailed in Appendix D in the Final Technical Report WA-RD 240.1.

***Traffic Reporter's* Screen Design**

The following section describes the traveler information screen, along with features and functions that were developed on the basis of information presented thus far. Results of the on-road surveys indicate that the Pre-trip Changer and Route & Time Changer groups are actively seeking pre-trip information and are likely to act on it. Therefore, the current version of *Traffic Reporter* is tailored as much as possible to those two groups. First, we describe the screen as it initially appears (Figure 1) and then as it appears in various stages of manipulation (Figures 2 to 4). These figures are in black and white, but the screen uses color codes to distinguish categories of speed, volume, and occupancy between freeway stations.

Initial Screen Display

The central feature of *Traffic Reporter's* screen (Figure 1) is a graphical representation of a 15-mile corridor of I-5 from the King-Snohomish County line in the north to downtown Seattle in the south. The left-hand side of the map shows 15 southbound ramps; the right-hand side of the map shows 19 northbound ramps. The ramps are labeled according to well known I-5 ramps. The map displays segments of the freeway (about half a mile each) between each freeway station. Each segment is colored according to a speed range.

The top of the screen, directly above the map, displays the title: *Traffic Reporter*. Underneath the title, in the upper left-hand corner, is a list of menus: File, Data, Lanes, Communications, and Help. These menus are explained later. In the lower left-hand corner of the screen is a box showing the current colors and associated ranges of speeds. Finally, the current day, date, time, and time the displayed information was gathered appear at the bottom of the screen. The screen is updated every minute.

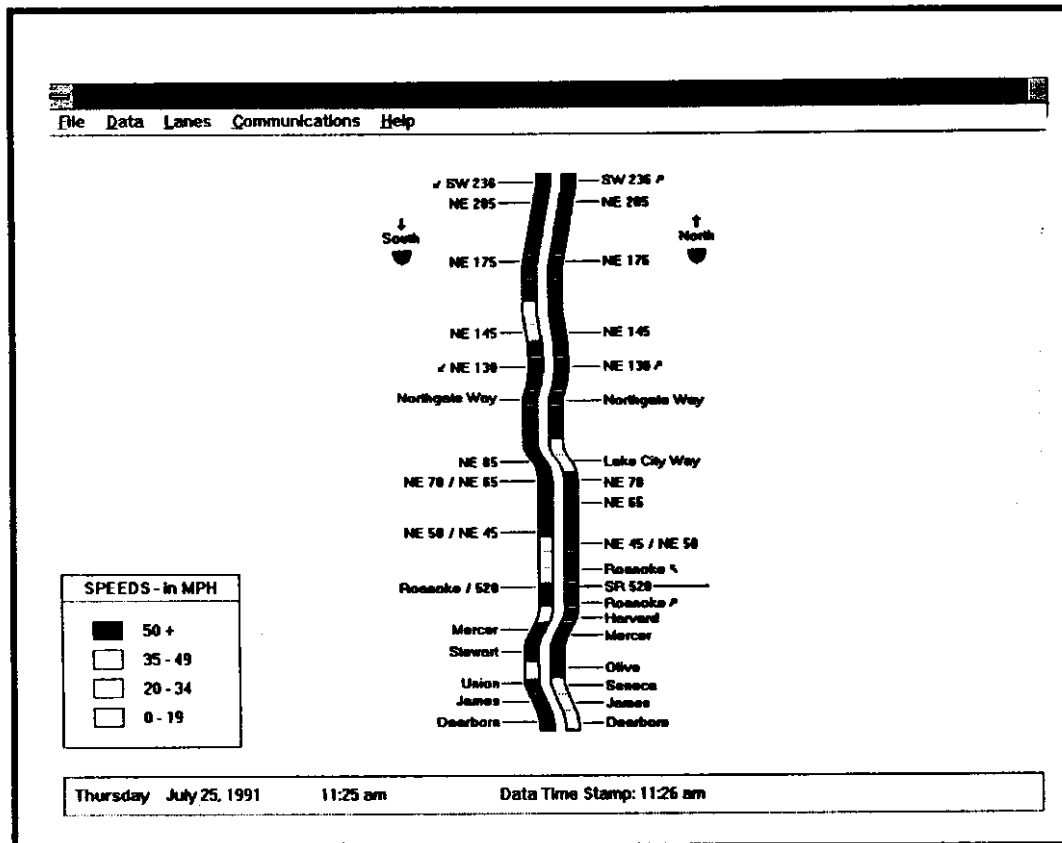


Figure 1. Freeway Map Screen As It Initially Appears

Features

The current features of *Traffic Reporter* were designed not only for our commuter audience, but for two other audiences as well: TV/radio traffic reporters and traffic engineers. Several features appear in the illustrations but will not be implemented until the next phase. The next section describes how the screen appears when features are used that cause the screen to change.

- **FILE.** This menu opens and saves configuration files and exits the program. Configuration files include map information, program settings, etc.
- **DATA.** All selections in this menu may be accessed by pulling down the menu or by the keyboard. The selections are as follows:

Display Speeds. This is the default selection. It displays freeway speeds between each station. Speeds are indicated in one of four colors according to ranges of speeds: green for 50+ mph, yellow for 35-49 mph, purple for 20-34 mph, and red for 0-19 mph.

Display Occupancy. This selection, for traffic engineers, displays the percentage of time vehicles are sensed by loop detectors. Occupancy is displayed according to one of four colors: green for 0-14%, yellow for 15-21%, purple for 22-34%, and red for 35%+.

Display Volume. This selection, also for traffic engineers, displays the number of vehicles traveling over loop detectors. Volume is displayed according to one of four colors: green for 200+, yellow for 150-199, purple for 100-149, and red for 0-99.

Set Range. This selection controls the numerical ranges associated with the color coding feature, and allows these ranges to be easily changed temporarily or permanently.

Show Faulty Data. When this selection is chosen, the areas of the freeway where the data are faulty are indicated in blue. Currently this covers only ill-formed data, but the next version of *Traffic Reporter* will show improbable faulty data as well.

Record Traffic Data. This selection allows the user to manually record traffic data as they are received. Recorded data can be played and interacted with in the same manner as live data.

Record Options. This selection allows the user to select up to ten different time frames during which traffic information can be automatically recorded; for example, a time frame could be 3:00 pm to 6:00 pm, Monday to Friday. This selection also controls how much data will be gathered; for example, it can be set to collect traffic information every other minute instead of every minute, thus saving disk space. Currently, this feature is being used to record peak hour traffic each day.

Replay Traffic Data. This selection allows the user to replay traffic data from a specific day by entering a date or by selecting a date from a list. A box then appears with controls similar to a tape recorder; the selections are rewind, play, fast forward, stop, and close.

- **LANES.** This menu will not be implemented until the next stage of this project. It will allow display of different types of lanes (for example, HOV versus regular lanes).
- **COMMUNICATION.** This menu establishes a communications connection with the source data. Through this menu a port is chosen, a modem initialized, and the dial feature implemented. The dial feature allows *Traffic Reporter* to continue dialing when there is no answer or when the line is busy.
- **HELP.** The only help displayed currently is a screen introducing *Traffic Reporter*. On-line help will be implemented in the next stage of this project.

Screen in Various Stages of Manipulation

From the initial screen, a user can quickly determine the current traffic situation. If the overview of the screen displays all stations in green, the user need go no further because our goal is to get users (other than traffic reporters and traffic engineers) into their cars and on their

way--not to have them access all the system's functions. However, if the overview of current speed ranges reveals a need for further exploration (such as an area of red stations), other traffic information may be accessed as follows.

(1) Mean speed rates of selected stations. This information is accessed by the zoom function. The zoom function works by moving the cursor over the freeway map. At that point, the cursor turns into a magnifying glass. By clicking the mouse button, a box appears to the left of the freeway map and shows the stations magnified with specific mean speed rates rather than speed ranges. (See Figure 2.)

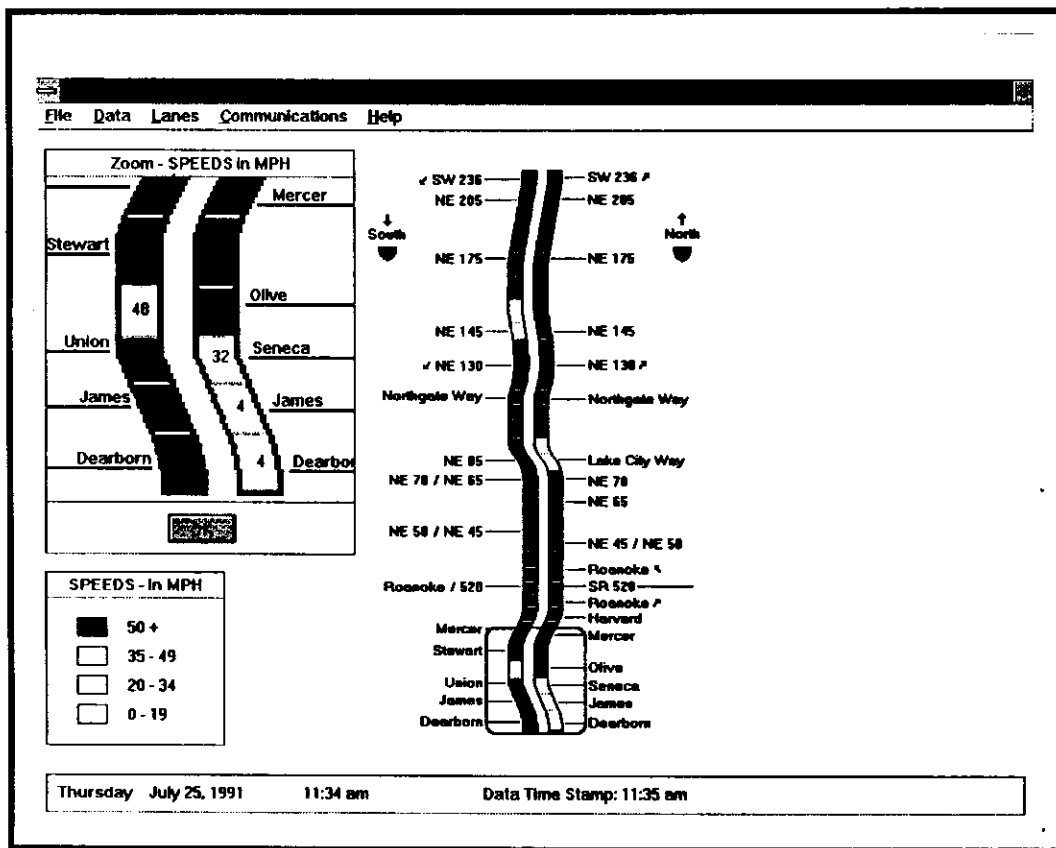


Figure 2. Freeway Map Showing Zoom Function

(2) Estimated travel time and vehicle speed for a trip between any two ramps. This information is accessed by clicking the mouse button on an entrance and an exit ramp. A box

to the right of the freeway map indicates the ramps selected and shows estimated travel time and speed between those two ramps. (See Figure 3.)

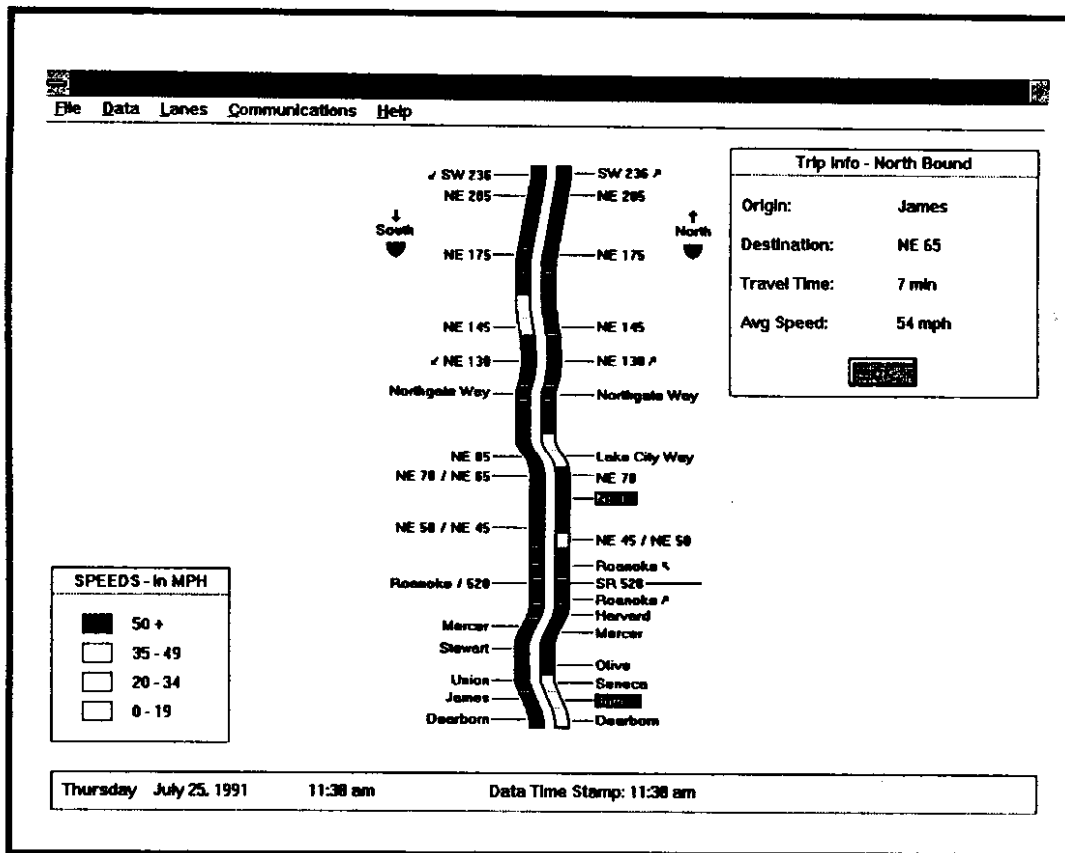


Figure 3. Freeway Map Showing Estimated Speed and Travel Time between Two Ramps

(3). The best exit ramp or entry ramp to take for a specific trip. The best exit ramp can be determined by double-clicking the right button on the mouse at an origin ramp. A table appears to the right of the freeway map showing estimated rates of speed and travel time to all possible exit ramps currently displayed. The best entry ramp can be determined by double-clicking the left button on the mouse at a destination ramp. A similar table appears, this time showing estimated rates of speed and travel time to the destination ramp from all possible entry ramps currently displayed. (See Figure 4.)

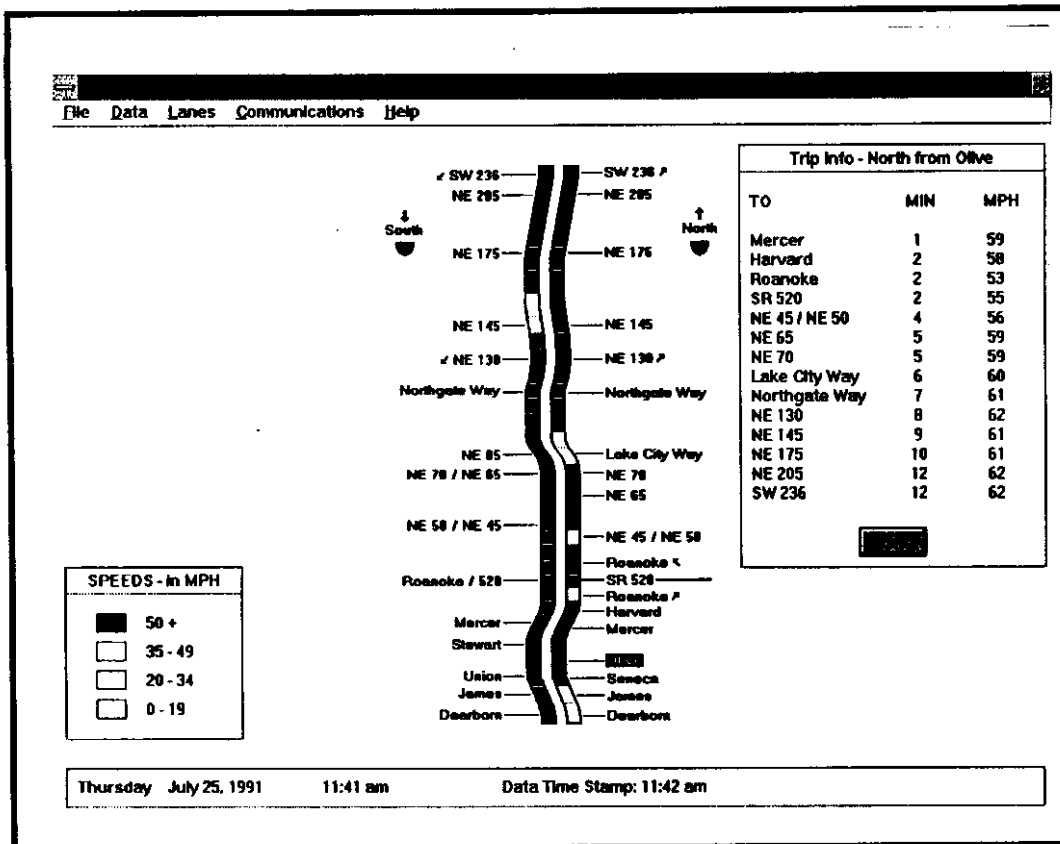


Figure 4. Freeway Map Showing Times and Speeds to Possible Exit Ramps

PROCEDURES

Work on this project was conducted in three stages. First, we conducted a second on-road commuter survey (Survey 2), which was a follow-up to an on-road commuter survey (Survey 1) conducted in an earlier phase of this project. Along with Survey 2, we conducted a non-response survey. Second, we implemented a prototype of *Traffic Reporter*. Third, we conducted usability tests on the *Traffic Reporter* prototype. Following are the procedures used in conducting the surveys and usability tests. Implementation of *Traffic Reporter* is described in an earlier section.

Motorists Surveys

Survey 2 was accomplished by distributing about 4,700 questionnaires (of which about 42% were returned) to commuters traveling north on I-5 into downtown Seattle as part of their morning commute. The survey sought answers to questions in five categories: (1) characteristics of the commute, (2) commuter choices and behavior, (3) delivery and use of traffic information, (4) characteristics of east/west commuters who used one of the Lake Washington bridges or I-405, and (5) descriptive data for driver classification.

The data gathered from these questionnaires were analyzed in SPSS-X on the Max mainframe at the University of Washington. Frequencies were calculated for all variables; Pearson correlations were applied to interval scaled data; and Spearman correlations were applied to all ordinal and a few nominal scaled variables if the coding met the assumptions of the Spearman routine.

Finally, cluster analyses and chi squares within clusters were conducted to determine how the make-up of motorist groups from the south compared to those from the north, and to find the significant differences between the groups' responses on specific questions. The same four questions used in Survey 1 to cluster respondents were used in Survey 2. These questions were:

- When you are on I-5, how often does traffic information cause you to divert to an alternative route?
- Before you drive, how often does traffic information influence the time you leave?
- Before you drive, how often does traffic information influence your means of transportation (e.g., car, bus)?
- Before you drive, how often does traffic information influence your route choice?

We conducted a non-response survey to determine if non-respondents constitute a subgroup of commuters with markedly different commuting patterns and behaviors. This survey, designed to coincide with data collection and analysis from Survey 2, was aimed at identifying and obtaining information from a random sub-sample of non-respondents. We contacted 50 non-respondents either by mail or by phone and asked questions about their commute and, specifically, the four questions above.

Usability Testing

Once the initial design of *Traffic Reporter's* screen was implemented, we conducted usability tests to determine the system's effectiveness and ease of use. While the ultimate end user of *Traffic Reporter* is the Puget Sound commuter, other initial users of the system will be TV and radio media personnel, and Washington State Department of Transportation (WSDOT) traffic engineers. Therefore, in conducting the usability tests, we assessed three different user groups: commuters, media personnel, and WSDOT traffic engineers. We eliminated commuters who were unlikely to change their driving behavior based on traveler information, the group we call Non-changers. Additionally, because *Traffic Reporter* is a PC-based system, we thought it important to test both those commuters who stated they would and those who stated they would not like to see a computer system developed for delivering traveler information. Subjects were selected from the 1,000 respondents to Survey 1 who expressed willingness to participate in an in-person interview and who, according to the survey results, fit the characteristics of the six groups (three remaining commuter groups and two computer-preference

groups) mentioned earlier. Media subjects consisted of three volunteers from Seattle news media: a radio traffic reporter, a radio news manager, and a radio/TV reporter (accompanied by a radio reporter/pilot). The traffic engineers were six volunteers from the Traffic Systems Management Center in Seattle.

We sought responses from commuters to five broad areas of questions: (1) potential change in commuter behavior, (2) interaction with the system, (3) interface design, (4) potential use of the system, and (5) desired delivery method of the information provided by the system. We wanted to obtain similar information from media personnel but with a focus on traffic reporting. From WSDOT traffic engineers, we sought subjective evaluations of *Traffic Reporter* as an addition to other information sources they would continue to use.

Based on the survey results that commuters need commute time estimates and information in order to alter their commute choices, we designed tasks that mimicked real traffic scenarios. Both inbound and outbound scenarios were presented to the commuters with various tasks within each scenario. The tasks were designed so that the use of almost any of *Traffic Reporter's* functions would allow the evaluators to obtain the "right" answer, but there was one method per task that was most effective.

The test answers were measured through scaled information, timed information (including mouse clicks), and ranked information. Additionally, commuters were asked open-ended questions about why they would or would not change a commute behavior, what additional information they might use to help with their commute decisions, and any other comments they might have pertaining to the system or their commute. While we applied both parametric and nonparametric statistical routines to the data, and the statistics supported our conclusions, we did not report these statistics in the technical report because of their instability given the small cell sizes. Rather, we reported descriptive statistics--medians, minimums, maximums, and frequency.

RESULTS AND DISCUSSION

The following section discusses the results of work conducted in Phase 2 of the *Traffic Reporter* project, including the on-road commuter survey, the non-response survey, and the usability tests.

On-Road Commuter Survey

The results of the on-road survey of commuters traveling north on I-5 into downtown Seattle (Survey 2) are similar to the results of the on-road survey of commuters traveling south (Survey 1) conducted in Phase 1 of this project. The results are grouped as follows:

(1) cluster analysis, (2) characteristics of the commute itself, (3) route choices, (4) delivery of traffic information, (5) demographic information, and (6) characteristics of motorists who used one of the Lake Washington bridges or I-405. (See Appendix B of the Final Technical Report, WA-RD 240.1 for a copy of the questionnaire.)

Cluster Analysis

This section reports results of a cluster analysis designed to divide the response group into commuter types and compare those types with a similar analysis from Survey 1. The key finding of the on-road survey was that the commuter “types” revealed in Survey 1 held consistently for Survey 2. We based our clustering of types on responses to four key questions in both surveys. These questions were:

- When you are on I-5, how often does traffic information cause you to divert to an alternative route?
- Before you drive, how often does traffic information influence the time you leave?
- Before you drive, how often does traffic information influence your means of transportation (e.g., car, bus)?
- Before you drive, how often does traffic information influence your route choice?

In addition to comparing Survey 2 with Survey 1 responses, cluster data from the two on-road surveys were extracted on one subgroup: respondents traveling east/west on the Lake Washington bridges or I-405 into downtown Seattle. Table 1 compares the east/west commuter types with the southbound and northbound commuter types for both surveys.

Table 1. Comparison of I-5 Southbound, I-5 Northbound, and East/West Respondents

	Southbound Commuters	Northbound Commuters	East/West Commuters
Pre-trip Changers	16%	15%	12%
Route & Time Changers	40%	45%	47%
Route Changers	21%	17%	15%
Non-changers	23%	23%	26%

The commuter types are relatively stable across geographical locations. The only noticeable differences were that east/west commuters are slightly more flexible about the time they leave but slightly less flexible about route and mode of transportation.

Commute Characteristics

Most respondents appear to commute alone five days per week, travel about 19 miles to work, with about nine miles of this total distance driven on I-5, and spend about 35-40 minutes for their entire commute. They travel about five miles more between home and work than respondents in Survey 1 and spend about five minutes more each way. Most respondents have greater flexibility as to the time they leave work for home than the time they leave home for work. Most respondents experience some stress during their commute. Most respondents (66%) place the greatest value on saving commute time, and 60% believe that increasing commute safety is very important. Only one-third believe that increasing commute enjoyment is

very important, and only about one-fifth place a lot of importance on reducing commute distance.

Route Choices

Slightly over half of the respondents (55%) believe they are very familiar with alternative routes, compared to about 62% in Survey 1; 36% are somewhat familiar, and 9% are not at all familiar with alternative routes.

Respondents modify their route from work to home more frequently than they modify their route from home to work: 56% of respondents sometimes or frequently change route between work and home, as compared to only 38% who stated they sometimes or frequently change route between home and work.

When asked what length of delay would cause respondents to divert from I-5, the average response was 18 minutes to routes they know and 28 minutes to routes they do not know. Respondents in this survey stated they will wait about two minutes longer than respondents in Survey 1 to change routes.

When respondents were asked where they choose their commuting routes, 43% stated that they make this choice while still at home or work; 18% choose on city streets; 19% choose near entrance ramps; and 20% choose after entering I-5. Northbound commuters are somewhat more likely to select their route prior to leaving than southbound commuters. (See Figure 5 for comparison with Survey 1.)

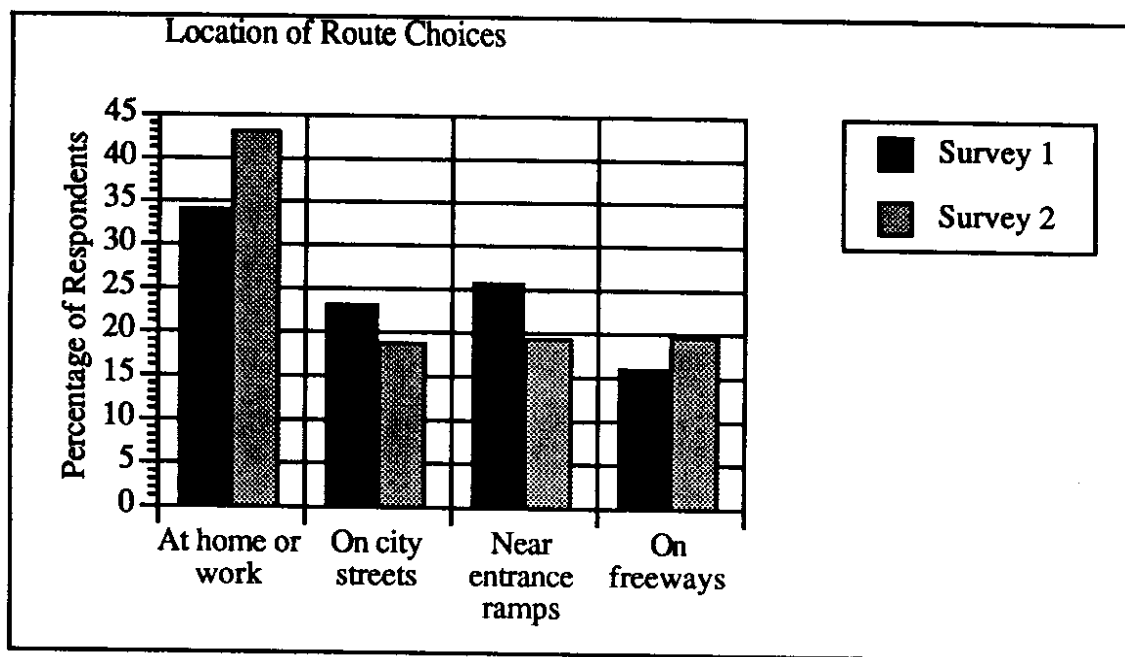


Figure 5. Comparison of Where Route Choices Are Made

When asked about the influence of six environmental factors on their choice of commuting routes, about 36% of the respondents reported that traffic messages frequently influence their choice (compared to only 28% in Survey 1); 29% reported that traffic congestion frequently influences their choice; about 23% reported that time of day frequently influences their choice. Only 8% believe that weather conditions frequently influence their choice of commuting routes, and only 11% believe that time pressures frequently have an influence. The responses to the last three factors were similar to Survey 1. Finally, 10% reported that errands frequently influence their choice (this factor was not included in Survey 1). See Table 2.

Table 2. Environmental Factors Affecting Choice of Commuting Routes

Environmental Factors	Frequently	Sometimes	Rarely
Traffic reports and messages	36.4%	45.1%	18.5%
Actual traffic congestion	29.4%	49.8%	20.8%
Time of day	23.4%	34.6%	41.9%
Weather conditions	8.2%	28.5%	63.2%
Time pressures	11.2%	34.9%	53.9%
Errands	10.3%	47.7%	41.9%

Delivery of Traffic Information

When asked about their preference for time and place to receive traffic information, half the respondents (57%) said they prefer to receive traffic information before leaving home or work. Almost one-third prefer to receive traffic information after beginning their commute but before entering I-5 (22% prefer city streets; 12% prefer near entrance ramps). Respondents least prefer to receive traffic information after entering I-5. See Table 3 for comparison with Survey 1.

**Table 3. Preference for Timing of Traffic Information:
Comparison between Both Surveys**

Time Preference	Survey 1	Survey 2
Before leaving home or work	53.2%	56.5%
While driving on city and county streets	22.4%	21.5%
When approaching entrance ramps	15.9%	12.2%
While driving on freeways	3.8%	9.8%

Depending on the driving decision, between 2% and 17% of respondents stated they are frequently influenced by traffic information before they drive. (In Survey 1, between 2% and 14% were frequently influenced by traffic information before they drove.) The data show that route choice and time for leaving are more influenceable than transportation mode;

additionally, the influence of traffic information on pre-trip route choice and departure time significantly correlate. Further, many respondents who said that their route choice is influenced before driving also responded on an earlier question that their route choice is influenced by traffic information in general.

For 63% of respondents en route, traffic information frequently or sometimes causes them to divert to an alternative route. This is about 10% more than in Survey 1. Respondents who said that their route choice is influenced while they were en route also replied to an earlier question that their route choice is influenced by traffic information in general and by actual traffic congestion.

When asked about availability of phones and computers, most respondents (97%) reported having access to a phone in their home and/or place of business. Almost three-fourths (70%) have access to a computer in their home or at their place of business. More than one in ten people have access to a phone in their car (12%), and 5% have access to a computer in their car.

When asked about their preferences for sources of traffic information, 81% of the respondents said that they prefer commercial radio before and during driving. The second most helpful source for receiving traffic information is TV reports (14%), followed by electronic message signs over I-5 (11%), and CB radio (5% before driving and 6% while driving). Least preferred is HAR (1%). See Table 4 for a comparison with Survey 1.

Table 4. Sources of Preferred Traffic Information

	Before Driving		While Driving	
	Survey 1	Survey 2	Survey 1	Survey 2
TV	11.7%	14.2%	-	-
Electronic message sign over I-5	-	-	11.4%	11.3%
Advisory radio indicated by flashing lights on highway signs	-	-	7.2%	0.8%
Commercial radio station	75.5%	81.1%	80.2%	81.4%
Phone	3.4%	-	0.8%	-
CB radio	0.2%	4.7%	0.4%	6.1%

When asked about helpfulness of traffic information received from various media, 67% of the respondents said that they consider information received from commercial radio stations very helpful. See Table 5 for considerations of other media. In Survey 1, the majority (55%) also rated messages received via commercial radio the most helpful. About 12% more respondents in Survey 2 than in Survey 1 considered commercial radio stations very helpful.

Table 5. Rated Helpfulness of Traffic Information Sources

Traffic Information Source	A lot	Some	Very little	Never used
TV	4.7%	13.5%	22.8%	59.0%
Electronic message sign over the freeway	5.8%	21.9%	42.6%	29.7%
Advisory radio indicated by freeway sign	5.3%	17.1%	37.4%	40.2%
Commercial radio station	66.9%	24.8%	6.2%	2.1%
Phone	.9%	3.5%	9.8%	85.9%

Respondents were asked whether they would use various media to receive continual, up-to-the-minute traffic information if it were available. A vast majority of the respondents (92%) stated that they would use a radio station dedicated to traffic information. Additionally, 35%, 27%, and 22% stated that they would use a phone hot line, a cable TV station dedicated to traffic information, and a computer delivery system, respectively. The only significant difference from Survey 1 is that only 15% in Survey 1 stated they would use a computer. When asked which media they would like to see developed first, most respondents (86%) said that they would prefer to see the development of a radio station dedicated to traffic information, then a phone hot line (8%), a dedicated cable TV station (3%), and a computer delivery system (3%).

Demographic Information

The distribution of the sample across gender was 54% male respondents and 46% female respondents. With regard to age, 50% of the respondents were under 41 compared to 61% in Survey 1. The largest difference is that 36% were in the 41-49 age group in Survey 2, while only 25% were in that group in Survey 1.

The northbound respondents seem to be better off financially than the southbound respondents. Survey 2 respondents (54%) reported living in households with earnings above \$60,000 per year. In Survey 1, only 35% reported living in households with earnings above \$60,000 per year.

The majority (54%) of respondents have no children 18 years or younger living with them; 39% have one to two children 18 years or younger living with them (this question was not asked in Survey 1).

Lake Washington Bridges and I-405 Users

East/west commuters who received the survey were most likely to be I-90 users. Slightly more than half the respondents (56%) who travel on I-90 east or west to downtown Seattle commute five days per week, while only 4% of respondents who use SR-520 commute five days per week. Again, this is because the natural route of east/west commuters who received the survey was across I-90. Of the respondents who travel on I-405 north and I-405 south, 16% commute five days per week.

When asked which sources of traffic information east/west commuters prefer to use in selecting a bridge for commuting to work over Lake Washington, 78% chose a commercial radio station. This is just slightly less than the north/south respondents (about 81%) who prefer a commercial radio station.

Half the east/west respondents are likely to choose a bridge for commuting over Lake Washington before leaving their homes (56%), with the next choices being while driving on city and county streets (19%), while driving on freeways (15%), and when approaching

entrance ramps (10%). In this regard, east/west route choice is very similar to north/south route choice.

Non-Response Survey

We eliminated 17% of the non-response sample because they were unavailable for various reasons and were in all likelihood non-commuters. Of the remaining 83% of the sample, 29 were contacted by phone and 21 (those who could not be contacted by phone) were mailed a short survey form. Sixty-two percent of the households contacted by phone did not contain a Seattle-bound commuter of the sex of the driver of the surveyed vehicle. Eighty-one percent of the households in the mail-survey group did not respond, likely because they did not contain a Seattle-bound commuter. These results suggest that non-respondents are likely to be non-commuters.

Usability Testing of Commuters

Changing Commute Behavior

It appears that the commuters who are predisposed to receiving traffic information via computer would be most easily influenced by *Traffic Reporter* to change departure time. In addition, it appears that on the basis of computer-based information, the Route & Time Changer group is most likely to change departure time. Most of these commuters commented that they would feel more comfortable changing their departure time if they had more information about overall traffic conditions. A number of commuters cannot change their departure time because of very rigid schedules.

The groups most likely to change route based on information from *Traffic Reporter* are the Route & Time Changer and Route Changer groups. Again, it appears that computer preference is a determining factor in whether members of a group are likely to use *Traffic Reporter's* information in deciding whether to change route. Furthermore, commuters want to know the cause of delay on the freeway and to confirm that changing their route saved them time.

Most of the commuters commented that they are fairly unwilling to change their mode of transportation (although no one totally ruled out the idea of changing transportation mode). Furthermore, several commuters mentioned that if there were a light rail system with a convenient schedule, they would reconsider their stance.

Interaction with the System

Although each task in the usability test required only one mouse move, commuters averaged about 1.5 times that number. Almost all commuters commented that with practice they would feel more comfortable moving around the system. However, several commuters mentioned that they found double-clicking of the mouse confusing.

Interface Design

Commuter comments on the interface design addressed three areas: dialog boxes, speed ranges and colors, and arrows. Most commuters thought that the type of information presented in dialog boxes was useful. However, because commuters drive to and from work from the same starting point to the same ending point every day, they would probably go to information dialog boxes only if the main screen showed a problem--i.e., if the I-5 lanes on the screen revealed a lot of red and purple. This preference seemed especially true of the zoom dialog boxes. Most commuters said that they might use the zoom feature to see if traffic on a "red" section of the freeway was just moving slowly or had stopped. However, they noted that if traffic had stopped, they would prefer to see that information on the main screen.

Although most commuters said they thought the speed ranges were both appropriate and useful, they would like some indication, such as a blinking light or other flagging device, to indicate when traffic was stop-and-go or completely stopped. Many commuters said they would like the slower speed ranges further divided, although they acknowledged that adding more speed ranges might clutter the screen and actually be confusing and therefore counterproductive. The commuters like the choice of colors used to indicate speeds, except for the color

purple, which *Traffic Reporter* uses to indicate speeds between red and yellow. Several commuters mentioned that the purple and red colors tended to run together when large blocks occurred next to each other. One commuter who was partially color-blind noted that color-blind individuals can tell what color a traffic light is by its position but that this method of distinguishing colors is not available on the *Traffic Reporter* screen.

The commuters were confused by what the arrows next to six of the exits meant. These arrows are supposed to indicate ramps that are exit-only or entrance-only. Commuters who did guess correctly based their ideas on prior knowledge rather than representations on the screen.

Potential Use of the System

All of the commuters seemed impressed with the system and said that if *Traffic Reporter* were available, they would use it. Almost all commuters especially liked the timeliness of *Traffic Reporter's* information compared to their current sources of traffic information. Most commuters, however, said that they would use *Traffic Reporter* only if (1) arterials and alternative routes were included and (2) traffic delays were explained (e.g., which lanes were affected, how long delays would be, etc.). Also, several commuters said that they would make consistent changes on the basis of *Traffic Reporter's* information only if over time they found that their changes saved them time and frustration. Furthermore, a number of commuters wondered what effect increased information might have on congested alternative routes.

Preferred Medium for Receiving Traffic Information

Many commuters commented that their choice of medium would depend on where they were when they needed traffic information. If they were in their cars, they would prefer to hear the information on the radio; if they were either at home or work before departing, they would prefer the information on a screen. Commuters ranked computers at home and work as

the most useful delivery medium, followed by radio, TV, other, cable TV, kiosk, and computer kiosk. In the "other" category, commuters chose a medium that they could access from their car. (It is interesting to note that respondents to our on-road survey ranked computer delivery much lower than those who took part in the usability tests, indicating that lack of familiarity with a delivery medium will cause it to receive a low ranking.)

Commuters overwhelmingly expressed the desire to be able to view and manipulate the system for themselves so that they could access information quickly and customize the system to their own commute. Many commuters expressed great displeasure with the traffic information they currently receive from TV or radio. The most common complaints were that the information was old and inaccurate, and that TV and radio stations tend to focus on only certain locations. Although commuters want to have more control over the information they receive, most of them also expressed concern about the time lapse between seeing *Traffic Reporter* before their commute and actually entering the freeway. Mainly for this reason, several commuters expressed the desire for a radio station dedicated to traffic information.

Usability Testing of Media Personnel

Interaction with the System

Media subjects revealed different information needs than commuters. In general, media personnel like the system's interactive capability. They believe the system's ability to determine time and speed estimates would be helpful for regular checks on normally congested areas. By comparing speed in a specific congested area with average speed in that area, reporters could tell commuters how much extra time it would take them if they used that route. The media personnel also thought time and speed estimates would be advantageous when comparing the traffic on the two bridges. However, the media personnel favor being able to compare the information about the two bridges rather than providing specific time and speed information per bridge to commuters; although in other situations they believe commuters often would want the specific traffic information also provided by *Traffic Reporter*. The media

personnel also believe time information is more important to commuters than speed information.

Regarding the function that displays the best entrances or exits, two of the subjects commented that information to an exit is more valuable than from an entrance. Unlike commuters, all media subjects thought that double-clicking was the fastest way to get the most information.

Regarding the function that provides information between any two ramps, one subject felt this function was the least useful because it took too long to compare several scenarios and the information provided was too specific for general broadcasting. On the other hand, one subject felt this function was best because it did provide specific information.

The subjects thought the zooming function was most useful if a specific problem arose, but that they would not know why the back-up or problem was happening.

Finally, the media personnel commented that *Traffic Reporter* cannot replace other sources of information, such as scanners, Metro, planes, cameras, cellular phone callers, or TSMC, but that it could help with sending out watchers, giving earlier confirmation of problems, and clearly focusing traffic information.

Interface Design

The subjects made the following comments and suggestions regarding the interface design. They thought the color coding useful except for the color purple. They suggested adding an incident box to provide information on traffic incidents. They would also like to integrate TSMC camera shots into the *Traffic Reporter* system. One way might be to use menus or layers, or a main screen showing incident information and camera shots confirming incident reports. The subjects felt that the display of northbound trip information to an exit was backwards. The ramps were displayed such that the nearest ramp (the most southern ramp) was first in the list. The subjects suggested sticking with a map metaphor, which would display the nearest ramp at the bottom (or southern) part of the list.

The subjects provided suggestions for increasing the scope of the system. They recommended adding HOV lanes, I-405, I-90, SR-520, Aurora, West Seattle Freeway, Alaskan Way Viaduct, Lake City Way, Bothell Way, First Avenue S. Bridge, SR-518, SR-167, Meridian, Ballard Bridge, Holman Road, Airport Way, East Marginal Way, and the Swamp Creek Interchange. Furthermore, they want coverage of I-5 extended to Marysville in the north and to Olympia in the south.

Other Comments by Media Personnel

The media personnel also recommended developing a touch-screen version of *Traffic Reporter*, adding more sensor loops, and changing the name of the system (the term *Traffic Reporter* is confusing because many of the media who report traffic information refer to themselves as traffic reporters). In general, they felt that all the functions were potentially useful and necessary for media, and that all functions should be kept if media were to be one of the main audiences.

Evaluation by Traffic Engineers

Concerns

The main concerns of the traffic engineers were about validity, time at ramps, the purple speed color, sensor loops on arterials, resolution, and distribution to the public. The traffic engineers were concerned about the validity of time and speed information. The information they currently receive comes in the form of volume and occupancy data from sensors in the roadways. In order for *Traffic Reporter* to deliver the speed and time information that commuters want, we employ an algorithm (also used by the TSMC) to translate volume and occupancy data into speeds. However, the traffic engineers felt that the algorithm was not calculating speeds with sufficient accuracy. (When TSMC personnel give congestion information, they use general terms, such as “heavy,” “light,” “moderate,” and “stop and go.”)

The traffic engineers cautioned that the time commuters spend at approach ramps may considerably increase their commute time, although the *Traffic Reporter* time indications are only for the time spent on the freeway itself. The traffic engineers felt that in order to paint a more accurate picture for commuters (thereby allowing them to make more informed choices), time spent on ramps should be included in the trip information box.

Almost all of the traffic engineers commented on the color coding used for *Traffic Reporter*. The two major complaints had to do with the use of the purple as a speed indicator and no color code for stop-and-go traffic. Several of the traffic engineers commented that the color purple seemed to run into the color red. Additionally, the traffic engineers wanted a color for stop-and-go traffic. The flashing red on the current TSMC system provides a quick visual overview of where traffic problems are occurring.

The traffic engineers agreed that commuters need arterial information. However, because of the way road sensor loops operate and because of the number of traffic lights on most arterials, they felt that other methods of collecting congestion information, such as cameras or lasers, will need to be developed before arterial information can be useful.

At least one of the traffic engineers stated that *Traffic Reporter's* current screen display is too detailed for either TV or CATV, where screen resolution is vastly reduced. If the information were to be transferred to a TV screen, ramp labels would need to be larger, but then the labels probably would not fit on the display.

Finally, the traffic engineers were concerned about the WSDOT's inability to distribute its traffic information to the general public. With the Perkin-Elmer system that currently receives and interprets sensor loop data, as well as with the new VAX system that will replace it, there is a limit on the number of users at any one time. Currently, not only is *Traffic Reporter* using the data, but so too are TCI cable and several radio and TV stations in the area. The issue of access to the data raises questions about who will pay and who will receive free information.

Possible Additions/Improvements

The traffic engineers offered a number of suggestions for additions and improvements to *Traffic Reporter*. Among those suggestions were the following:

- More blow-up maps showing cities, mileposts, and landmarks.
- Incorporation of weather conditions.
- Integration of cameras and text blocks explaining incidents and accidents.
- Addition of HOV lanes, express lanes, and ramp information.
- Separate lane information as opposed to the current aggregate lane information.

Other suggestions that would allow commuters to make more informed choices included the following:

- Color coding of trip information to compare specific trip information with average trip information.
- Icons of cars on the roadways to indicate spacing, speed, and congestion.
- Integration of bus information into the system (schedules, and time and cost comparisons with driving, etc.).

CONCLUSIONS AND RECOMMENDATIONS

This section presents the conclusions and recommendations from the commuter surveys and usability tests that were conducted in Phase 2 of this project.

Commuter Surveys

From our second on-road survey, we concluded that there is little difference in the overall commuting behavior and information needs of southbound, northbound, and east/west commuters. Most importantly, the four commuter types identified in Phase 1 of this project were found to exist almost identically in the Phase 2 population, so similar design principles for traveler information could be used for the entire Puget Sound area. It would be helpful to conduct similar studies in other cities to see if these design principles hold across the country.

In addition we conducted a non-response survey. From this survey we concluded that most of the non-respondents were non-commuters, indicating that respondents adequately represented the commuter population in the Puget Sound area.

Usability Testing of Commuters

Changing Commute Behavior

All commuters who evaluated the system stated they would be willing to change their departure time, route, and occasionally even transportation mode, given the right kind of information. However, commuters also said they would like *Traffic Reporter* to include information on arterials and alternative routes, as well as explanations of traffic delays. Also, several commuters said they would make consistent changes on the basis of *Traffic Reporter's* information only if after time they found that these changes saved them time and frustration. Therefore, future versions of *Traffic Reporter* should include:

- Graphical arterial information.
- Graphical incident information.
- A feedback mechanism.

In addition, special effort should be made to measure and improve the accuracy of information.

Interaction with the System

None of the subjects had any undue problems interacting with the system. However, all the subjects used more mouse moves than necessary, indicating that there are probably too many mouse actions to remember and use. Therefore, some of the mouse options should be deleted, especially in the touch-screen kiosk version.

Interface Design

Most subjects thought the type of information presented in dialog boxes was useful, but they would probably go to information dialog boxes only if the main screen showed a problem. Moreover, subjects want to know when traffic is completely stopped versus when traffic is just moving slowly. Therefore, a flashing color or other distinct marking should be added to the main screen to let commuters know where traffic is stopped.

Subjects liked the choice of colors used to indicate speeds, except for the color purple. Therefore, an alternative to the color purple should be used to represent speeds between those represented by red and yellow.

Subjects were confused by arrows next to six of the exits. (Those arrows were designed to indicate ramps that are exit only or entrance only.) Therefore, the ramp arrows should be deleted and another method found to represent one-way ramps.

Potential Use of and Delivery Medium for the System

All subjects said they would use *Traffic Reporter* if it were readily available. They commented that choice of delivery medium would depend on where they were when they

needed traffic information: if they were in their cars, they would prefer to hear the information on the radio; if they were either at home or work before departing, they would prefer the information on a screen.

Most of the subjects expressed concern about the time lapse between seeing *Traffic Reporter* before their commute and actually entering the freeway. Mainly for this reason, several commuters expressed the desire for a radio station dedicated to traffic information.

The majority of subjects expressed a desire to view and manipulate the system themselves. This argues in favor of touch-screen kiosk, PC, or audio phone delivery. While few subjects indicated a desire for computer kiosks, our studies have shown that lack of familiarity with a delivery medium causes it to receive a low ranking.

Based on the above results, we should do the following:

- Develop a version of *Traffic Reporter* for the use of radio and TV media.
- Explore an audio version of *Traffic Reporter* for dedicated radio or phone delivery.
- Develop a PC-based system geared toward commuters who use a touch-screen kiosk, or be willing to pay for additional information via home services, such as CompuServe.
- Expose the public to computer-based traveler information kiosks via TV delivery and, perhaps, a museum exhibit of *Traffic Reporter*.

It is imperative that testing and evaluation continue as system expansion occurs. Not only should media personnel be involved in this testing, but the needs of commuters must periodically be confirmed, as they are the ones who will ultimately be making decisions based on the information. In addition, the developers of *Traffic Reporter* must work closely with the Traffic Systems Management Center to provide an optimal system.