Development of Human Factors Guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO); Exploring Driver Acceptance of In-Vehicle Information Systems

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FOREWORD

This report is one of a series of nine reports produced as part of a contract designed to develop precise, detailed human factors design guidelines for Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO). Among the other topics discussed in the series are a functional description of ATIS/CVO, comparable systems analysis, task analysis of ATIS/CVO functions, alternate systems analysis, identification and exploration of driver acceptance, and definition and prioritization of research studies.

The report discusses the problem of user acceptance of new technology and documents several empirical studies designed to further understand this issue as related to ATIS/CVO systems. A tentative model for driver acceptance of ATIS devices, based in part on the obtained experimental results, is proposed.

A. George Ostensen, Director
Office of Safety and Traffic
Operations Research and Development

NOTICE

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16. Abstract

This document is part of an integrated program to develop human factors guidelines for advanced in-vehicle information systems. This document provides both an analytic and empirical determination of the human factors issues specific to user acceptance of Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO) systems. Previous research indicates that automatic teller machine technology has not enjoyed widespread acceptance. Two questionnaire-based experiments identified features that drivers find desirable for ATIS systems. A model-based approach for determining drivers' preferred features was also used with success. An experiment using a route guidance simulation that presented a real-time video of on-the-road driving scenes, and a map used for route selection and the purchase of traffic information showed that drivers accepted the ATIS information even when it was only 77 percent accurate. An experiment that addressed CVO function acceptance provided tentative recommendations for the introduction of ATIS systems into commercial vehicles.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yards	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: Volumes greater than 1000 l shall be shown in m^3				
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact)		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celcius temperature	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.71	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact)		
°C	Celcius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

* SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.

(Revised September 1993)

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LIST OF ABBREVIATIONS

AAA	American Automobile Association
AARP	American Association of Retired Persons
ANOVA	Analysis of Variance
ATA	American Trucking Association
ATIS	Advanced Traveler Information Systems
ATM	Automated Teller Machine
CB	Citizen band
COTR	Contracting Officer's Technical Representative
CTA	California Trucking Association
CVO	Commercial Vehicle Operations
FHWA	Federal Highway Administration
h	hour
IMSIS	In-Vehicle Motorist Services Information Systems
IRANS	In-Vehicle Routing and Navigation Systems
ITS	Intelligent Transportation Systems
LCD	Liquid crystal display
MANOVA	Multivariate Analysis of Variance
MIAT	Modified Innovation Acceptance Theory
min	minute
MRA	Multiple Regression Analysis
NASA	National Aeronautics and Space Administration
NHTSA	National Highway Traffic Safety Administration
PC	Personal Computer
PFA	Principal Factor Analysis
RGS	Route Guidance Simulator
RPM	Revolutions per minute
SAS	Statistical Analysis Software
SPSS	Statistical Package for Social Science
TAM	Technology Acceptance Model
TLX	Task Loading Index
TRB	Transportation Research Board
TV	Television set
U. S.	United States
VCR	Videocassette recorder

EXECUTIVE SUMMARY

The goal was to investigate human factors issues specific to user acceptance of Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO) systems. This was accomplished both analytically and empirically.

Chapter 1 defines the problem area by reviewing available prior research. Automated Teller Machines (ATM's) are described as a case history in acceptance of new technology. Although ATM's are ubiquitous and have been available to consumers for almost two decades, less than half the population uses ATM's. Even those who do use ATM's seldom take advantage of all the features the technology provides. Finally, older consumers (50+ age group) tend not to use ATM's at all. Consumers do not accept new technology merely because it exists.

Simulation studies of ATIS devices indicate high acceptance (70 to 95 percent) by drivers. However, part of this acceptance may be due to demand characteristics in the laboratory and to problems in matching real-world motivation. For example, cash rewards during simulated trips may not have the same motivational effects as being stuck in traffic for long periods of time. Studies that surveyed the behavior of urban commuters indicated much lower rates of diversion (50 percent or less) from usual routes.

A useful starting point for explaining consumer acceptance of new technology is the model created by Mackie and Wylie (1988) to address the procurement of large, expensive military systems. This model was modified to create a consumer-oriented Technology Acceptance Model (TAM) better suited for Intelligent Transportation Systems (ITS) technology. This model is quite complex with many variables and parameters.

Chapter 2 presents two experiments based upon questionnaire methodology. In experiment 1, 109 drivers were shown two videotapes about TravTek. In experiment 1B these same drivers plus 20 commercial vehicle operators were given a demonstration of CityGuide route selection software. Experiment 1 used a questionnaire with 155 subjective rating dependent variables and experiment 1B used 93 variables. Results from these experiments were analyzed in three phases. First, descriptive statistics were calculated directly. This analysis for experiment 1 permits easy comparisons with TravTek data collected in Orlando because 21 items in the questionnaire were taken directly from the TravTek survey. Second, a repeated-measures analysis of variance (ANOVA) was used to examine relationships between subject variables and knowledge of system capabilities as tested in the questionnaire. Third, a model based upon constructs of fidelity, attention, system trust, self-confidence, capabilities understanding, and driver characteristics was used to explain feature-pattern desirability as calculated from a Principal Factor Analysis (PFA) with a Varimax rotation. This model was very successful in reducing the large set of subjective rating variables to a very small number of underlying factors in both experiment 1 (six factors) and 1B (four factors). These experiments revealed patterns of features that drivers find desirable and related them to constructs that account for acceptance of ATIS technology. Thus, the present model-based approach should be continued because it provides important information that is hidden when only descriptive statistics are presented.

Chapter 3 presents an experiment using the Battelle Route Guidance Simulator (RGS). This simulator uses real-time video presentation of actual on-the-road driving scenes, thus avoiding some of the key limitations of earlier simulator research that has been based upon artificial hypothetical road networks or static presentation of traffic scenes. The driver sees two computer displays. The first shows actual traffic scenes in Seattle in real-time. The second is a touch screen with a map of Seattle; the driver uses this to select his or her route and to purchase traffic information. Before starting the simulation, the 48 drivers indicated their preferred route from downtown Seattle to a landmark shopping mall in Bellevue. This destination forces drivers to cross Lake Washington. Since there are only two bridges across the lake, the experimenters have considerable control over traffic conditions encountered by the drivers regardless of the route selected. Results showed that drivers accepted ATIS information almost always: only 7.8 percent of the simulated journeys were on the indicated preferred route.

An important independent variable in this experiment was information reliability, which could be either 100 percent or 77 percent accurate. Will inaccurate information cause drivers to ignore ATIS advice? Results showed that drivers continued to purchase traffic information, even when it was only 77 percent accurate. While trust in the system decreased after it gave erroneous information that caused delays, harmless inaccurate information did not decrease driver trust. Furthermore, subsequent accurate information caused trust to increase again.

Chapter 4 presents an experiment that addressed CVO function acceptance issues. In this study, paper and pencil questionnaires were administered to both local and long-haul drivers. The questionnaires were coupled with verbal explanations and examples of function applications. A direct magnitude estimation task, a psychophysical forced-choice analysis and a relatively new link-weighted network analysis (Schvaneveldt, 1990) were used to understand user acceptance issues of potential CVO functions.

Sixteen potential ATIS functions were rated for their value as job performance aids by two groups of commercial vehicle drivers (local drivers and long-haul drivers). A network analysis was used to identify preliminary groupings of the functions which differed in driver-assigned value. For both local drivers and long-haul drivers, ATIS functions that improved driver safety were judged most valued. Ancillary information services were judged to be of little or no value and perhaps even of negative value because of potential interference with the driver's primary task of vehicle operation. Other ATIS functions such as routing aids, fleet management, and dispatch control were rated differently by local and long-haul drivers. Local drivers attached some job-related value to these functions; whereas long-haul drivers appeared to be neutral, at best.

From these as yet unsupported findings, tentative recommendations can be made for strategies to introduce ATIS systems into commercial vehicles. Since both groups of drivers placed considerable value on ATIS functions that increase driver safety, functions such as hazard warning, road condition information, and automatic emergency aid requests should be included in any initial commercial vehicle ATIS systems. For long-haul drivers, the introductory suite of functions may also include vehicle and cargo monitoring as well as enhanced voice and message communications functions. The incentives for drivers to use this type of safety configuration is obvious. It is clearly intended to increase their personal safety. As long as the components of the initial system operate within acceptable limits of information accuracy and system reliability, commercial driver acceptance should be facilitated. Moreover, acceptance by fleet operators should also be facilitated on the premise that increasing driver safety will improve accident avoidance. There may be two benefits for fleet operators in this approach to ATIS introduction. First, reducing accidents directly reduces overall operating costs. Second, emphasizing driver safety may have the added effect of increasing driver loyalty and hence reducing turnover rates. Thus, the advantages, and the incentives, appear to be present for both drivers and management to adopt an ATIS system that is configured for driver safety.

As the driver-safety ATIS is deployed, there will be opportunities to highlight the value of additional functions. For example, including a vehicle locating function would allow an automatic aid request to include the vehicle's current location, thereby speeding the response of emergency vehicles. The fact that a vehicle locating function is also at the core of many vehicle and fleet management functions introduces a strong negative for some drivers; but appropriate early education to emphasize the safety value may overcome some of the resistance. The addition of a vehicle locating function may be best introduced for local drivers. In our study, local drivers rated routing and re-rerouting functions relatively highly as job performance aids. Without the vehicle locating function, the routing functions require considerable driver set-up; however, with vehicle locating, the routing functions can automatically provide better guidance to the driver. As they navigate around congestion and into unfamiliar areas, local drivers may find that a vehicle locating function has value beyond its connection to driver safety.

The incremental introduction of ATIS functions into a base system configured for driver safety appears to be a strategy that will initially meet some of the needs of both drivers and fleet operators. The base system does not include those functions that may be most valuable to fleet operators because those same functions are likely to be the most resisted by drivers. As the base system is deployed and accepted, there should be a foundation for introducing more ATIS functions. These added functions must be accompanied by appropriate education of both drivers and fleet operators and by proper management for change. The incremental introduction of ATIS/CVO systems suggested here is one piece of the total program for acceptance.

Chapter 5 presents conclusions about driver acceptance of ITS technology. A tentative model for driver acceptance of ATIS devices, based in part on the obtained experimental results, was formulated. However, additional research will be required to validate this model. Recommendations for the design of equipment, educational techniques, and incentives that could be used to promote ITS acceptance and use in CVO are provided.

CHAPTER 1. ASSESSING DRIVER ACCEPTANCE: PROBLEM DEFINITION

The objective is to begin addressing the problem of user acceptance of in-vehicle technology as part of the Intelligent Transportation Systems (ITS). Emphasis will be given to issues of acceptance associated with Advanced Traveler Information Systems (ATIS) and Commercial Vehicle Operations (CVO). The main body of this report provides a broader context for considering these issues by discussing the multi-faceted problem of user acceptance of new technologies in general. The six specific points (a through f) defined in the Statement of Work are addressed in appendix A, (pp. 153-165). A review of the applicability of research approaches based on the assessment of attitude formation is given in appendix A.

The issue of user acceptance of new technology is a difficult one that cannot be fully explored within the scope of this project. The material presented in this report represents a culling of existing literature and data, some of which addresses general issues of technology acceptance and resistance, and some of which analyzes user reaction to specific systems. Each topic that is presented may influence an eventual product of this project through incorporation into system design guidelines, recommendations for training, or suggestions for facilitating the adopting of change in large organizations. The goal is to identify the options available for further research and to provide some guidance in the approach to studying user acceptance issues. ITS acceptance issues will not be resolved by literature review, but the information developed in this subtask provides a framework for productive investigations of driver acceptance of ATIS/CVO in-vehicle technologies.

BACKGROUND

Resistance is a common first reaction to change. Some users can be expected to put up a barrier that must be overcome before the benefits of an innovation are understood and accepted. At the other extreme, some users may perceive an innovation as the perfect answer to a problem and adopt it immediately. Other reactions to change may include compliance, acquiescence, and active or passive resistance. This range of reactions also may characterize someone's initial, short-term or final, long-term response to change. The introduction of ATIS/CVO technologies is likely to encounter this full range of potential responses from the driving population.

The introduction, adoption, and diffusion of an innovation through the potential user population appears to follow an S-shaped curve that represents the cumulative percentage of user adoption over time since introduction (Herbig, 1991). The first to adopt are often labeled "innovators," whereas "laggards" is the term applied to those who wait to adopt or who never adopt an innovation. The percentage of innovators in the user population will determine the initial success of an innovation. The percentage of laggards partly determines the asymptote of the cumulative adoption curve. As the labels imply, there is a pro-innovation bias in much of the work that has studied innovation adoption and diffusion. Innovators are encouraged and, in fact, new products are often designed to appeal to the requirements of the innovators. Innovation diffusion beyond the innovators depends on bandwagon effects as others emulate the innovators. Laggards are viewed as deficient in some way. A further implication of these labels is that there should be some consistent characteristics of innovative users and of laggards. However, this implication lacks empirical support. Adoption of innovation seems to be situation or innovation specific. An innovator for one product may be a laggard for another. Moreover, studies that have searched for consistent personality traits associated with innovativeness have not found them (Robertson & Kennedy, 1968).

A Case History

As an example of the problem of user acceptance of innovation, consider the history of the Automated Teller Machine (ATM). Since its introduction into test markets in 1974, ATM's have become as common place as banks, shopping malls, and supermarkets. ATM's provide access to banking services at virtually any hour of the day or night and, with the introduction of inter-bank networks, at almost any location. With an ATM, users can deposit or withdraw funds, transfer funds between accounts, and recently, even buy stamps and tickets for public transportation.

There are two important parallels that can be drawn between ATM's and the emerging ITS applications. First, freedom of movement is highly valued in our society. People do not like to stand in line at the bank, nor do they like to be constrained by bumper-to-bumper traffic congestion. Second, both ATM's and ITS technologies, particularly CVO applications, interpose a machine in what has traditionally been a face-to-face interaction. The bank teller and the dispatcher are replaced, at least some of the time, by automated systems. One important difference, however, is that ATM's require no initial investment by the user, whereas ITS applications must be purchased by the user.

Given the services and convenience available through ATM's, one might expect that user acceptance is not a problem. The Exchange Network, based in Seattle, has provided the following data. In 1990, the network had about 4.7 million accounts and handled 40 million transactions. In 1991, there were about 5.0 million active accounts and 47 million transactions. For 1991, then, that averages 9.4 transactions per account for the year, an increase of almost one transaction per account from the prior year. In informal surveys, current users of ATM services reported usage at three to five times the average annual rate, suggesting that perhaps less than half of the account holders are generating all of the transactions. In support of the informal surveys, the Exchange Network estimates that 35 to 40 percent of the account holders generate most of the ATM transactions. The highest level of usage comes from the 18-to-24 age group, and usage in the over-50 age group is virtually nonexistent. Among frequent ATM users, only 30 percent report ever having used the ATM to make deposits into their accounts. Forty percent of frequent ATM users report that they have used the night depository at the bank instead of the ATM, even though the ATM issues a receipt for the transaction while the night depository does not. Very small percentages report using the additional services available through ATM's. Frequent ATM users have reported waiting in line at the post office for 15 min or more instead of buying their stamps at an ATM.

The lessons from the history of ATM's are:

- After almost 20 years and with the ATM infrastructure now in place, less than half the population use ATM's.
- Add-on features may not be used at the same rate as the original functions.
- Age is an important correlate of ATM usage. The over-50 age group does not use ATM's even though many current members of that age group were in their thirties when the technology was introduced.

THE ACCEPTANCE OF INNOVATION

A large number of factors can influence the acceptance of an innovation. An innovation may solve a serious, longstanding problem, but if the price tag is too high, the innovation will not be accepted. If those in positions of authority prescribe one solution, other innovations may never even be considered. If users deem an innovation to be an invasion of privacy or an abridgment of their personal freedom, the innovation is likely to be resisted. If an organization is known to be unreceptive to change, individuals in that organization may show greater resistance to innovation than would otherwise be expected. If the innovation is difficult to use, acceptance will be less likely. A sophisticated, elegant innovation may fail in the marketplace because no one is aware of it. An inferior innovation may achieve wide acceptance or at least usage compliance if the users' incentives are structured appropriately. In some cases, an innovation is accepted or resisted because of a positive or negative value on a single dimension. More typically, some combination of costs and benefits, positives and negatives, across many dimensions determines the relative acceptance or rejection of an innovation.

A full consideration of reactions to ITS would incorporate relevant topics from a variety of fields of study. For example, the social psychology of attitude change (Lewin, 1951) is appropriate to understanding how an individual confronts change in general. The measurement of attitude and the relationship between attitudes on behavior are important for understanding the acceptance of new technology (Fishbein & Azjen, 1975; Fazio, 1986). Because of the relevance of this topic to the problem of ITS user acceptance, a brief review of attitude measurement and influence on behavior is given by an experimental social psychologist in appendix A, pp. 165-172.

For CVO applications, organizational behavior becomes directly relevant to the adoption of innovation because it can either facilitate or impede workers' involvement with new technology (Turnage, 1990; Zuboff, 1982). Issues of ITS system complexity and usability must be addressed, as well as concerns about driver overload and underload (Hancock & Caird, 1992a). For drivers of private vehicles, the potential market for specific innovations should be explored (e.g., Turrentine, Sperling, & Hungerford, 1991). For all classes of users, the microeconomic conditions are important to the analysis of cost-benefit and competitive advantage. The macroeconomic costs to society of creating the ITS infrastructure also must be considered. Traffic safety must be realistically projected so that personal and societal risks can be accurately assessed. Finally, the availability of the enabling technologies must be projected within a multiple-stage introduction of ITS systems into integrated solutions to transportation problems (Hancock & Caird, 1992b).

In contrast to these high-level considerations, the Statement of Work requests detailed answers to six points that span the relatively separate disciplines mentioned above. The list of points includes:

a. Reasons for resisting new technology.
b. Techniques used by drivers to resist new technology.
c. Estimated percentage of drivers likely to resist use of in-vehicle technology.
d. Estimated percentage of drivers likely to follow recommendations provided by an in-vehicle system.
e. The conditions by which acceptance or rejection of advice is used/taken by users (e.g., the effects of weather, severity and/or potential magnitude of congestion, travel time savings, reliability of the quality and accuracy of information, and the medium used to convey the information).
f. Potential techniques (e.g., incentives, education, system design, etc.) for promoting acceptance and use of in-vehicle ITS technology.

An attempt was made to answer these specific points in appendix A, pp. 153-165, although the answers are limited by the prescribed approach, namely, literature review. The remainder of the body of this report will address the more general issues of acceptance, the complexities, and the constraints associated with providing explicit answers to the points listed above. Most importantly, a structural model is provided as a basis for guiding further research.

To illustrate the multi-disciplinary aspect of addressing the six specific points, consider point "c" for non-commercial drivers. For one approach, estimating the percentage of drivers likely to resist in-vehicle systems requires a catalog of reasons for resistance to innovation. That catalog would likely include: "I'm just comfortable with the way things are now" to "I can't afford it" to "I can do it better myself" to "I can't stand that synthetic voice telling me what to do." In other words, the reasons would range from an unreasonable "stonewall" resistance to change in any form to a negative reaction to an implementation detail perhaps found in one small ITS component. In addition to the catalog itself, each reason for resistance would be associated with the conditions under which it applies. Clearly, "I can't afford it" is not applicable for resisting the use of your current vehicle's cruise control mechanism. Creating a percentage estimate from these source data would be an adventure, at best. Moreover, since in-vehicle technology consists of a variety of components and separable subsystems, the process would probably have to be repeated on a function-by-function basis. For instance, safety-conscious older drivers, who rarely if ever have used currently available cruise controls, may favor reliable collision avoidance systems to help them in situations to which they can no longer react as quickly. Whereas, younger drivers, including those who are frequent users of cruise control, may reject adaptive cruise control systems because they prefer to change driving lanes and go around instead of accommodating to slower vehicles (Turrentine et al., 1991).

Another approach to estimating resistance relies on analogies with other systems and on composite acceptance curves (Herbig, 1991). If the history of ATM usage is considered to be representative of the classic S-shaped adoption curve, it might be concluded that ITS acceptance will be gradual during the first 8 to 10 years, reaching perhaps 5 to 10 percent of the population during that period. As the infrastructure continues to evolve, ITS acceptance and usage can be expected to accelerate about 10 years from introduction and reach, perhaps, 40 percent of the population after 20 years. These predictions are based on the tenuous assumption that the ATM and ITS applications are fully comparable, that ITS technology will evolve at an appropriate rate, and that the social and economic climate will not change substantially. Of course, the time course of the growth in ITS acceptance could differ substantially from ATM usage.

If estimating in-vehicle technology resistance for the CVO environment is considered, a first-glance analysis might suggest that the answer would be derived from a straightforward business decision. If the fleet managing organization has the resources for the initial investments, if the projected savings define an acceptable pay-back rate, and if the new technology affords other competitive advantages, then the new technology is likely to be adopted by the organization. In making a business decision, projected savings may be based on directly measurable cost factors such as:

- Fuel savings resulting from more efficient routing leading to less high-speed driving to maintain schedules.
- Reduced maintenance costs because of lower mileage and less equipment abuse.
- Better on-time delivery of perishable cargo resulting from tighter driver control.
- Lower accident rates in an overall safer system.

Other cost factors also must be estimated, including items such as worker training costs, productivity losses resulting from worker discontent, personnel turnover, subversion or even sabotage of the new system, and worker stress resulting from the feeling of being constantly monitored and managed (Zuboff, 1982). These added costs derive from the reactions of individual workers to the introduction of new technology. These cost factors are easy to overlook because they are difficult to quantify. Ultimately, the success of in-vehicle CVO technology may depend on the acceptance or resistance by individual drivers who share many of the same concerns as drivers of private vehicles. The costs of personnel training and staff turnover can easily offset savings from reduced fuel usage and maintenance, thereby reducing the pay-back rate.

As a point of comparison, in manufacturing applications, new technologies have failed to meet expected productivity gains an estimated 50 to 75 percent of the time with the failures more often attributed to problems between the organization and its workers than to the technology itself (Turnage, 1990). Perhaps the organization's expectations for productivity gains were too high; perhaps if the expectations were lower, the initial investment would not have been made. CVO applications might be expected to show a comparable pattern of success for much the same reasons (Schauer, 1989).

Estimating the percentage of drivers likely to follow in-vehicle system recommendations (point "d") is perhaps even more difficult because it is highly dependent on the specific conditions. On a positive note, Allen, Ziedman, et al. (1991) report a simulation study in which more than 95 percent of their subjects diverted from their current freeway route in response to a 30-min congestion delay. The congestion was either detected by the driver in the simulated forward view or reported by one of three levels of simulated ITS navigation information systems, or both. Given the advance warning provided by the navigation systems, diversion often occurred before traffic congestion was encountered. In this study, 84 percent of the driver-subjects diverted in response to an 11-min delay. To simulate real-world motivation, subjects were rewarded $1 for each 5 min saved and penalized $1 for each 5 min lost during their simulated trips.

In another simulation study, Bonsall and Parry (1991) report that, overall, about 70 percent of the advice provided by a simulated ITS-type system was accepted. The primary independent variables in this study were the quality of advice being generated and the driver's familiarity with the artificial environment. When the system-generated advice usually led to near-minimal travel times, the advice was accepted almost as often as in the Allen, Ziedman, et al. (1991) study. On a subject's first journey through the simulated data base, system advice was nearly always taken. As subjects became more familiar with the simulated environment, acceptance of system advice decreased as other factors, such as the extent to which advice was corroborated by other evidence, came into play.

In contrast to these findings from simulation studies, Khattak, Shofer, and Koppelman (1991) report that less than 50 percent of their surveyed commuters diverted from their usual route even for delays as long as 50 min. Consistent with these data, Spyridakis, Barfield, Conquest, Haselkorn, and Isakson (1991) report that 63.1 percent of their surveyed subjects rarely modified their routes from home to work, and 42.2 percent rarely deviated from their normal route going from work to home. Route changes in this study were triggered by delays of about 20 min.

From these data, it can be argued that acceptance of advice generated by ITS systems should be 80 percent or better if the simulation findings are to be believed, or that acceptance will be no better than 50 percent based on the survey data. The difficulty is that there are problems with both types of data. One simulation study explicitly created demand characteristics that could lead to overestimates of advice acceptance. Allen, Ziedman, et al. (1991) paid subjects to minimize travel time and presented advice that appeared to minimize travel time, and the subjects accepted the advice. In Bonsall and Parry's (1991) simulation, subjects saw only the lowest level of simulation. The driver's display showed a map-like representation of the next intersection, an indicator of the heading to the destination, text information stating what the various directions lead to, and some advice about which turn to take. With even small amounts of conflicting evidence provided to the subjects, such as recommending turning away from the heading to the destination, advice acceptance dropped considerably. The survey data provide reports of what drivers recall doing when they encountered traffic congestion. Both surveys focused on travel time delay as a key factor in drivers' decisions to change routes with delay left to be a subjectively estimated value. The surveys provide no data on actual delays for usual versus alternative routes. Likewise, no data are given on driver's estimates of travel time via alternate routes, nor is any context provided for interpreting the basis for drivers' decisions to divert from the normal route.

A compound estimate for ITS system/advice acceptance can be generated by combining the tenuous acceptance projections, based on ATM data, with the estimated upper and lower bounds of advice compliance, based on the survey and simulation studies. The 90+ percent and the 50 percent values from the studies described above can be used as upper and lower bounds on the acceptance of ITS in-vehicle advice. If ITS in-vehicle systems are introduced in the year 2000 and it takes 20 years for them to reach 40 percent of the population, then by 2020, about 20 to 35 percent of all navigation decisions will be based on advice accepted from ITS systems. This must be considered a very gross estimate, particularly because the technology acceptance curve for ITS could differ substantially from the ATM data. Other examples of acceptance curves, sometimes called "diffusion" curves, are given in appendix A, p. 158.

APPROACHES TO STUDYING DRIVER ACCEPTANCE

One result of examining the broad context of innovation acceptance is that it illuminates the difficulties of achieving a detailed understanding of user acceptance. There are so many factors that are clearly important. There are many other factors of indeterminate importance, and there are so many conditions that appear to influence whether and how a given factor applies in a specific situation.

In this section an attempt is made to constrain the approach to the problem in ways that make sense given the limited time and effort allocated to this task and that appear to lead to a useful result. Specifically, an attempt will be made to better organize the dimensions and attributes of innovation acceptance with the goal of defining what aspects of driver acceptance can be identified and manipulated experimentally. Possible research techniques focusing on when to measure acceptance during the life span of an innovation are discussed. Also discussed are some of the measurement devices that might be useful in deciding how to gather data on innovation acceptance.

A Structural Model of Innovation Acceptance

From some of the background discussions, it is clear that acceptance of innovative technologies involves categories including economic, safety, organizational, and psychological factors. Beyond the identification of potentially discrete categories, it is also clear that different factors may affect different aspects of innovation acceptance. A private-vehicle driver may accept the concept of an in-vehicle navigation advisory system but not be able to afford the device itself. To extend these small-scale linkages between factors and outcomes, an analytic structure is needed that will begin to define the relationships among factors.

As a starting point, consider the innovation acceptance theory of Mackie and Wylie (1988). Originally devised to address the procurement of large military systems, the theory is oriented to the acceptance of expensive, one-of-a-kind systems that were deliberately designed to solve relatively specific problems. The theory seems to provide adequate coverage of that special domain. It focuses on identifying the attributes of acceptance that are relatively internal to an individual user and, in a military context, would probably determine that individual's ultimate decision to use the system or to turn it off. The theory also highlights the two external factors that determine the behavior of military personnel; that is, the prevalent view of the individual's operational unit and direct orders from superiors.

To adapt the Mackie and Wylie (1988) model to our environment, many augmentations must be specified. Figure 1 presents an initial attempt at specifying a more general structural model of innovation acceptance. Definitions pertaining to figure 1 are given in table 1.

In figure 1, the section surrounded by the dashed line can be viewed as internal to the individual system user (adapted from Mackie & Wylie, 1988). The components outside the dashed line represent classes of external factors that can influence an individual's perception, understanding, and assessment of an innovative technology.

At the left edge of figure 1 are two components labeled *Problem Definition* and *Innovation Announcement* (features of the model are identified in italics). These components are the starting points for the process of innovation acceptance. Given a defined problem and an innovation that addresses the problem, initial contact is made with the individual's *Understanding of Problem* and *Initial Awareness of Innovation*. These aspects feed into the individual's judgment about whether there is a *Need for Improvement* or whether current approaches to the problem are adequate. Past experience with innovations, the perceived features of the current product, the weighting of expert opinions, an assessment of personal risk, and the assessment of the availability of help all set the stage for a more complete evaluation of an innovation. These factors determine the user's readiness to assess a new product or system. Significant negatives at this level could lead to immediate rejection of the innovation. For example, significant negative experiences with earlier innovations or a perception of major personal risk could yield a form of "stonewall" resistance.

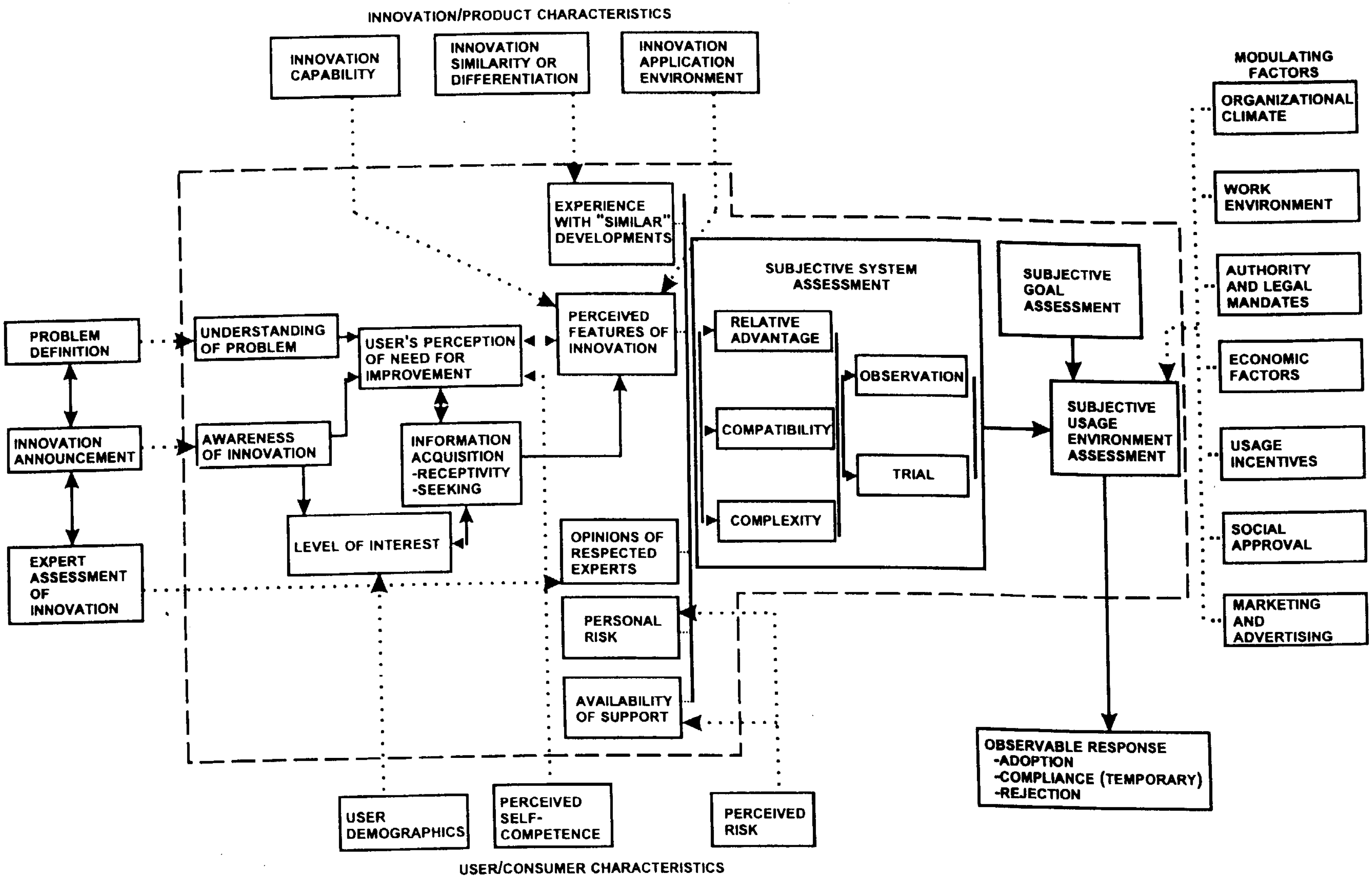


Figure 1. A structural model of the components of innovation acceptance adapted from Mackie & Wiley (1988).

Table 1. Definition of terms for figure 1.

USER/CONSUMER CHARACTERISTICS	
User Demographics	Grouping and subgrouping attributes of users including such variables as: Age, Income, Location (driving environment), Education, Product Knowledge, Acquisitiveness, and Venturesomeness. Assumed to affect Level of Interest and to affect indirectly Perceived Need for Improvement.
Perceived Self-Competence	User's confidence in their ability to function in their current environment and to adapt to changes in that environment. Includes variables such as: Self-Efficacy (user confidence about success in using innovation) and Performance Satisfaction (level of satisfaction with the status quo). Assumed to affect Perceived Need for Improvement.
Perceived Risk	A composite of economic, technical, and psychosocial risk factors such as: skill level and training required, personal safety. Assumed to affect Personal Risk.
INNOVATION/PRODUCT CHARACTERISTICS	
Innovation Capability	Defined relative to Problem Definition focusing on the relative advantage of the innovation compared to the status quo and to other product offerings. Assumed to affect Perceived Features of Innovation.
Innovation Similarity or Differentiation	Comparability with previous innovations experienced by the user. Affects Experience with "Similar" Developments.
Innovation Application Environment	Encompasses variables such as: purported Relative Advantage of innovation over current methods, Compatibility with the user's needs and the user's other activities, Communicability of the innovation's characteristics and benefits, Complexity of understanding and using the innovation, and Divisibility, or the extent to which the innovation requires a large initial investment in time, effort, or money. Assumed to affect Perceived Features of Innovation.
MODULATING FACTORS	
Organizational Climate	Concerns the willingness of formal organizations to incorporate change. The organization's flexibility and venturesomeness is a key, as well as the flexibility and venturesomeness of individual managers at key positions in the organization. The organizational support structures and the role of an Innovation Advocate are also important.
Work Environment	The types of change introduced by an innovation include: change in the control exercised by a worker, change in cognitive demand, change from executing an operation to monitoring it, reduced opportunities for problem solving, increased responsibility for production, greater visibility of performance to supervisors, and changes in social contact, interaction and support.
Authority and Legal Mandates	Decisions made by organizational superordinates or mandates of law requiring the use of an innovation (e.g., a corporate decision to adopt a specific computing system, seatbelt laws).
Economic Factors	Both macroeconomic and microeconomic factors can be effective modulators. Periods of prosperity may increase the user's ability to pay for innovations, or prosperity may allow a disgruntled worker to change jobs more easily, thereby avoiding an innovation in the first job.

Table 1. Definition of terms for figure 1 (continued).

MODULATING FACTORS (Continued)	
Usage Incentives	In organizations, incentives may include bonus pay that depends on successful use of an innovation, greater promotability within the organization, or the threat of firing for non-compliance. For the purchaser of an innovation, rebate programs and tax incentives are examples of corporate and governmental inducements.
Social Approval	Approval by a referent social group takes many forms. An ecologically sound innovation may be preferred by some users and make no difference to other users. Maintaining social and professional status is important, as is maintaining personal dignity.
Marketing and Advertising	Effective marketing of an innovation can influence the initial adoption of an innovation. This includes highlighting the relationship between the potential user's needs and the capability of the innovation, the potential user's pricing sensitivity, and tailoring the presentation of the innovation to the potential user's current behavior.

The component of the model labeled *Subjective System Assessment* encompasses three kinds of rational tests and two types of empirical test(s) that can be used to evaluate an innovation. The individual assesses the innovation on its inherent *Complexity*, on its *Compatibility* with other aspects of the individual's environment, and on the probable *Relative Advantages* that the innovation may afford. *Observation* of the innovation in action and of its results provide one source of empirical data on the effectiveness of the innovation, and *Trial*, or hands-on experimentation with the innovation, provides a second source of direct experience with the innovation. In the structural model, the result of the subjective system assessment is the primary outcome related to the prospective user's attitude toward the innovation. But, as was previously mentioned (see appendix A, pp. 165-172), attitude is not highly correlated with behavior. Reflecting this distinction, the output of the subjective system assessment is but one input to the process that ultimately leads to an *Observable Response* that can be interpreted as *Adoption*, *Compliance*, or *Rejection*.

In a simple world, the model as described so far would suffice. A problem has been identified, a solution has been proposed, and the individual users decide whether the solution works for them. In the real world, however, the other components of the model become important. Along the top edge of figure 1 is a set of components that apply to specific *Innovation/Product Characteristics*. At various stages during the evaluation of an innovation, an individual user may conclude that the innovation does not offer enough *Capability* to warrant acceptance. If so, its capabilities could be increased to address other aspects of the problem. The other classes of system-specific factors include *Similarity* or *Differentiation* from past innovations, and the relationship between the innovation and its intended *Application Environment*. Table 1 also contains a brief definition of each of these variable classes as well as definitions of the factors discussed below. This is not an exhaustive list of classes; as other categories of independent variables are identified, the list can be expanded.

Along the bottom edge of figure 1 are classes of factors that represent the *User/Consumer Characteristics*. *User Demographics* includes those characteristics of individual users that can identify groups of users that may share a common reaction to innovation. For example, drivers living in an area of urban sprawl may be more interested in ITS systems than drivers living in rural settings (Green & Brand, 1992). In figure 1, user demographics are shown to affect *Level of Interest* in an innovation. The relative power of each demographic factor remains to be determined for ITS applications. For individual users of an innovation, *Perceived Self-Competence* includes two factors reflecting the user's view of his/her own performance capabilities. Self-efficacy is an estimate of how well the individual could function in a new environment, and performance satisfaction is the individual's estimate of how well things are being done in the current environment. The individual's perception may or may not match objective performance. Low self-efficacy combined with high performance satisfaction could yield strong resistance to change. Perceived self-competence is assumed to affect the *User's Perception of Need for Improvement* in the structural model. The class of variables subsumed under *Perceived Risk* include those factors that can be perceived by a user as posing some form of threat. A threat can range from a *Personal Risk* of injury to a fear of being embarrassed during a training session. Perceived Risk is represented as affecting two components of the structural model. The Personal Risk component could be viewed as a repository of the negative aspects of risk, whereas *Availability of Support* could be viewed as the collection of countermeasures or antidotes for the negative risk aspects.

Along the right-hand edge of figure 1 are *Modulating Factors*, or those that exert only indirect effects on the assessment of an innovation. For example, *Authority and Legal Mandates* may force someone to use an innovation, but without liking it. As suggested above, cost or other *Economic Factors* may prevent acceptance of an innovation for which the individual sees a clear need. The modulating factors are perhaps best described as a set of powerful influences that often determine the short-term outcome of the evaluation process but which do not necessarily change one's mind about an innovation. For example, an organization's decision maker may bend to a prevailing conservative climate while realizing that a new technology would provide a clear competitive advantage. Alternatively, a manufacturer's rebate program or a tax break for investment in new technology could tip the scales enough to allow adoption of an innovation.

There are two components of the model that have not yet been discussed, namely the components labeled *Subjective Goal Assessment* and *Subjective Usage Environment Assessment*. Subjective Goal Assessment incorporates such things as how important is it to achieve the minimum commuting time and just how important is it to retain this job given the changes that are being forced upon the user. Subjective Usage Environment Assessment is the final decision-making component of the structural model. It is at this point that all factors are weighed and the individual's response to an innovation is generated. It is the final common path that includes the user's subjective assessment of the innovation itself and its utility in the given environment. That response, as suggested earlier, can range from total acceptance to total rejection, with many levels compliance between these two extremes.

The structural model described here is not intended to be a complete, final product, but rather a focus for further consideration. In its current state, the model lacks the dynamics that seem pervasive in the process of reacting to innovation, and there are probably important components that have been overlooked. The model can be enhanced as the properties of innovation acceptance are explored.

The following example illustrates how dynamic properties of acceptance might be added to the structural model. There are several automatic trip recorders available on the current market. Typically, the devices measure and record such data as vehicle weight, speed, revolutions per minute (RPM), fuel, etc. The data are used to generate management reports to support driver control, scheduling, and maintenance, as well as to track fuel economy. Some long-haul trucking companies have used the management reports to identify optimal profiles for the operation of vehicles. Driving within the profile results in lower fuel costs and reduced maintenance costs, both of which are obvious benefits to the companies. When the trip recorders were first introduced, drivers reacted negatively, viewing the devices as snoops and enforcers in the cab. Given the driver rejection, fleet operators responded either by using the trip recorder data to fire non-compliant drivers or by creating compliance standards and linking drivers' bonus pay to those standards. Both techniques induced higher levels of compliance, but the incentive plan has led drivers to actively use the real-time reporting capabilities of the trip recorders to track their operating performance (R. Clarke, NHTSA, personal communication, 1993).

The two responses by the fleet operators induced other changes. Using the terminology of the structural model, there were probably changes in the organizational climate and in the nature and level of social approval within the drivers' peer group. For most drivers, there were certainly changes in their experience with innovative systems, some positive and some negative. For some drivers, there may have been changes in their perception of the need for improvement and in their level of interest. All of these changes may become more or less permanent and carry over to the next innovation that is introduced.

There appear to be several levels at which to apply the proposed structural model of innovation acceptance. Most of the model would seem to apply at an innovation concept level. For example, the structural model could be used to help in understanding the acceptance of and resistance to the concept of a trip navigation system to aid in solving the problem of traffic congestion. In moving toward more concrete levels, the model also seems appropriate for the evaluation of specific implementations of ITS systems. A level that also should be addressed is the acceptance or rejection of situation-specific outputs or advice from ITS in-vehicle systems. When a trip navigation system recommends detouring around a congested area, is the structural model described here still appropriate for assessing the acceptance of the advice?

Empirical Approaches to Analyzing Acceptance

Exploring innovation acceptance requires knowledge of appropriate methodologies. Three approaches will be considered for studying innovation acceptance that could yield useful results. The first approach results in an analytic point solution. Following the tradition of normal market research, the goal is to produce informed estimates of the potential market size; in this case, for various forms of ATIS/CVO systems. Further estimates of the number of consumer decisions to purchase the technology should translate directly into estimates of acceptance rates for the systems. To the extent that the consumer population is subdivided, acceptance rates could be obtained for various subgroups of the general population and for operators of commercial vehicles. Historically, this form of market research has proved most effective for product improvements that provide a competitive advantage in an existing market. When the methodology is applied to innovative products and the opening of new markets for which there is no historical model, the estimates and projections are more difficult and less accurate.

Burger, Ziedman, and Smith (1989) used these marketing research techniques in an inventory of CVO precursor systems. They surveyed the product literature and identified six categories of CVO in-cab support systems that were either on the market in 1988 or nearly on the market. In all, the authors catalogued the usage environments and user interface characteristics of 52 systems ranging from refrigeration monitoring systems to vehicle tracking systems. The report also included estimates of the percentage of 18 classes of commercial vehicles using each type of support system projected to 1992. The authors admit to having little or no confidence in the absolute percentages reported, but they do argue that the relative percentages of systems by vehicle type are probably appropriate. Unfortunately, neither Burger and his colleagues nor the sponsoring agency of the earlier report is conducting a validation study.

The second approach with merit argues for combining acceptance assessment with usability testing. Clearly, system usability is an aspect of acceptance and, because usability testing typically occurs late in the development cycle, the acceptance of a system could be assessed with known capabilities and implementation details. Performance measures could be obtained along with subjective measures of workload and user preferences. The problem with this approach comes from the same source as its strength. Assessing acceptance late in the development cycle increases the cost of making changes that could affect acceptance. By the time prototype systems are incorporated into simulator and on-road studies, it is anticipated that most of the flaws will have been removed.

The third approach is to adopt some of the newer techniques currently being used to aid in defining system requirements. The "House of Quality" approach (Hauser & Clausing, 1988) and the prospective use of multiple subjective measures (Bittner, 1991; Tolbert & Bittner, 1991) provide two candidates. Each of these options starts with the initial definition of the problem that the innovation addresses and attempts to acquire data about how potential users react to the planned system functions, implementation characteristics, and usage environment. The advantage of this approach is that assessment of acceptance can be initiated early in the development cycle. The disadvantage is that the definition of ATIS/CVO systems will be evolving, and the subjects must operate with notional systems in any early data collection effort. This complicates data collection, but the results should help to refine the system definitions.

Potential Measurement Techniques

There are several potential approaches to measuring driver acceptance. For example, one could assess stated preferences (what subjects say they would do), reported preferences (what subjects say they have done), or actual preferences (field observations) (Khattak et al., 1991). Stated preferences are often influenced by the demand characteristics of the data collection environment. Reported preferences are affected by recall dynamics, and working with actual preferences requires facilities far beyond those available for this task. Product features can be assessed for their linkage to general attributes of acceptance and to intentions to purchase (Holak & Lehmann, 1990). Psychophysical measurement techniques can be applied to the assessment of physical design (McCallum, 1991). Subjective workload assessments can be used to tap the perceptual, physical, and cognitive demands of different system designs (Tolbert & Bittner, 1991). For each of these approaches, there are challenges regarding the details of the data acquisition and manipulation process.

From our survey of the current literature, there appears to be no single adequate measurement technique that captures driver acceptance. A variety of subjective and performance measures has been attempted in studies using hypothetical situations (Tong, Mahmassani, & Chang, 1987), artificial environment simulations (Bonsall & Parry, 1991), and simulations using familiar environments (Allen, Ziedman, et al. 1991). Unfortunately, there has been no attempt to validate measures across procedures or to coordinate the different measures of driver acceptance.

This task provides the opportunity to bring some consistency to the measurement of driver acceptance of new automotive technology. Starting with the concepts behind proposed ITS in-vehicle systems and ending in possible road tests of prototype systems, a measurement tool for driver acceptance can be defined, refined, and at least partially validated. The measurements should be as simple as possible and as direct as the several levels of analysis will allow. Because the project started with hypothetical ITS systems, performance measures must be eliminated, leaving a variety of subjective approaches. Subjective tools must be developed that provide diagnostic power to determine source(s) of resistance. For instance, it must be determined whether resistance comes from a lack of usability or from a mismatch between system capabilities and the problem application. Any subjective tool also should provide information about the relative importance of the various sources of resistance, such as system capability or system usability.

There is an existing subjective assessment technique that can serve as an heuristic model for designing the type of measurement tool that is needed. The model is the NASA-Task Loading Index (NASA-TLX) (Hart & Staveland, 1986). Following the lead of Beith, Beith, Vail, and Williams (1990), it is proposed that a set of about 7 to 10 rating scales be created that will address several components of the acceptance of innovation. Using the structural model described above, scales could be created for constructs such as:

- Relative advantage.
- Apparent complexity.
- Ease of use.
- Compatibility with other driving activities,
- Safety improvements.
- Relative importance of the problem.
- Relative personal risk.

In addition to these diagnostic scales, some form of an overall assessment is required. Two candidates are:

1. How much would you pay for such a system?
2. How strongly would you recommend this system to others?

These two ratings will provide some checks on the internal consistency of the data and perhaps some insight into how different subjects are using the rating scales.

In assessing the relative importance of the components, the NASA-TLX approach can be followed or other techniques can be adopted if they produce more robust measures of the relationships among components. One such candidate is a link-weighted network analysis that estimates the associations among component "nodes" in a network and that provides for a higher level grouping of components into closely coupled clusters (Schvaneveldt, 1990). Such an approach may help to identify those components of acceptance that must be satisfied first. For instance, an ITS system may need to address a relatively important problem and provide a strong advantage over other approaches before it is worth the effort to assess system usability or safety advantages. Moreover, the clustering of components and the relative importance of clusters may change as potential ITS system users become more familiar with the planned capabilities and as the systems themselves mature (Schvaneveldt et al., 1985). Regardless of the technique chosen, the relative importance of the components of acceptance must be included in any measure of acceptance.

CHAPTER 2. EXPERIMENT 1 AND 1B

EXPERIMENT 1 METHOD

Subjects

A total of 109 subjects participated in this study. Subjects ranged in age from 18 to 85 years old. A total of 57 of the subjects were male and 52 were female (figure 2). All subjects were licensed drivers who drove at least once a week in the Seattle area. Twelve additional subjects began the study but did not complete it. One subject had a child to care for, two older subjects had difficulty understanding the concepts being presented, and the nine remaining subjects did not finish in the time they had available due to a scheduling conflict at the group's facility. Each subject was paid for their time and thanked for participating.

Subjects were recruited from organizations in the Seattle metropolitan area. These organizations included the University of Washington, senior citizens' centers, churches, and other service organizations. Subjects were paid $10 per hour for their participation and could choose either to keep the payment or to donate it to an organization of their choice.

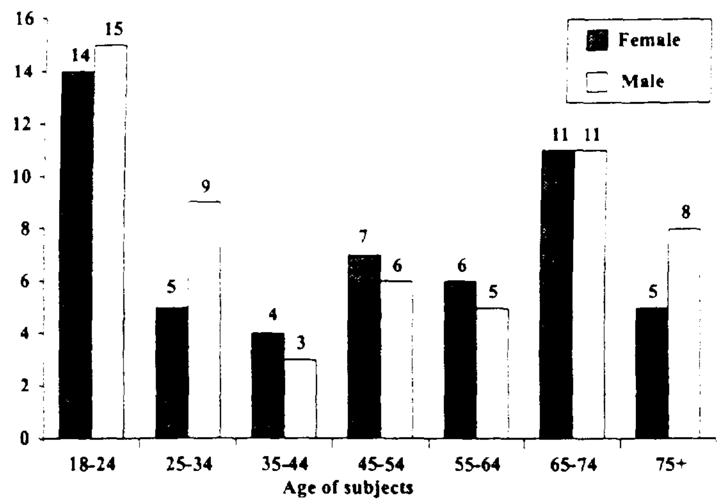


Figure 2. Age and gender distribution for subjects participating in experiment 1.

Apparatus

The apparatus for this experiment consisted of a Dukane overhead projector, an InFocus LCD monitor, a Panasonic TV/VCR, and stopwatches (Health Tech, Spalding, and Micronta brands). The video image from the television/videocassette recorder (TV/VCR) was output through the liquid crystal display (LCD) monitor and overhead projector in order to create a display large enough for small group viewing. Audio output from the TV/VCR was adjusted in each session so that all subjects could hear the recorded sound.

Materials

Materials for this experiment (see appendix B, pp. 173-250) included two videotapes showing the TravTek system, a consent form, a driver demographic characteristics questionnaire that included technology use items, a questionnaire designed to assess user acceptance information, and photocopied maps of the Orlando area (figures 3 and 4).

The first video was an edited version of the American Automobile Association's (AAA) TravTek system orientation video. This video explained the benefits and options of the ATIS and lasted approximately 15 min. The other video was a split-screen presentation that contained out-the-window views of a filmed route from the Harry P. Leu Botanical Gardens to Church Street Station in Orlando, Florida, using a TravTek system-equipped car. A video overlay of the TravTek system screen was presented in the lower left corner of this video while, periodically, a full-screen view of the TravTek system was shown. Voice messages provided by the TravTek system were recorded as well. The route, which included residential streets, four-lane State roads, and a portion of the Interstate, was approximately 14 min long.

Experiment 1 used a quasi-experimental design. Independent and attribute variables that were measured include: *AGE*, *GENDER*, demographic variables, and technology use. Technology use items included questions that asked about subjects' use of vehicle technologies (e.g., anti-lock brakes, air bags) and household technologies (e.g., VCR, microwave oven, personal computer [PC]). Table 2 summarizes the independent variables.

Table 2. Independent variables in experiment 1.

INDEPENDENT VARIABLES	DESCRIPTION
Videotape	(1) General introductory video (edited AAA tape) (2) Split-screen view from the Botanical Garden to Church Street Station
Age	(1) 18-24 (2) 25-54 (3) 55-64 (4) 65-74 (5) 75+
Gender	(1) Female (2) Male
Other quasi-experimental variables	Years driving, marital status, education level, ethnic group, income, household size, miles driven, auto type, number of trips, technology use, familiarity with cities shown in presentations, computer anxiety, etc.

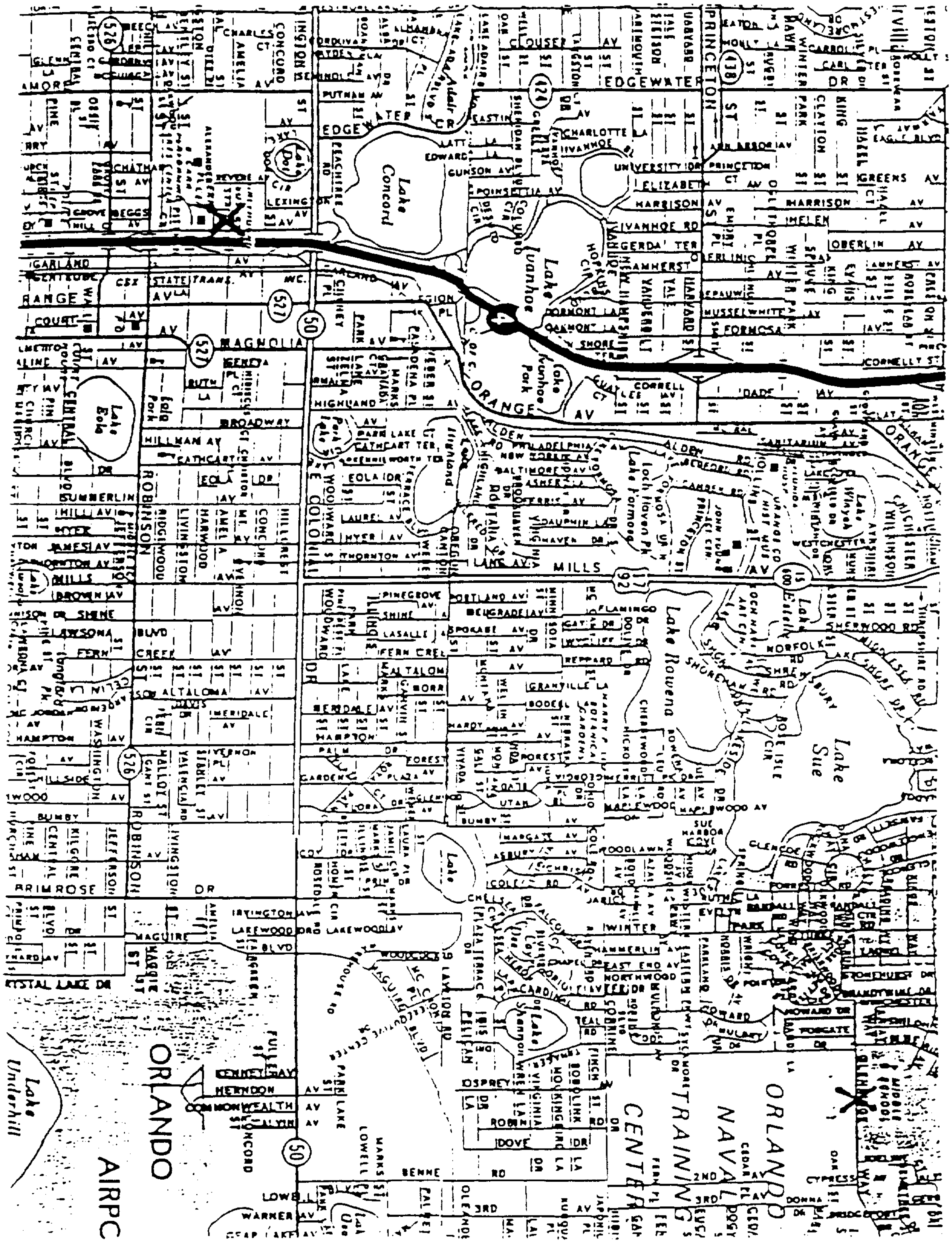


Figure 3. Practice map.

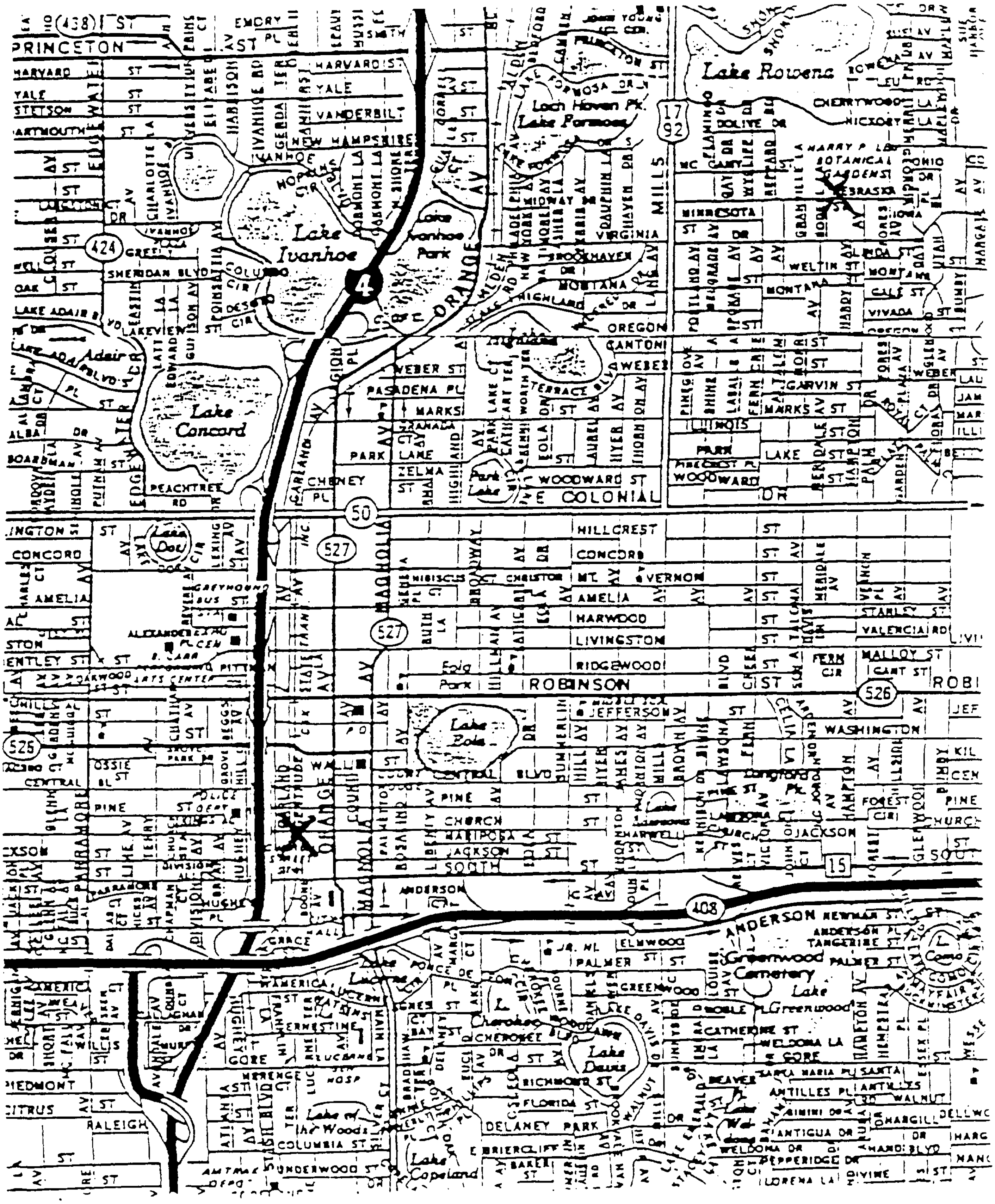


Figure 4. Map of Harry P. Leu Botanical Gardens to Church Street Station route.

Several dependent variables were assessed by the TravTek system questionnaires, all of which are shown in appendix B:

- TravTek System Capabilities (p. 178)
- TravTek System Feature Desirability (p. 183)
- TravTek Demonstration Fidelity (p. 188)
- TravTek: Modifying Your Trip to Avoid Traffic (p. 190)
- TravTek: Trust & Self-Confidence (p. 192)
- TravTek User Acceptance Issues (p. 196)
- TravTek Perceived Usefulness (p. 203)
- TravTek Perceived Ease of Use (p. 205)
- TravTek User Test Questions (p. 207)

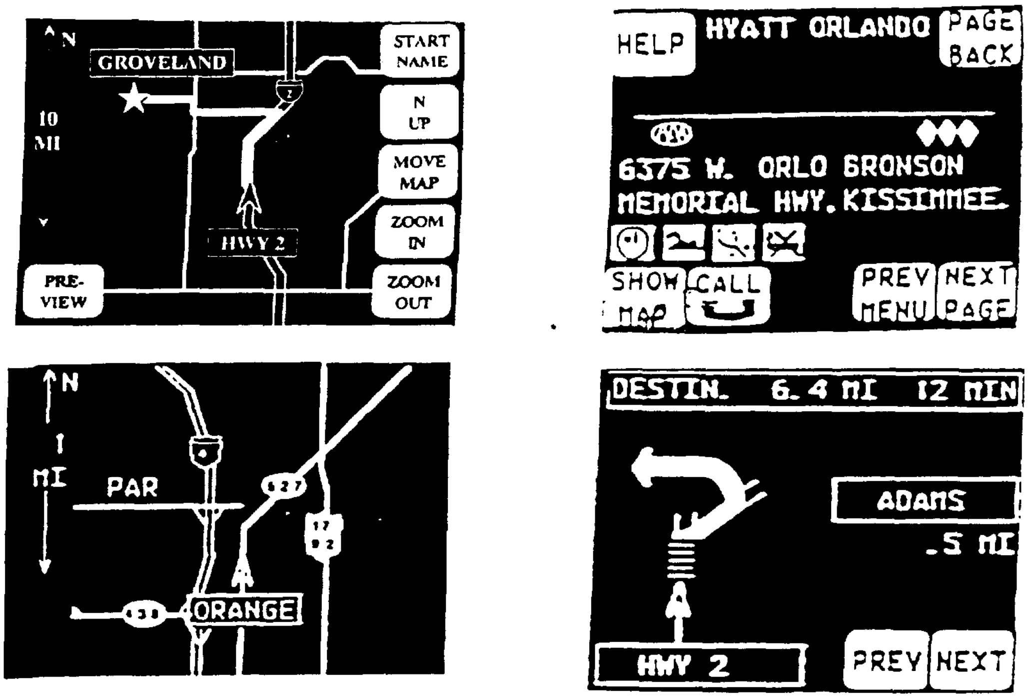
Table 3 summarizes the dependent variables in experiment 1.

Table 3. Dependent variables in experiment 1.

DEPENDENT VARIABLES	DESCRIPTION
Capabilities understanding	Score of total correct items for TravTek system capabilities and total correct items for each subsystem
Attention to the demonstration	0 - 100 scale
Psychological fidelity	0 - 100 scale
Features desired	0, 1, or 2 rating for each feature
Performance tolerances	Range of incorrect times or a range of how many errors the system could make
System trust & self-confidence	0 - 100 scale
User acceptance issues	0 - 100 scale
Perceived usefulness	0 - 100 scale
Perceived ease of use	0 - 100 scale
Travtek system user test	Subset of items from TravTek system user test survey for comparison purposes

To keep the data organized, the questionnaire was copied onto several different colors of paper, each color representing a specific video portion of the experiment. Two maps of the Orlando area (taken from portions of the Gousha Fastmap of Orlando) were copied onto different colors of 216 x 279 mm paper and increased 10 percent in size. The first map consisted of an origin (a middle school) and destination (a Greyhound bus station) marked with a large red "X". The other map was the route shown in the associated TravTek system video. The origin (Harry P. Leu Botanical Gardens) and destination (Church Street Station) were also marked with a large red "X". Subjects were provided with markers to draw their routes on the paper maps (figures 3 and 4).

Examples of the information presentation formats used in the TravTek system were copied onto an overhead transparency. Two sample electronic maps, two text or icon displays, and one voice message were presented on this overhead. A copy of these examples is shown in figure 5.



Electronic Maps

Text or Icon Displays

Voice: "Turn right on Robinson."

Figure 5. Examples of TravTek system information presentation formats.

Procedure

Subjects received a brief description of the ATIS research and of what they would be doing during the study. They read and completed informed consent sheets stating their rights as subjects and completed the questionnaire that asked demographic and technology use questions (see appendix B, p. 173). After filling out these items, subjects were told how to use their stopwatches. When all subjects had indicated that they could operate their stopwatches, they were walked through an example map routing task (from the middle school near Glenridge Way to the Greyhound Bus Station in Orlando). Subjects were shown a copy of the map (the experimenter identified the route origin and destination) and then told them that they would be asked to turn their maps over, start their stopwatches, draw the route they would take if they were actually visiting the Orlando area, turn off their stopwatches when finished, and record the time shown on the stopwatch display. The experimenter told them that even though they were timing the routing task, accuracy was more important. Steps were reviewed until each subject understood the procedure. The routing task was meant to directly involve the subjects in the experiment as a contrast to the passive observation of the videotape. This task was used only to orient the drivers; the data collected from the self-timing procedure was not used in hypothesis testing. As a result, the possibility that the self-timing procedure may add additional error into the data was not a concern. This was deemed to be the most efficient procedure. In addition, this task provided subjects with an immediate comparison to the automated routing functions of the TravTek system.

A few minutes were taken to familiarize subjects with what they needed to look for in the videotapes as some subjects had heard of the TravTek system but none had ever used it. The overhead with examples of TravTek system's information presentation formats (figure 5) was reviewed.

As a final step, the list of potential feature headings (bold items) in the TravTek system capabilities section was read aloud to subjects while they followed along on their questionnaire copies (appendix B, p. 178). Subjects then had the opportunity to ask for clarification of item definitions before they viewed the videos.

When all questions had been answered, the experimenter instructed the subjects to turn over their experimental packets and watch an edited AAA TravTek system video, paying particular attention to the types of features that were previously reviewed. The experimenter told subjects that the video image and the TravTek system voice might not always be clear, but to try not to be distracted by either. The unclear image and voice presentations were not random. The unclear voice refers to the synthesized voice used for audio messages that was not as clear as natural speech. The lack of image clarity was due to loss of image quality from using a second generation source. This loss of quality led to slightly blurred symbology and words. This might lead to decreased user acceptance relative to actual traffic drivers who had more time to adapt to the synthesized voice and a clearer visual image. As soon as the first video ended, subjects were instructed to complete the questionnaire as quickly as possible, but were told that accuracy was most important. They were also told to work independently and were allowed to leave the room to take a break as soon as they finished the first set of questions. They were asked to remain quiet if they chose to remain in the experimental testing room and not to look ahead in their experimental packets. The experimenter answered any questions and picked up the completed questionnaires.

All subjects completed the TravTek system questionnaires (*TravTek System Capabilities* through *TravTek User Test Questions*, appendix B, pp. 178-214) after completing both the routing task and watching the video. Subjects were given another break during which the experimenter collected the questionnaires and prepared for experiment 1B.

Subjects were tested in approximately 14 small groups. The group size ranged from 3 to 12 subjects. Some groups were composed of a single age group (younger, older) of subjects and some were composed of mixed age groups. Most groups contained both male and female subjects. Education level varied some within each group. There was relatively little ethnic diversity in each group.

The total time for subjects to complete the study ranged from 1 h and 53 min to approximately 3 h and 15 min. Younger groups of subjects, as a whole, took less time than older subjects (although there were exceptions for individuals). The longer completion time primarily for older subjects may be correlated with greater fatigue relative to younger and faster subjects. Indeed, we did not present a third video and set of questions as being beyond the endurance of older drivers. Table 4 shows the experimental tasks and the time range for each activity.

Table 4. Time table for experiment 1.

ACTIVITY	TIME
Pre-experiment, demographic questionnaire, practice map routing task	30-45 min.
Edited AAA TravTek system video	15 min.
Questionnaire	20-55 min.
Break	5 min.
Botanical Gardens to Church Street Station video	15 min.
Map routing task	3-5 min.
Questionnaire	20-50 min.
Break	5 min.

EXPERIMENT 1B METHOD

Subjects

The same subjects that participated in experiment 1 also participated in experiment 1B. Two of the subjects in experiment 1 had to leave before completing experiment 1B due to other commitments. In addition, 21 commercial vehicle operators participated only in experiment 1B. All commercial drivers were male and less than 54 years old. A few ethnic groups were represented. Education level had some variation (less than high school through some college).

Apparatus

The apparatus for this experiment consisted of a Dukane overhead projector, an InFocus LCD monitor, and an AST 486/25 laptop computer with a color display. The computer screen image was output through the LCD monitor and overhead projector in order to create a display large enough for group viewing.

Materials

The informed consent sheet and the demographic and technology use questionnaires were completed in experiment 1 by private drivers. Commercial drivers completed an informed consent form and a similar demographic questionnaire (appendix B, p. 245, section G). Zagat-Axis CityGuide for Windows (1991) software for New York City was installed on the laptop computer for demonstration purposes. The CityGuide system uses a mapping data base from Etak, Inc., and survey data from Zagat Survey. The program can be used to plan routes and access information about hotels, restaurants, and landmarks. A questionnaire was developed for this experiment that paralleled the items asked in experiment 1 (appendix B, p. 240). The independent and attribute variables that were measured include *AGE*, *GENDER*, demographic variables, and technology use. Table 5 summarizes the independent variables of experiment 1B.

Dependent variables were assessed by questionnaires that paralleled the TravTek system questionnaires and are also shown in appendix B:

- CityGuide System Capabilities (p. 213).
- CityGuide System Feature Desirability (p. 216).
- CityGuide Demonstration Fidelity (p. 219).
- CityGuide: Trust & Self-Confidence (p. 221).
- CityGuide User Acceptance Issues (p. 225).
- CityGuide Perceived Usefulness (p. 232).
- CityGuide Perceived Ease of Use (p. 234).
- CityGuide User Test Questions (p. 236).

Table 5. Independent variables in experiment 1B.

INDEPENDENT VARIABLES	DESCRIPTION
Age	(1) 18-24 (2) 25-54 (3) 55-64 (4) 65-74 (5) 75+
Gender	(1) Male (2) Female
Other quasi-experimental variables	Years driving, marital status, education level, ethnic group, income, household size, miles driven, auto type, number of trips, technology use, familiarity with cities in presentations, computer anxiety, etc.

Table 6 summarizes the dependent variables in experiment 1B.

Table 6. Dependent variables in experiment 1B.

DEPENDENT VARIABLES	DESCRIPTION
Capabilities understanding	Score of total correct items for the CityGuide system capabilities
Attention to the demonstration	0 - 100 scale
Psychological fidelity	0 - 100 scale
Features desired	0, 1, or 2 rating for each feature
System trust & self-confidence	0 - 100 scale
User acceptance	0 - 100 scale
Perceived usefulness	0 - 100 scale
Perceived ease of use	0 - 100 scale
Other CityGuide system items	1 - 6 scale

Procedure

Subjects were tested in the same groups described in experiment 1, except for the commercial vehicle operators, who only participated in experiment 1B. Following completion of experiment 1, a researcher demonstrated the use of the CityGuide system software. The 15-min demonstration consisted of a brief introduction on how the software is used and two scenarios. Scenario 1 was used to demonstrate how to find a route between LaGuardia Airport and a hotel near the Metropolitan Museum of Art. Subjects were shown text instructions and a route map for the route generated by the CityGuide system, and were also given information about the hotel. Examples of the instructions, hotel information and city map are shown in figures 6 through 8.

In scenario 2, the researcher described how to find the Gershwin Theater and a restaurant near the theater. The researcher followed the same script each time and the demonstration was presented to maintain consistency. Subjects were given an opportunity to ask questions following the demonstration. They were then asked to complete the CityGuide system questionnaires (appendix B, pp. 213-239). When subjects were finished with this questionnaire, they were paid and thanked for their participation.

Commercial vehicle drivers filled out informed consent sheets and a demographic survey (that contained most of the items from the private driver demographic survey as well as the items specifically related to commercial vehicle operation) prior to the demonstration (see appendix B, p. 240).

Before the demonstration began, the experimenter instructed the commercial vehicle drivers to view the CityGuide system with regard to how it might be used by commercial drivers (even though the scenarios focused on private vehicle applications).

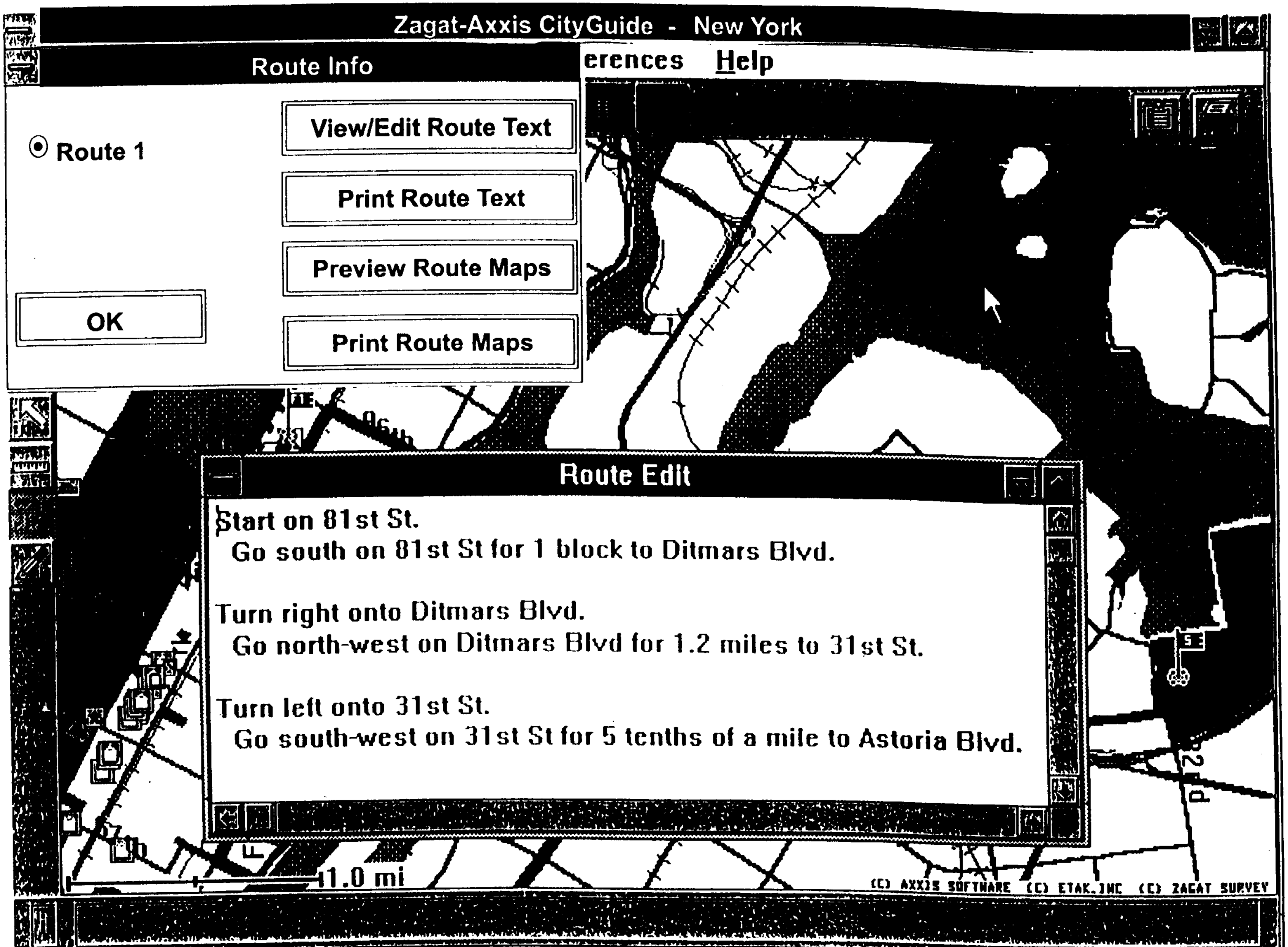


Figure 6. Example of CityGuide system text instructions.

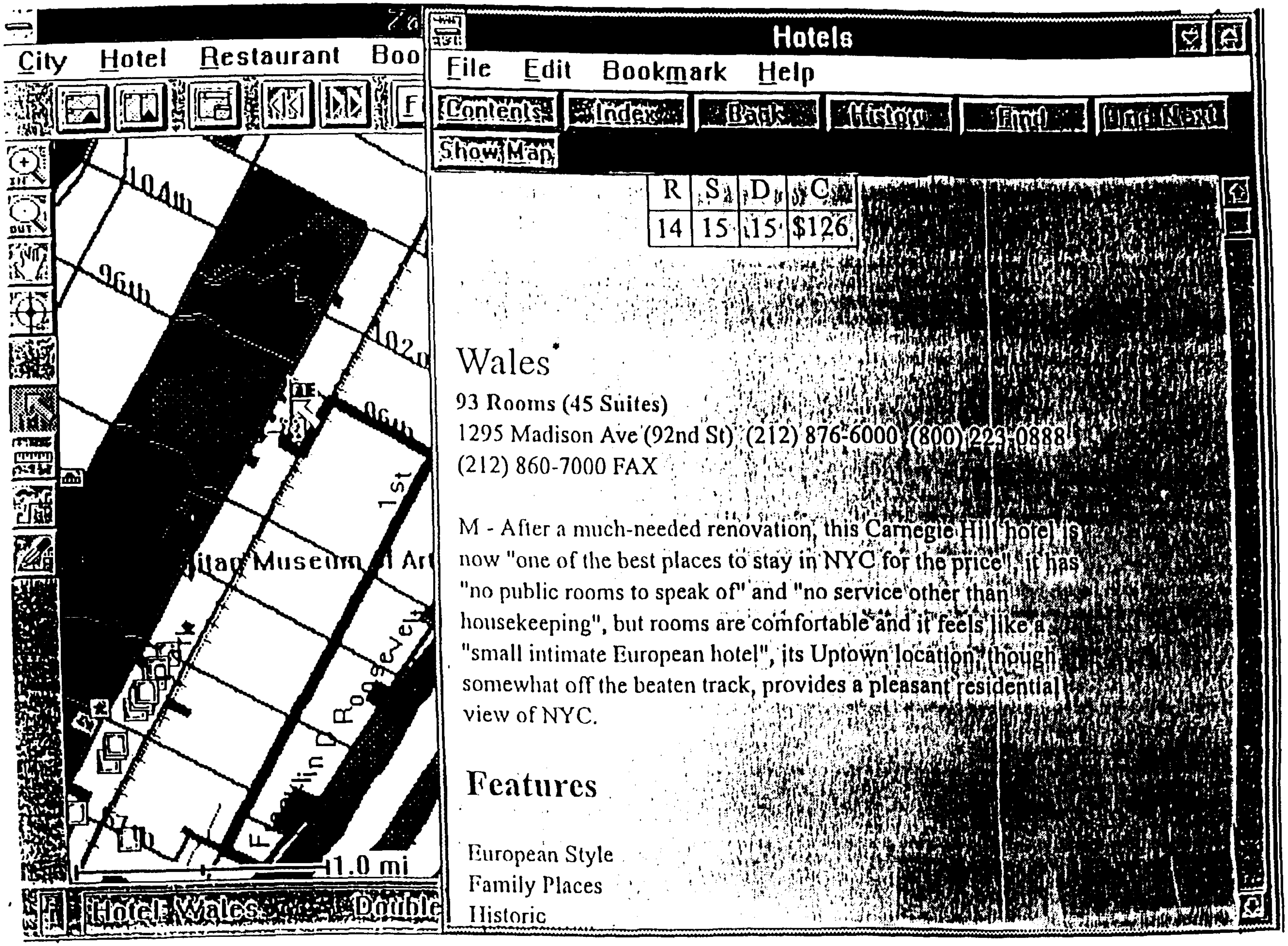


Figure 7. Example of CityGuide system hotel.

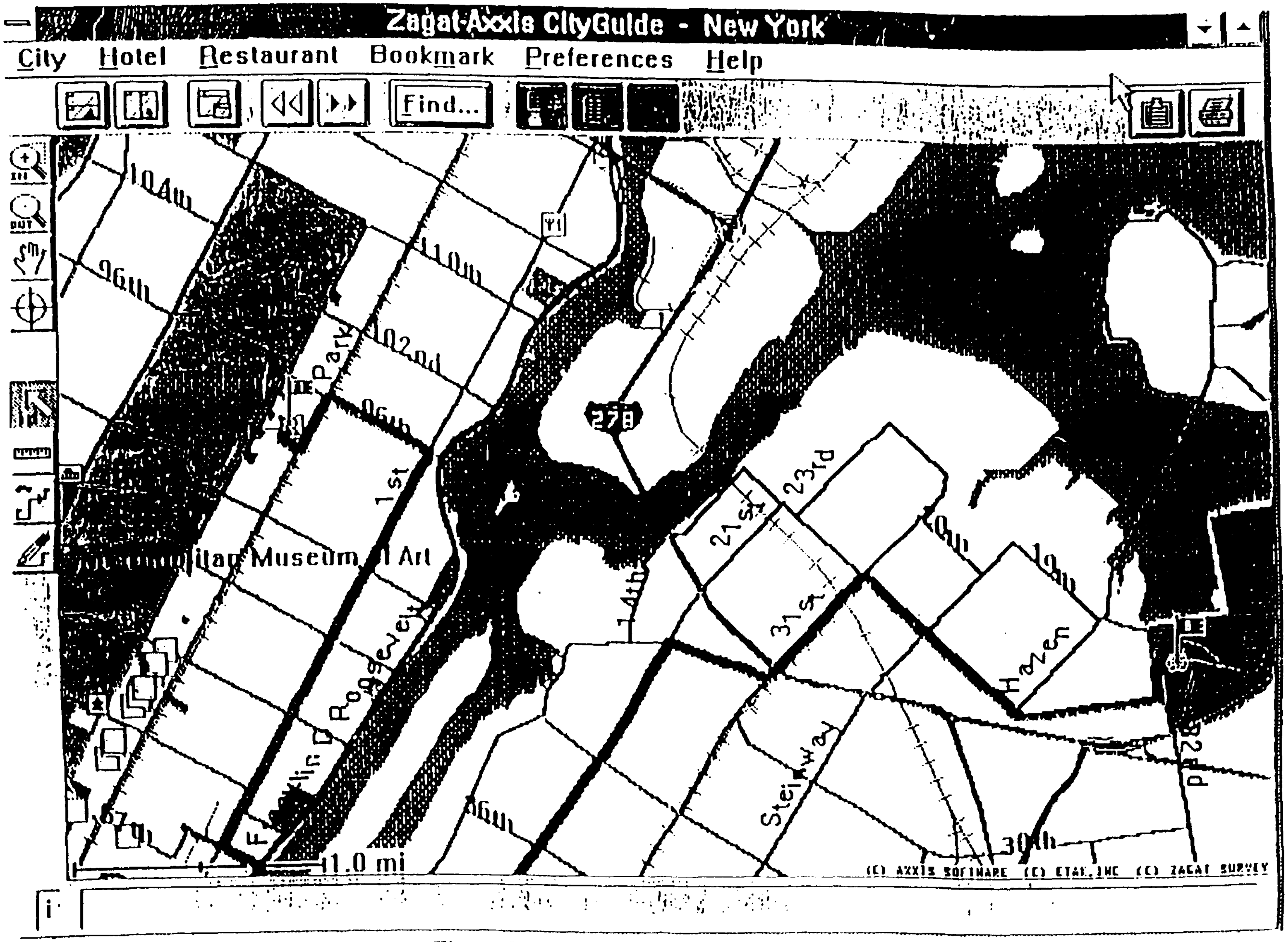


Figure 8. CityGuide map.

EXPERIMENT 1 RESULTS

Examined in the analyses were 5 objective rating dependent variables and 155 subjective rating dependent variables. The five objective dependent variables were the percent correct scores for the TravTek system capabilities items: (1) trip planning, navigation, and routing; (2) services and attraction information; (3) in-vehicle road sign information; (4) safety and warning information; and (5) a total for all system capabilities. These scores indicated the drivers' understanding of the TravTek system. A factor analysis of the percent correct scores from a specific binary-form questionnaire item category was used to create two composite variables. The remaining subjective rating dependent variables were factor-analyzed as related groups of questionnaire items and used to create 18 composite variables. These composite variables then succinctly represent the several individual variables in a way that provides greater statistical reliability compared to the individual variables.

The composite variables provide the basis for examining the relationships in figure 9. The directional links in figure 9 are hypothetical; they are based upon Battelle's analysis of the consumer acceptance model described in chapter 1. Those models too are global and not immediately useful. The new model uses local concepts that can be evaluated directly from the set of questions administered to drivers. This experiment tests the hypothetical relationships represented in figure 9. The goal of experiment 1 is to understand what variables drive consumer acceptance; that is, what feature patterns (shaded box) do drivers want?

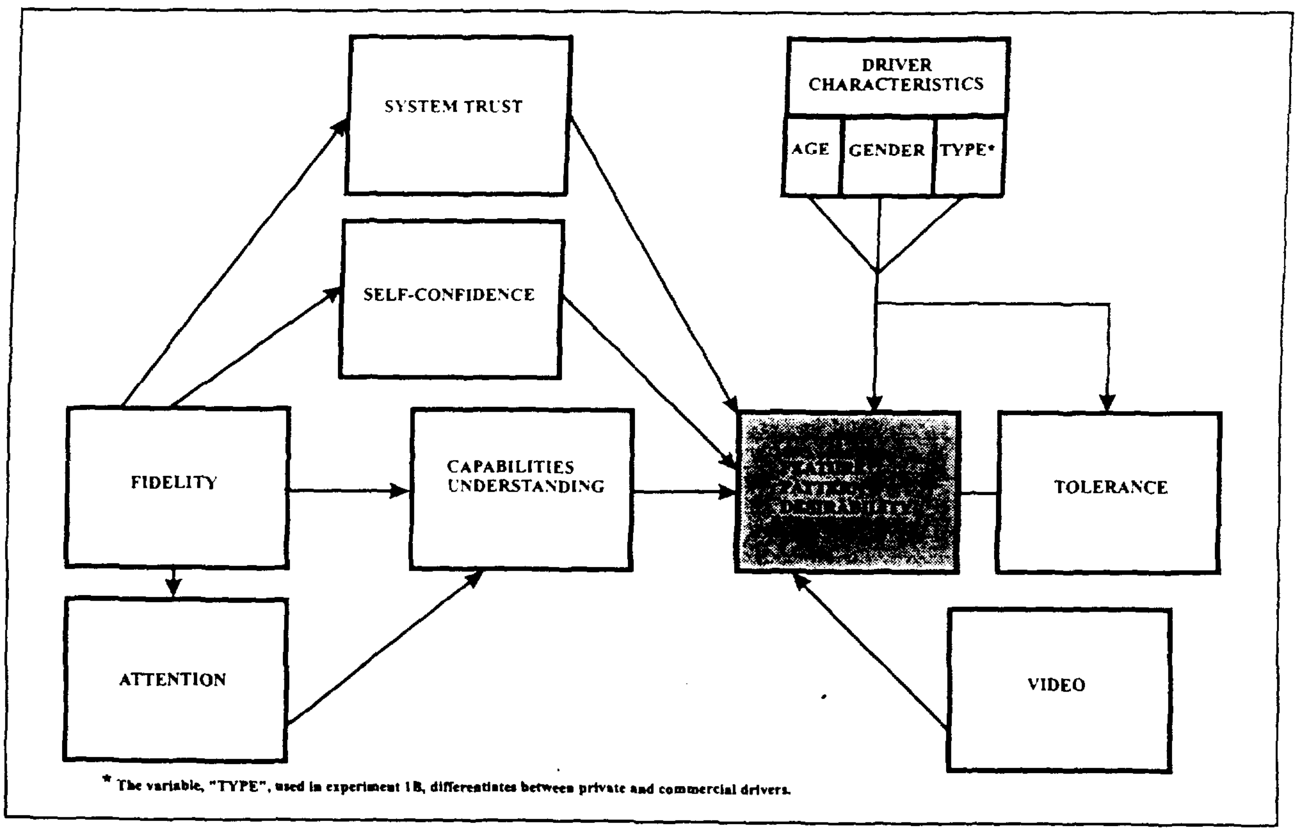


Figure 9. Composite variable feature pattern relationships.

The analyses were conducted in three phases using the SPSS/PC+, version 5.0, software package. In the first phase, descriptive statistics were calculated for items taken from a survey used in the TravTek system demonstration project. In the next phase, a repeated-measures analysis of variance (ANOVA) was used to examine the relationships between *AGE*, *GENDER*, *VIDEO* (1 = the AAA TravTek system tutorial, 2 = an on-road TravTek system demonstration) and the total percent correct score for the TravTek system capabilities items. The variable for *AGE* consisted of two levels: younger drivers (18 to 54 years) and older drivers (55 to 85 years). In the final phase of the analyses, three parts aimed at identifying the relationships among the variables shown in figure 9. Results from each phase of the analyses are described below. ANOVA tables are presented in appendix C (pp. 251-261).

Phase 1. TravTek System User Test Questions - Descriptive Statistics

In the first phase of the analyses, a subset of questionnaire items was taken from *Your TravTek System Driving Experience*, the survey given to drivers who participated in the TravTek System Demonstration Project in Orlando, Florida. These items are listed in table 7 and are shown in appendix B under the heading *TravTek User Test Questions* (p. 207). The items are related to information presentation formats (i.e., guidance map, route guidance, voice guidance), usefulness of the system in various driving situations, value of the TravTek system in terms of how much a driver would pay for it, and traffic-related factors. Relevant means were calculated for these items and are shown in figure 10 through figure 30. Then a repeated-measures analysis ANOVA was performed for each of these items.

Table 7. TravTek system user test questions.

TEST QUESTIONS	
The TravTek system's guidance display was easy to learn.	TRAV1A
The TravTek system's guidance display was easy to use.	TRAV1B
The TravTek system's guidance display was useful.	TRAV1C
The TravTek system's route map was easy to learn.	TRAV2A
The TravTek system's route map was easy to use.	TRAV2B
The TravTek system's route map was useful.	TRAV2C
The TravTek system's voice guide feature was easy to learn.	TRAV3A
The TravTek system's voice guide feature was easy to use.	TRAV3B
The TravTek system's voice guide feature was useful.	TRAV3C
Of the two routing displays, the Route map and the guidance display, which did you prefer?	TRAV4
Overall, the TravTek system was easy to learn.	TRAV5A
Overall, the TravTek system was easy to use.	TRAV5B
Overall, the TravTek system was useful.	TRAV5C
Do you think the TravTek system would be useful for at-home daily driving?	TRAV6A
Do you think the TravTek system would be useful for out-of-town vacation driving?	TRAV6B
Do you think the TravTek system would be useful for out-of-town business trips?	TRAV6C
How much would you be willing to pay for the TravTek system?	TRAV7
Rank...energy conservation.	TRAV8A
Rank...environmental quality.	TRAV8B
Rank...highway/traffic safety.	TRAV8C
Rank...relief of highway congestion.	TRAV8D

Figure 10 (TRAV1A) shows mean ratings for the TravTek system's guidance display ease of learning as a function of *AGE* and *VIDEO*. Error bars in this and subsequent figures indicate standard deviations. The ANOVA resulted in a significant main effect for *AGE*, $F(1,102) = 18.97, p < 0.001$, and a significant main effect for *VIDEO*, $F(1,102) = 5.78, p < 0.018$. Younger drivers (mean = 4.8) rated the TravTek system's guidance display easier to learn than older drivers (mean = 3.9). Ease of learning ratings increased from video 1, the AAA TravTek system tutorial videotape (mean = 4.3) to video 2, the on-road TravTek system demonstration videotape (mean = 4.6).

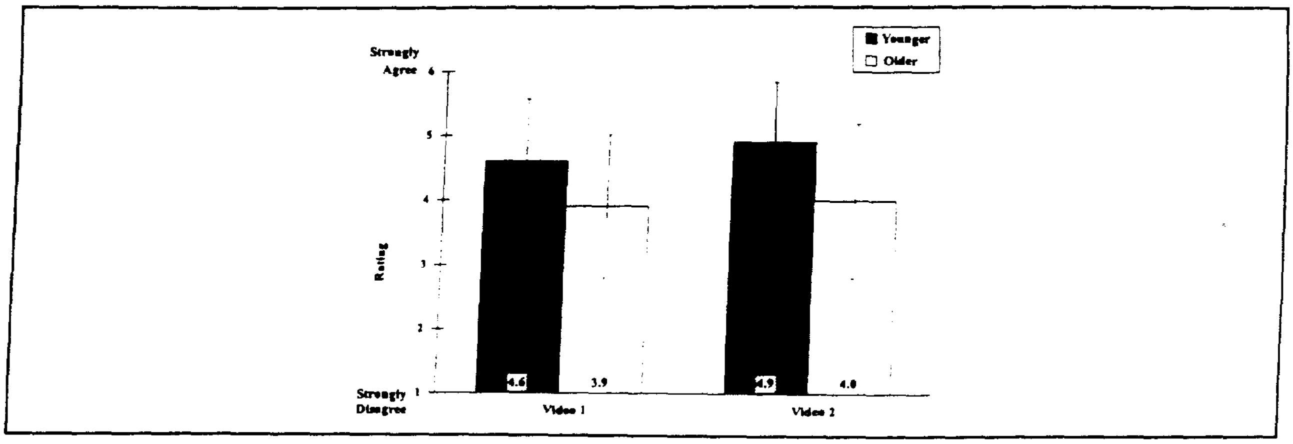


Figure 10. The TravTek system's guidance display was easy to learn. (TRAV1A)

Figure 11 (TRAV1B) shows mean ratings for the TravTek system's guidance display ease of use as a function of *GENDER* and *AGE*. A significant *GENDERxVIDEO* interaction occurred, $F(1,99) = 5.26), p < 0.024$. Female drivers' ratings increased more from video 1 (mean = 4.0) to video 2 (mean = 4.6) than male drivers' ratings from video 1 (mean = 4.2) to video 2 (mean = 4.4). A main effect for *AGE*, $F(1,99) = 16.86, p < 0.001$, and a main effect for *VIDEO*, $F(1,99) = 20.68, p < 0.001$, were also significant. Younger drivers (mean = 4.6) rated the system's guidance display easier to use than older drivers (mean = 3.9). Ease of use ratings increased from video 1 (mean = 4.1) to video 2 (mean = 4.5).

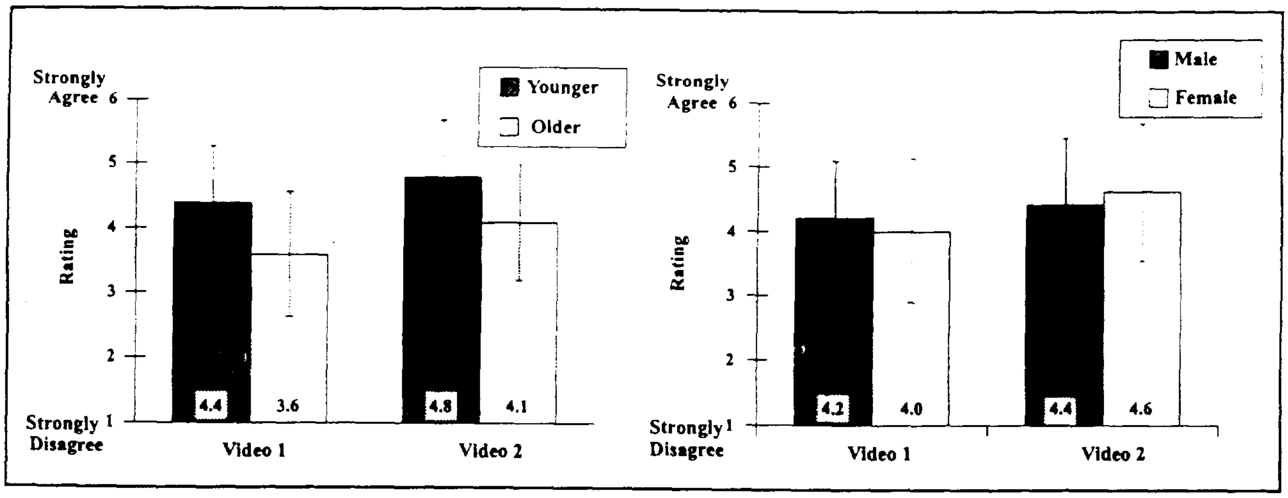


Figure 11. The TravTek system's guidance display was easy to use. (TRAV1B)

Figure 12 (TRAV1C) shows mean ratings for the TravTek system's guidance display usefulness. The ANOVA resulted in a significant main effect for *AGE*, $F(1,99) = 7.71$, $p < 0.007$, and a significant main effect for *VIDEO*, $F(1,99) = 7.05$, $p < 0.009$). Younger drivers' ratings were higher (mean = 4.7) than older drivers' ratings (mean = 4.2). Usefulness ratings increased from video 1 (mean = 4.4) to video 2 (mean = 4.6).

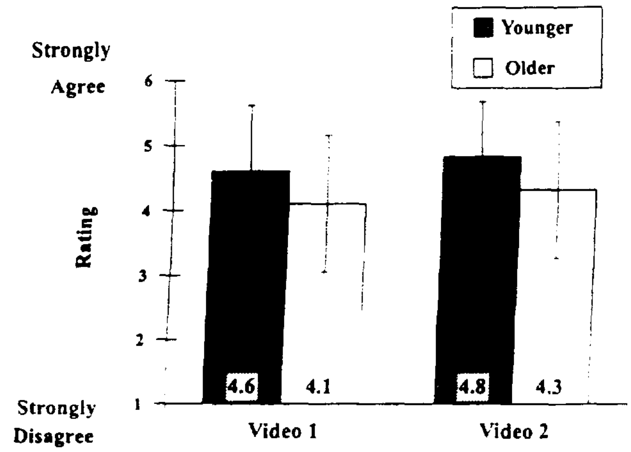


Figure 12. The TravTek system's guidance display was useful. (TRAV1C)

Figure 13 (TRAV2A) shows mean ratings for the TravTek system's route map ease of learning. A three-way interaction for *AGE*, *VIDEO*, and *GENDER* was significant, $F(1,102) = 5.26$, $p < 0.024$. Older female drivers rated the route map easier to learn after video 2. Both age groups of male drivers and the younger age group of female drivers rated the route map as less easy to learn after video 2. The two-way *AGExVIDEO* interaction, $F(1,102) = 5.12$, $p < 0.026$, captures most of the variance of the three-way interaction. Younger drivers' ratings of ease of learning decreased from video 1 (mean = 4.7) to video 2 (mean = 4.4). Older drivers' ratings increased from video 1 (mean = 3.9) to video 2 (mean = 4.1).

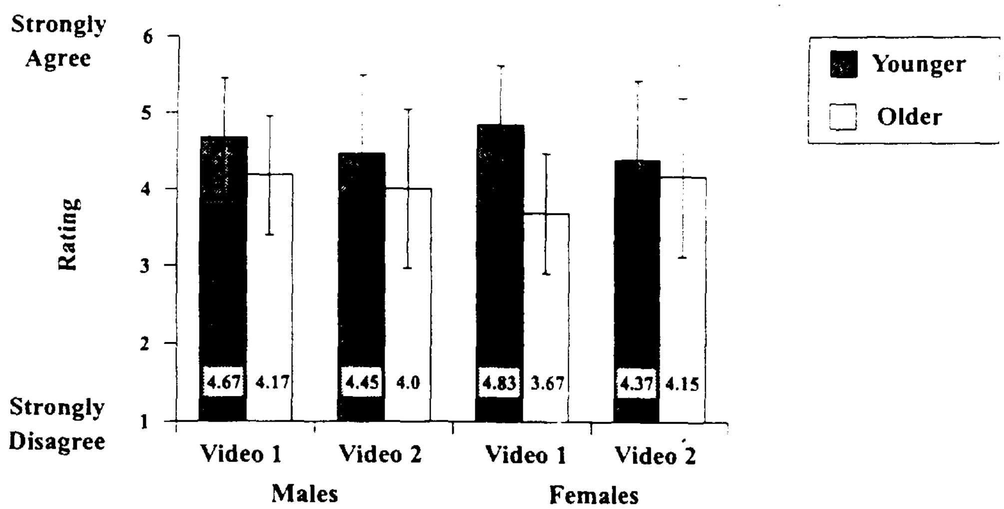


Figure 13. The TravTek system's route map was easy to learn. (TRAV2A)

Figure 14 (TRAV2B) shows mean ratings for the TravTek system's route map ease of use. A significant *AGExVIDEO* interaction occurred, $F(1,99) = 4.07, p < 0.046$. Younger drivers rated the route map as easier to use after video 1 (mean = 4.6) than after video 2 (mean = 4.2). Older drivers rated the route map as easy to use after video 1 (mean = 3.8), but more easy to use after video 2 (mean = 3.9). The main effect for *AGE* was also significant, $F(1,99) = 8.51, p < 0.004$, with younger drivers giving higher ratings than older drivers.

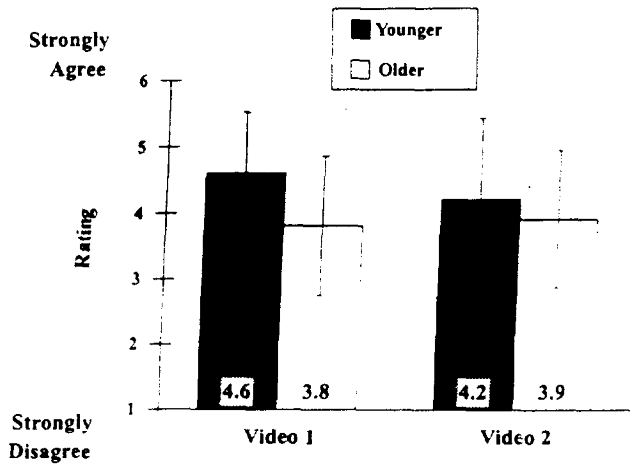


Figure 14. The TravTek system's route map was easy to use. (TRAV2B)

Figure 15 (TRAV2C) shows mean ratings for the TravTek system's route map usefulness. A three-way interaction for *AGE*, *GENDER*, and *VIDEO* was significant, $F(1,100) = 6.68$, $p < 0.011$. Older female drivers rated the route map as slightly more useful after video 2. Both age groups of male drivers and the younger age group of female drivers rated the route map as less useful after video 2. The two-way *AGExVIDEO* interaction, $F(1,100) = 6.68, p < 0.011$, captures most of the variance of the three-way interaction. As figure 15 (TRAV2C) illustrates, younger drivers' ratings of usefulness decreased from video 1 (mean = 4.8) to video 2 (mean = 4.3), whereas older drivers' ratings of usefulness increased slightly from video 1 (mean = 4.1) to video 2 (mean = 4.2). The main effect for *AGE* was significant, $F(1,100) = 4.85, p < 0.030$. Younger drivers (mean = 4.5) rated the route map usefulness higher than older drivers (mean = 4.2).

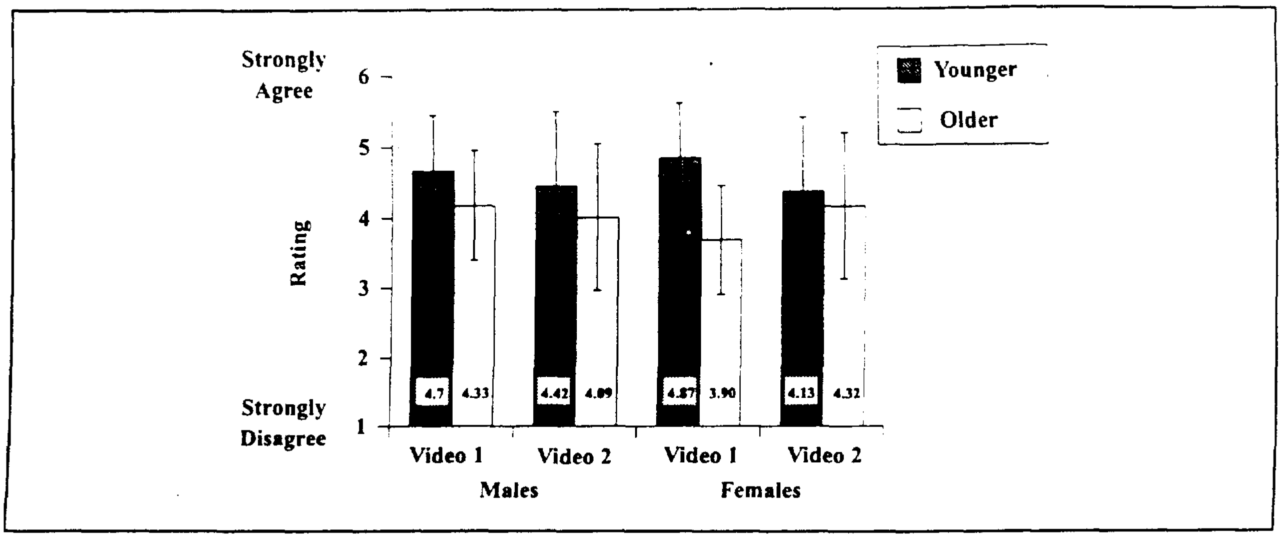


Figure 15. The TravTek system's route map was useful. (TRAV2C)

Figure 16 (TRAV3A) shows mean ratings for the TravTek system's voice guide feature ease of learning. The ANOVA resulted in a significant main effect for *AGE*, $F(1,102) = 5.80$, $p < 0.018$, and a significant main effect for *VIDEO*, $F(1,102) = 10.06$, $p < 0.002$. Younger drivers (mean = 4.8) rated the TravTek system's voice guide feature as easier to learn relative to older drivers (mean = 4.4). Ease of learning scores increased from video 1 (mean = 4.5) to video 2 (mean = 4.8).

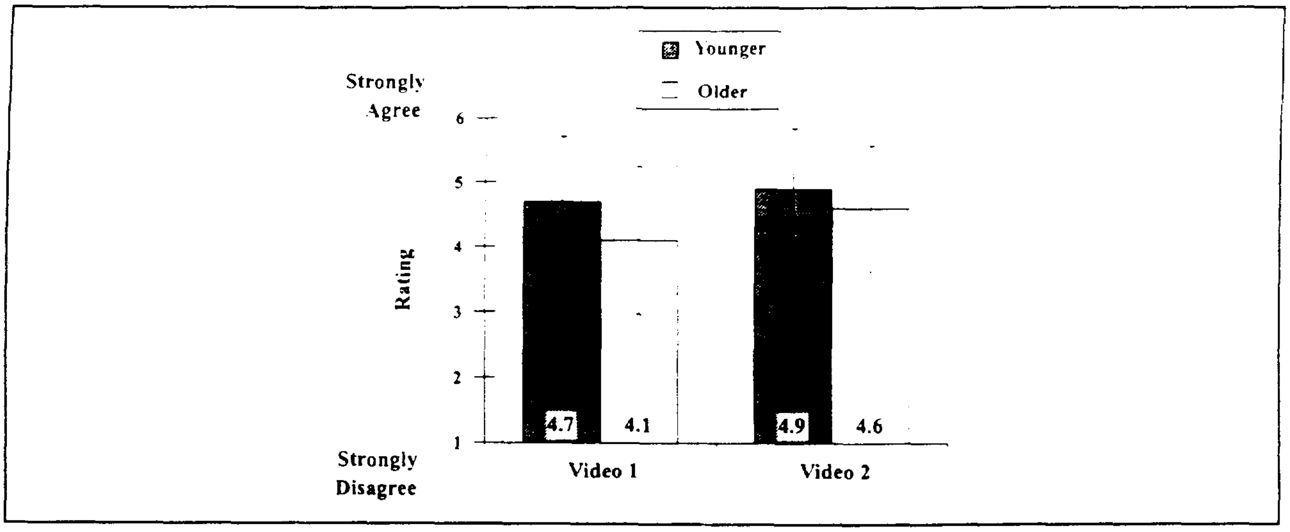


Figure 16. The TravTek system's voice guide feature was easy to learn. (TRAV3A)

Figure 17 (TRAV3B) shows mean ratings for the TravTek system's voice guide feature ease of use as a function of *AGE* and *VIDEO*. The ANOVA resulted in a significant main effect for *AGE*, $F(1,100) = 6.08$, $p < 0.015$, and a significant main effect for *VIDEO*, $F(1,100) = 12.00$, $p < 0.001$. Younger drivers (mean = 4.8) rated the TravTek system's voice guide feature as easier to use than older drivers (mean = 4.3). Ease of use ratings increased from video 1 (mean = 4.4) to video 2 (mean = 4.8).

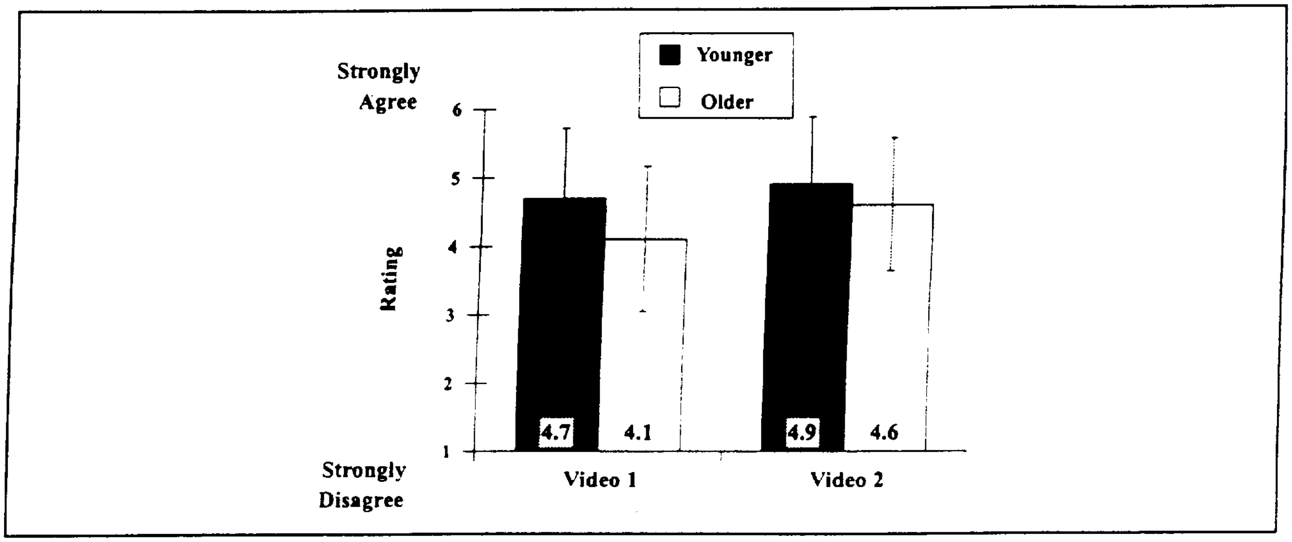


Figure 17. The TravTek system's voice guide feature was easy to use. (TRAV3B)

Figure 18 (TRAV3C) shows mean ratings for the TravTek system's voice guide feature usefulness ratings. A significant main effect occurred for *VIDEO*, $F(1,100) = 9.30$, $p < 0.003$, with usefulness ratings increasing from video 1 (mean = 4.1) to video 2 (mean = 4.6).

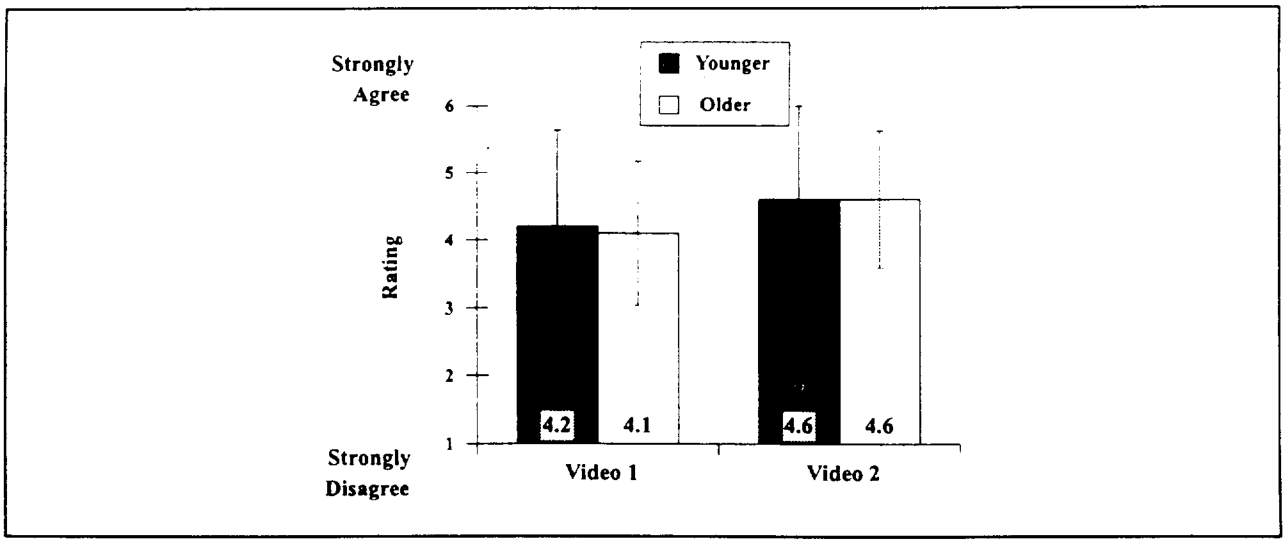


Figure 18. The TravTek system's voice guide feature was useful. (TRAV3C)

Figure 19 (TRAV4) shows mean ratings for display preference. A significant main effect occurred for *VIDEO*, $F(1,99) = 39.01$, $p < 0.001$, with ratings after video 1 (mean = 3.2) tending toward a preference for the route map. Ratings after video 2 (mean = 4.0) tended toward a preference for the guidance display.

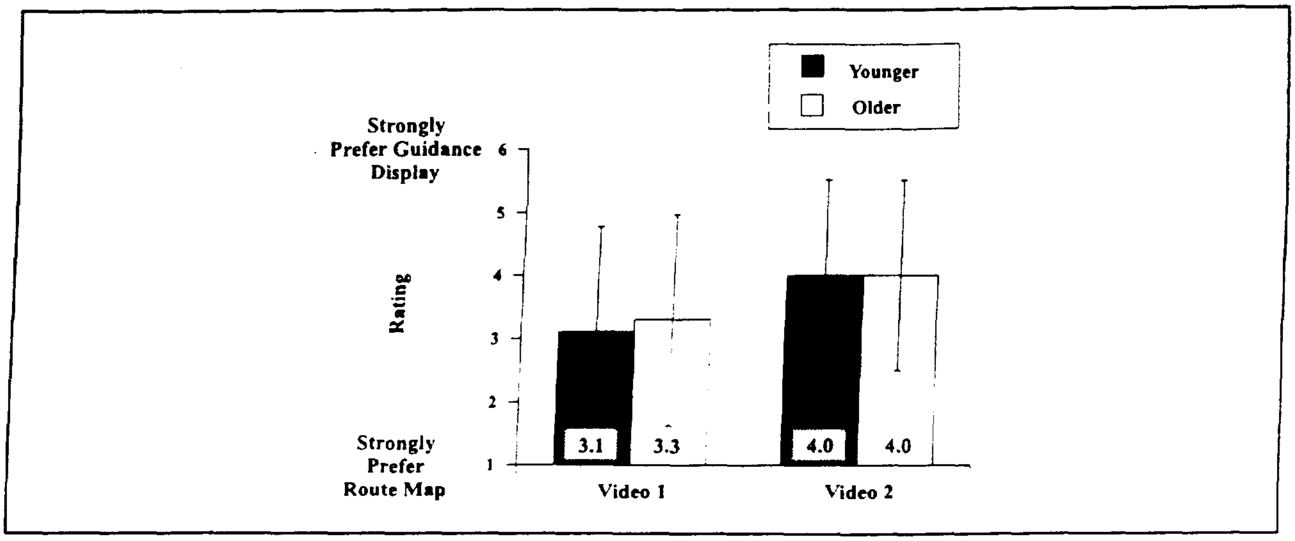


Figure 19. Of the two routing displays, route map, and guidance display, which did you prefer? (TRAV4)

Figure 20 (TRAV5A) shows mean ratings for the TravTek system's overall ease of learning. A main effect for *AGE* was the only significant result, $F(1,102) = 23.36$, $p < 0.001$. Younger drivers' ratings (mean = 4.7) indicated that they found the TravTek system easier to learn than older drivers (mean = 3.9).

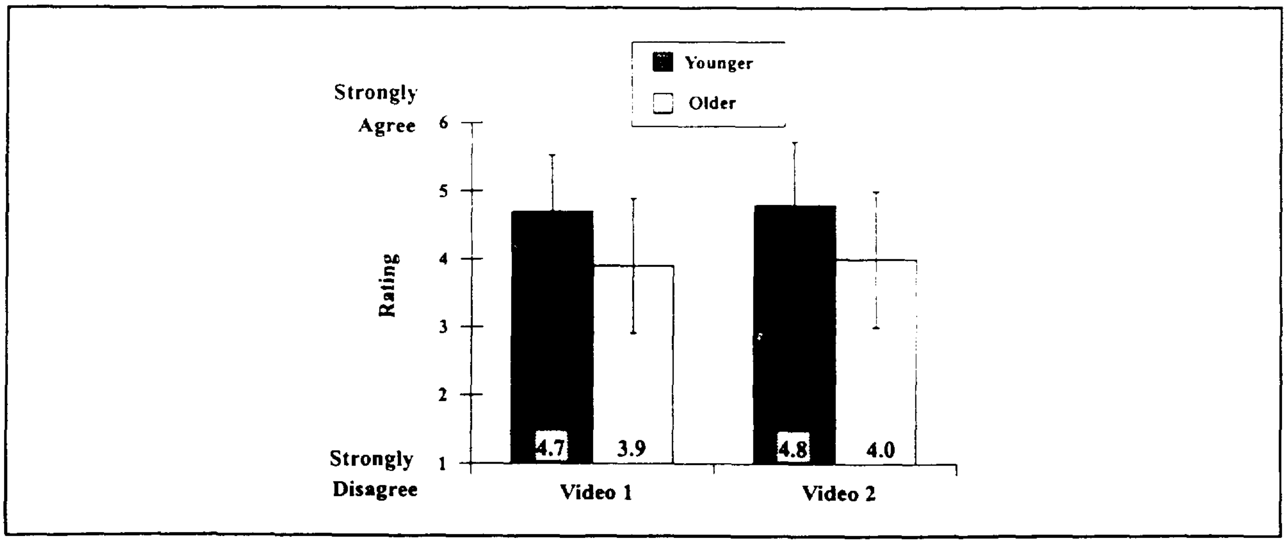


Figure 20. Overall, the TravTek system was easy to learn. (TRAV5A)

Figure 21 (TRAV5B) shows mean ratings for the TravTek system's overall ease of use. The ANOVA resulted in a significant main effect for *AGE*, $F(1,100) = 13.95$, $p < 0.001$, and a significant main effect for *VIDEO*, $F(1,100) = 5.35$, $p < 0.023$. Younger drivers' ratings of overall ease of use were higher (mean = 4.6) than older drivers' ratings (mean = 3.9). Ease of use ratings increased from video 1 (mean = 4.2) to video 2 (mean = 4.4).

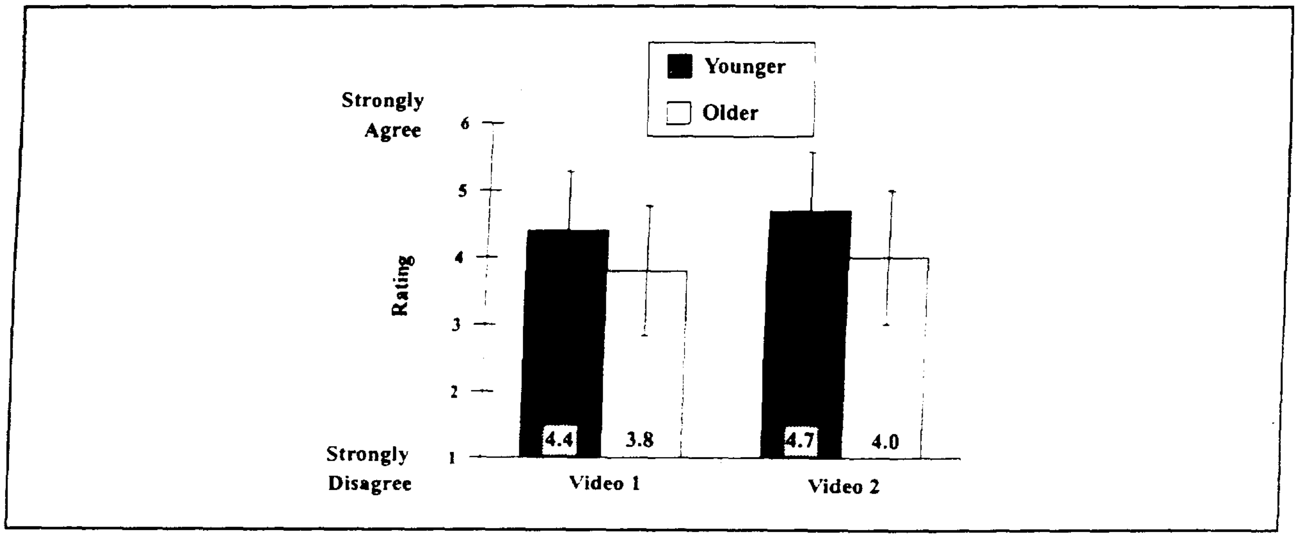


Figure 21. Overall, the TravTek system was easy to use. (TRAV5B)

Figure 22 (TRAV5C) shows mean ratings for the TravTek system's overall usefulness. A main effect for *AGE* was the only significant result, $F(1,100) = 4.74$, $p < 0.032$. Younger drivers' mean ratings (mean = 4.6) were higher than older drivers' mean ratings (mean = 4.2).

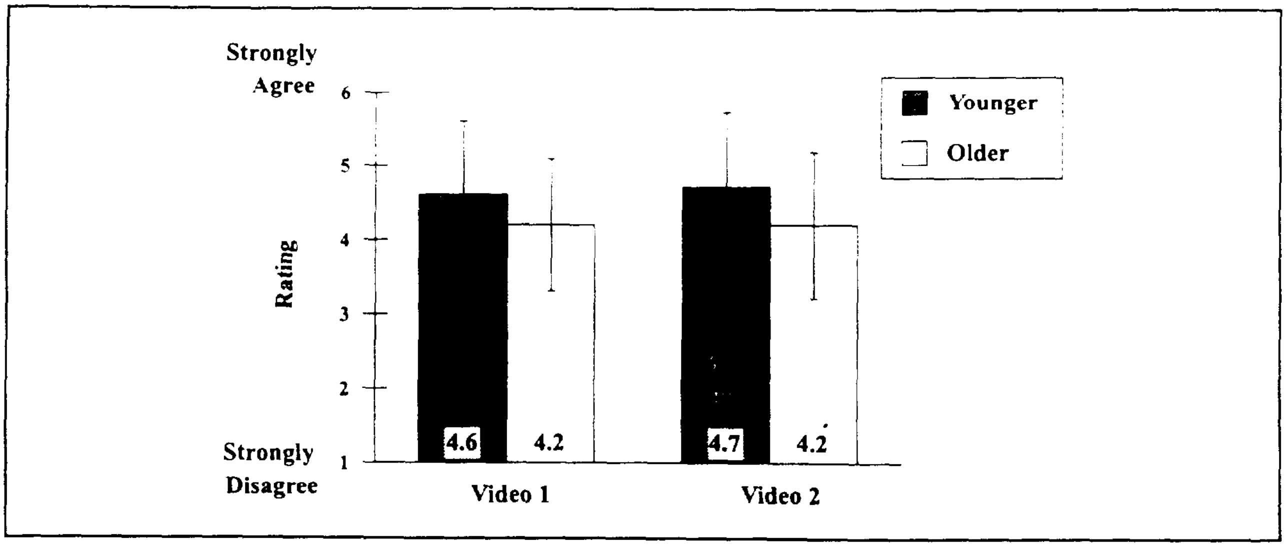


Figure 22. Overall, the TravTek system was useful. (TRAV5C)

Figure 23 (TRAV6A) through figure 25 (TRAV6C) show the percentages of drivers responding "yes" (as a function of *AGE* and *VIDEO*) that they would find the TravTek system useful for (a) at-home daily driving, (b) out-of-town vacation driving, and (c) out-of-town business driving. In general, a higher percentage of younger drivers indicated that the TravTek system would be useful in each situation than was indicated by older drivers.

Figure 23 (TRAV6A) shows the percentage of drivers indicating that the TravTek system would be useful for at-home daily driving. The percentage of younger drivers indicating that the TravTek system would be useful for video 1 was 24.3 percent and for video 2 was 27.6 percent. The percentage of older drivers indicating that it would be useful for video 1 was 12.6 percent and for video 2 was 14.3 percent.

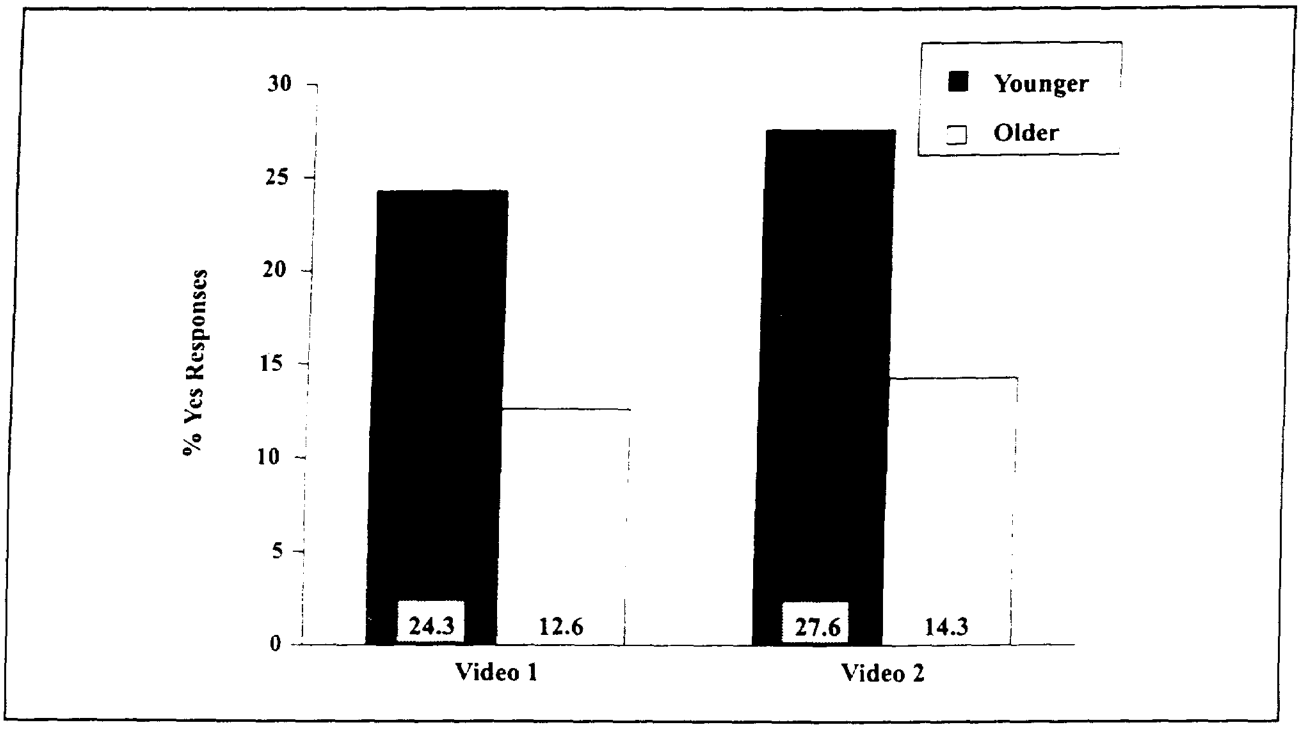


Figure 23. Do you think the TravTek system would be useful for at-home daily driving? (TRAV6A)

Figure 24 (TRAV6B) shows the percentage of drivers indicating that the TravTek system would be useful for out-of-town vacation driving. The percentage of younger drivers indicating that the TravTek system would be useful for video 1 was 57 6 percent and for video 2 was 59.6 percent. The percentage of older drivers indicating that it would be useful for video 1 was 39.6 percent and for video 2 was 37.5 percent.

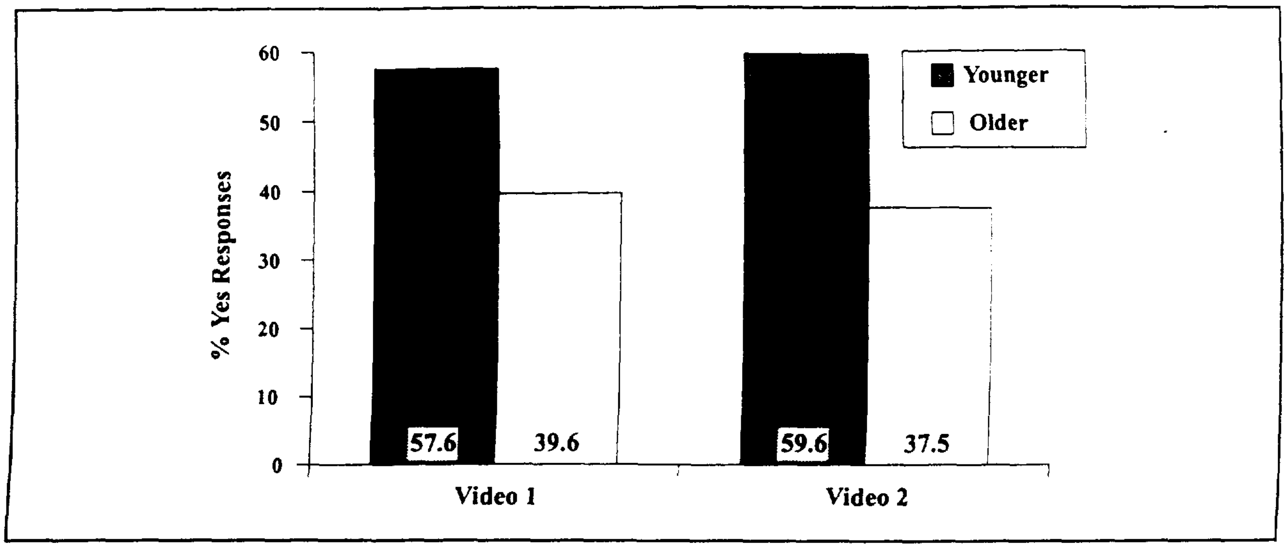


Figure 24. Do you think the TravTek system would be useful for out-of-town vacation driving? (TRAV6B)

Figure 25 (TRAV6C) shows the percentage of drivers indicating that the TravTek system would be useful for out-of-town business driving. The percentage of younger drivers indicating that the TravTek system would be useful for video 1 was 60.2 percent and for video 2 was 60.2 percent. The percentage of older drivers indicating that it would be useful for video 1 was 35.0 percent and for video 2 was 36.9 percent.

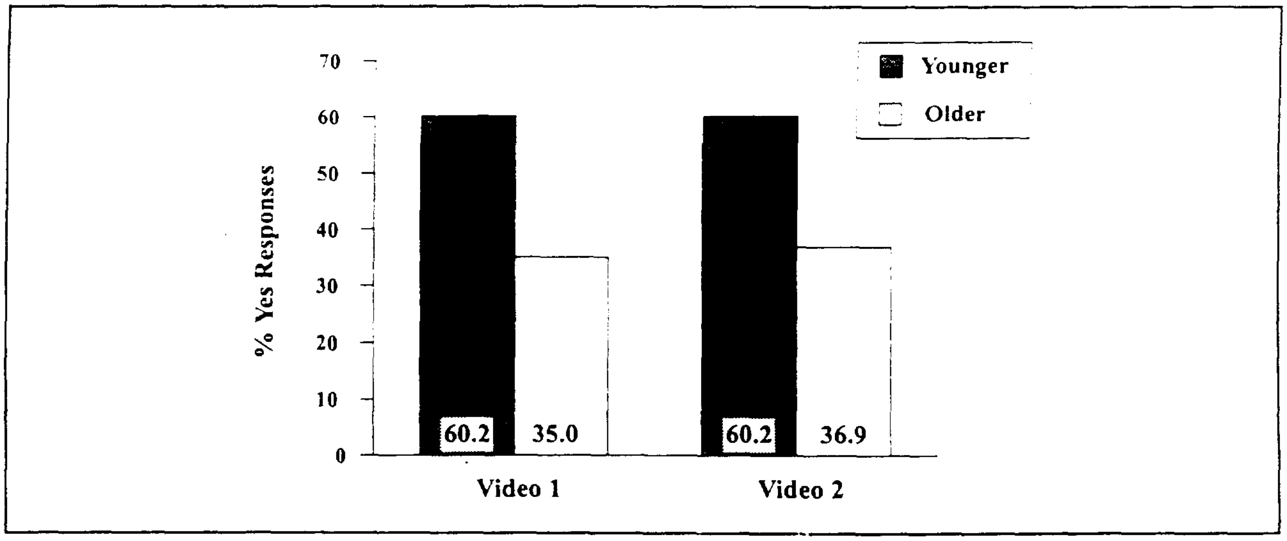


Figure 25. Do you think the TravTek system would be useful for out-of-town business trips? (TRAV6C)

Figure 26 (TRAV7) shows the amount drivers indicated they were willing to pay for the TravTek system after each video. The mean amounts younger drivers were willing to pay following video 1 was $850 and following video 2 was $837. The mean amounts older drivers were willing to pay following video 1 was $656 and following video 2 was $746.

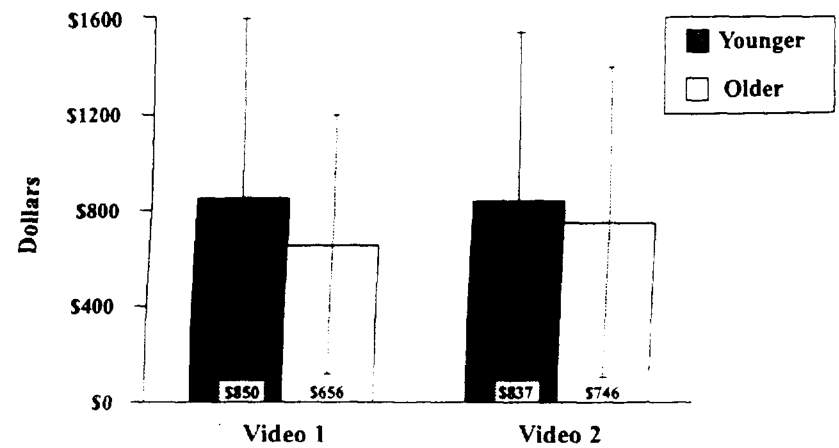


Figure 26. How much would you be willing to pay for a TravTek system? (TRAV7)

Figure 27 (TRAV8A) through figure 30 (TRAV8D) show mean ratings of the importance of traffic-related factors. In general, subjects ranked highway/traffic safety and relief of highway congestion as more important factors. They ranked energy conservation and environmental quality as less important factors.

Figure 27 (TRAV8A) shows the mean rating for the importance of energy conservation. A significant *GENDERxVIDEO* interaction occurred, $F(1{,}96) = 5.93$, $p < 0.017$. Male drivers' ratings remained the same from video 1 to video 2 (mean = 2.8). However, female drivers' ratings increased from video 1 (mean = 2.7) to video 2 (mean = 3.0), indicating a slight decrease in the mean rating of the importance of the problem.

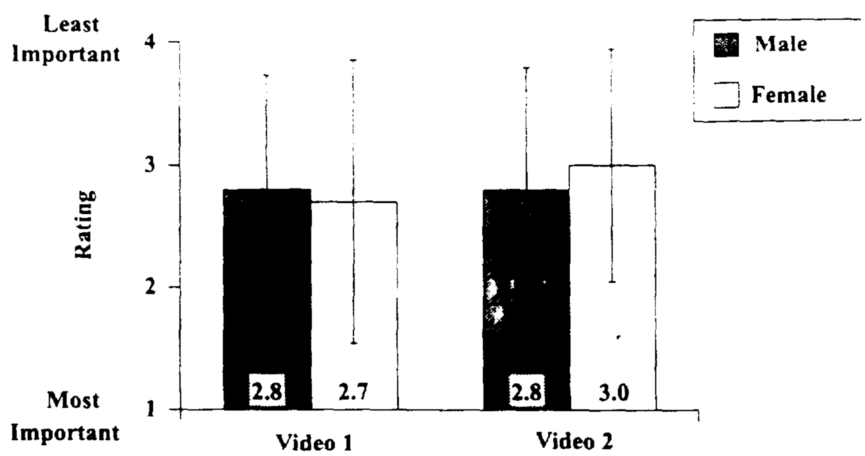


Figure 27. Rank...energy conservation. (TRAV8A)

Figure 28 (TRAV8B) shows the mean rating for the importance of environmental quality. Younger subjects' mean rating for video 1 was 2.9 and for video 2 was 3.0. Older subjects' mean ratings for video 1 was 2.7 and for video 2 was 2.9.

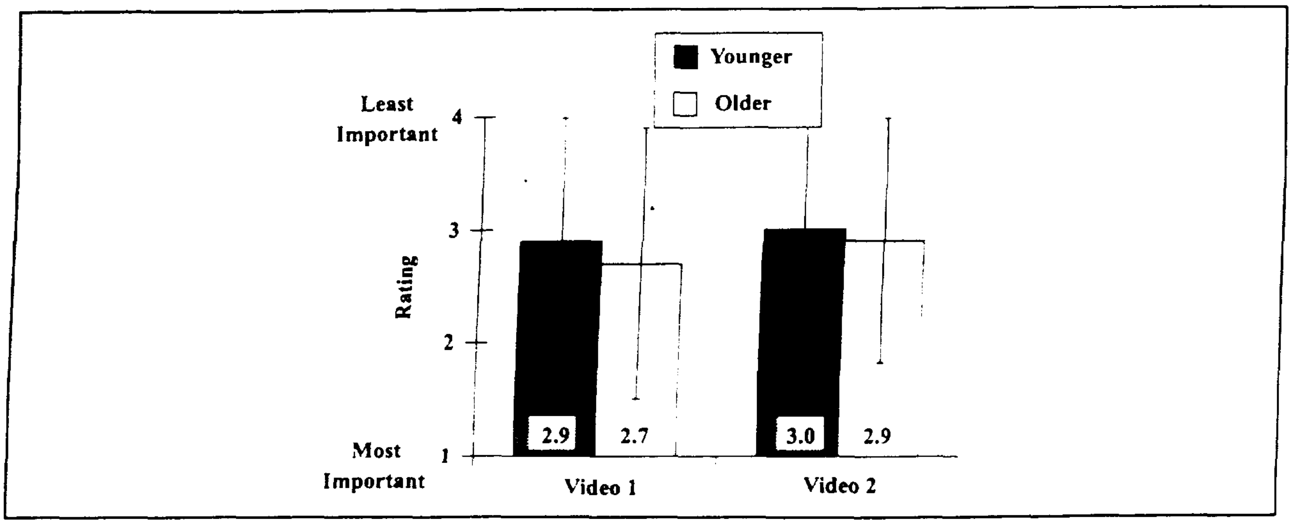


Figure 28. Rank...environmental quality. (TRAV8B)

Figure 29 (TRAV8C) shows the mean rating for the importance of highway/traffic safety. Younger subjects' mean rating for video 1 was 1.9 and for video 2 was 2.0. Older subjects' mean rating for video 1 was 1.8 and for video 2 was 1.7.

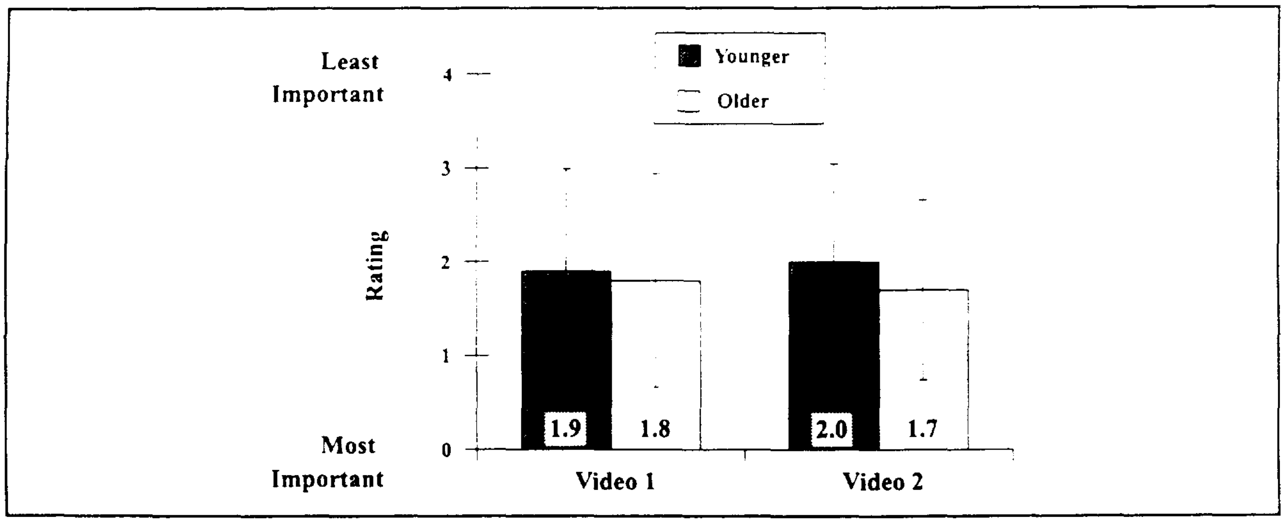


Figure 29. Rank...highway/traffic safety. (TRAV8C)

Figure 30 (TRAV8D) shows the mean rating for the importance of relief of highway congestion. Younger subjects' mean rating for video 1 was 2.0 and for video 2 was 1.9. Older subjects' mean rating for video 1 was 2.0 and for video 2 was 1.8. These non-significant results are presented to facilitate their later comparison with results of the TravTek System Demonstration Project (Orlando site).

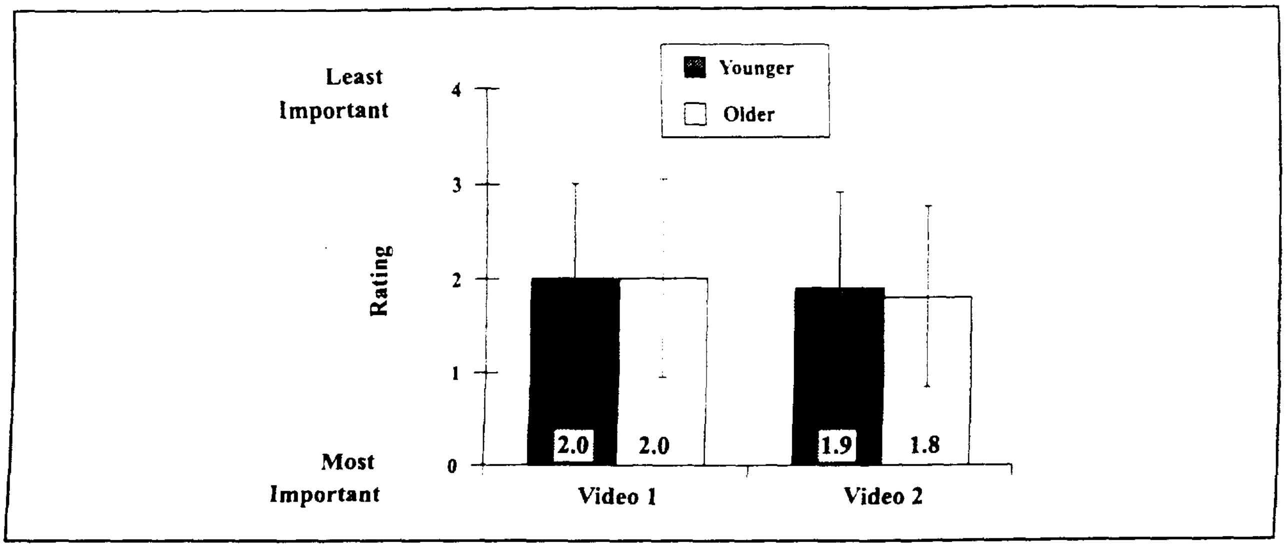


Figure 30. Rank...relief of highway congestion. (TRAV8D)

Phase 2. Age, Gender, Video, and Mean Percent Correct Scores on the TravTek System User Test

The second phase of the analyses examined *AGE*, *GENDER*, and *VIDEO* relationships for the five objective dependent variables, the mean percent correct scores for each of the TravTek system capabilities items. The mean percent correct scores for each of the sets of items showed no significant effects. However *AGE* and *VIDEO* influenced the mean percent correct scores for the system as a whole and are presented in figure 31 as the scores for all system capabilities for younger and older drivers after each video presentation. For younger subjects (18 to 54 years), mean percent correct scores were 72.8 and 69.7 for video 1 and video 2, respectively. For older subjects (55 to 85 years), mean percent correct scores were 64.6 and 64.2 for video 1 and video 2, respectively. An interaction between *AGE* and *VIDEO* indicates that younger subjects' scores decreased from video 1 to video 2, while older subjects' scores changed very little, $F(1,102) = 8.50$, $p < 0.004$.

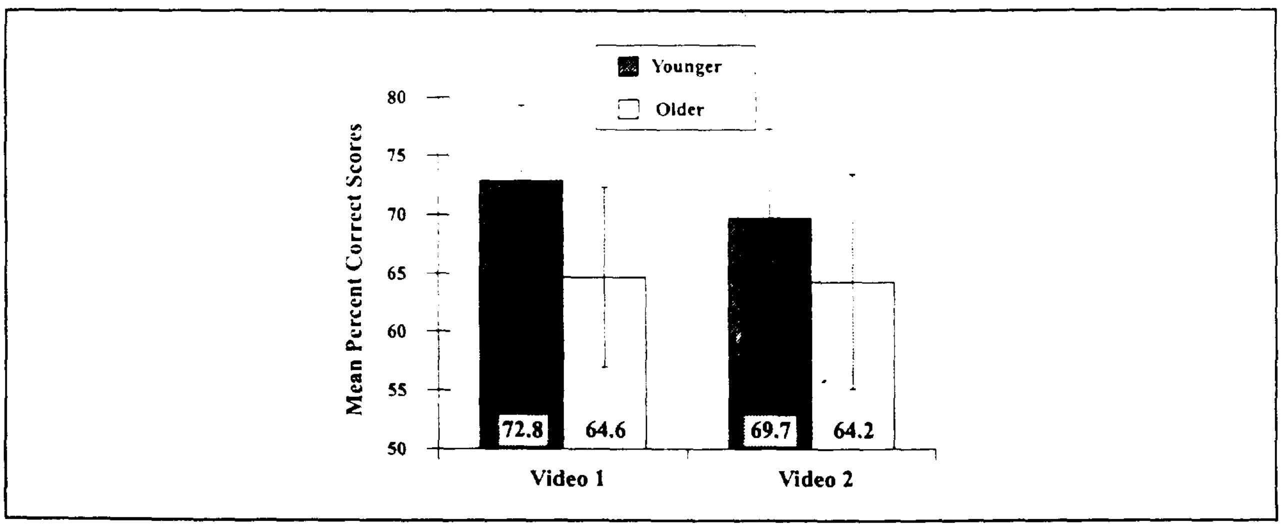


Figure 31. Mean percent correct scores for all system capabilities.

Phase 3. Identifying Relationships Among Variables

The last phase of the analyses was conducted in three steps aimed at identifying relationships among the variables shown in figure 9. During the first step, the feature patterns were determined via a factor analysis of driver responses on the *TravTek System Features Desirability* questionnaire. Mean values and other descriptive results for individual features were also developed. During the second step, composite variables were developed from individual questionnaire items. The first-order relationships among these composite variables were then explored correlationally. During the third step, multiple correlational analysis evaluation of the relationships between the individual feature patterns was done. This final step resulted in an understanding of the connection between the feature patterns, demographic variables (*AGE* and *GENDER*) and the derived composite variables (i.e., *tolerance patterns, system trust*, etc.). Results of the three steps of this analysis are described below.

Feature Patterns

The feature patterns were derived and verified from the results of the respective factor analyses of the 52 unfamiliar- and 52 familiar-city responses on the *TravTek System Feature Desirability* questionnaire (appendix B, p. 183). The primary focus was on the unfamiliar-city patterns because of expectations that drivers would require the most comprehensive sets of features in unfamiliar cities (and unfamiliar portions of familiar cities). The derivation and verification processes are described in the following subsections.

Deriving the Feature Patterns

As a first step in the analyses to derive the feature patterns, the mean values for the TravTek system feature desirability items were calculated. Features with mean desirability ratings greater than or equal to 1.5 made up the most desired features category. Table 8 lists these 14 features. Features with mean desirability ratings less than or equal to 0.5 made up the least desired features category. Table 9 lists these eight features. To summarize, the most desired features were *current position, congestion information, other real-time traffic information,* and *emergency aid requests.* All but three of the most desired features were for unfamiliar-city applications. *Voice advertising information* was the only unfamiliar-city feature pattern in the least desired features category. Driver comments during debriefing indicated that they did not want to be distracted by voice messages for advertising. The majority of least desired features related to the *coordination of travel* and the *advertising information.* The *position/location, parking information,* and *only signs relevant to the driver's pre-planned route* features were the remaining least desired features.

These results do not explain why certain feature patterns are more or less desirable. More specifically, they do not reveal how variables such as driver characteristics, attitudes, and understanding influence feature pattern desirability. This factor analysis method was used to first identify feature patterns and then identify variables that influence these feature patterns. This factor analysis approach reduced the numbers of individual analyses from the total number of feature patterns (52 for unfamiliar-city driving and 52 for familiar-city driving) to a more manageable number of feature patterns (six for unfamiliar-city driving). Reducing the number of analyses avoided a large experiment-wide error rate and provided a more parsimonious model for driver acceptance. Moreover, it was expected that these feature patterns would represent integrated functional groupings that drivers would expect in the actual final ATIS design.

Table 8. TravTek system most desired features.

UNFAMILIAR CITY	FAMILIAR CITY	TRAVTEK FEATURE	ITEM NO.
1.7	—	Position/location of your vehicle provided by: electronic map display	DES1
1.5	--	Congestion information provided by: electronic map display	DES4
1.5	--	Pre-drive route selection: that accepts driver preferences	DES12
1.8	1.5	Pre-drive route selection: that calculates route to avoid congestion	DES13
1.8	--	Route guidance: that corrects your route after a missed turn	DES14
1.7	--	Route guidance: that responds to changes in congestion by generating a new route	DES15
1.6	--	Route guidance: shown on an electronic map with a view of the whole route	DES16
1.5	--	Multi-destination trip planning function: allows selection of scenic routes	DES19
1.7		Notification of road closures or detours provided by: electronic map display	DES36
1.5	--	Street names, highway numbers and distances to towns/exits provided by: electronic map display	DES42
1.7	--	Street names, highway numbers and distances to towns/exits provided by: text or icon display	DES43
1.5	--	Hazard warning of road construction or accident occurrence provided by: electronic map display	DES53
1.6	1.5	Aid request: automatic when airbag is activated	DES61
1.7	1.6	Aid request: use the system to call for help manually	DES62

Table 9. TravTek system least desired features.

UNFAMILIAR CITY	FAMILIAR CITY	TRAVTEK FEATURE	ITEM NO.
--	0.5	Position/location of your vehicle provided by: voice	DES3
--	0.4	Coordination of travel: with bus time tables	DES7
--	0.4	Coordination of travel: with real-time bus information	DES8
--	0.4	Parking information present: by voice	DES27
--	0.3	Advertising information provided by: electronic map	DES29
--	0.3	Advertising information provided by: text or icon display	DES30
0.3	0.2	Advertising information provided by: voice	DES31
--	0.5	Only signs relevant to the driver's pre-planned route	DES50

Table 10 summarizes the method for determining the feature patterns from the unfamiliar-city responses following an approach successful in previous time-course investigations (Harmon, 1976; Bittner, 1992). This method featured a Scree-test cutoff (Harmon, 1976) that is typically more parsimonious than a unity eigenvalue cut-off (hence the minimum eigenvalue was 1.71 in this case). Additionally, the Varimax procedure was used to orthogonally rotate the resulting factors to facilitate interpretation (Harmon, 1976).

Table 10. Method for determination of feature patterns.

STEPS USED TO DETERMINE FEATURE PATTERNS
Principal factor analysis (PFA) was performed using the SPSS/PC+ software package.
Data were 52 unfamiliar-city feature desirability variables from the TravTek System Features desirability section of the TravTek System Questionnaire.
A total of 109 drivers provided responses after each of two video presentations (218 cases).
A Scree-test cutoff, with a 1.71 minimum eigenvalue, resulted in six factors.
Varimax rotation was applied to a total of six factors.

The results of the principal factor analysis were six feature patterns summarized in table 11. It can be seen that a *Basic Map* display is indicated by the first feature pattern (Factor I) with the other feature patterns representing various overlays of features (e.g., *Voice, Text/Icon*). Summarized in this table are the variables most associated with each feature pattern. The numbers in parentheses show the correlations between individual variables and the relative feature patterns. These feature patterns include mixes of feature patterns drawn from IRANS, IMSIS, etc. This was consistent with driver comments that clusters of feature patterns from IRANS and the other systems go together functionally.

Table 11. Desired feature patterns.

FACTOR	NAME	DESCRIPTION
I	Basic Map	Vehicle position/location (0.76) and 16 other features that make up a basic map display.
II	Voice	Street names, highway numbers, and turnoff/city distances (0.82) and 11 other voice overlay features.
III	Text/Icon	Road closures or detours (0.75) and 9 other text/icon overlay features.
IV	Coordination of Travel	Overlay of advertising map (0.71), text-icon (0.68) and voice (0.62) information with bus timetable (0.66), real-time bus information (0.65), airline (0.66) information, and 6 multi-destination trip planning and other functions.
V	Map Simplification	Simplify to only map signs relevant to route (0.62), with advisory speeds for potential hazards (0.62), and regulation information.
VI	Monitoring & Emergency Response	Overlay of text/icon (0.61) and voice (0.59) vehicle monitoring, and 4 other related factors, including manual and automatic aid request (call 911).

Verifying the Feature Patterns

The derived feature patterns were "verified" for the familiar-city responses by comparison of unfamiliar- and familiar-city factor scores. The results of the familiar-city responses were first factor analyzed following the unfamiliar-city approach described in table 12. The familiar-city factor analysis revealed six factors that, on-the-surface, appeared consistent with those summarized in table 11.

To more conservatively evaluate this consistency, the separate feature pattern scores of unfamiliar- and familiar-city results were cross-correlated. Table 12 summarizes the results of the cross-correlation of the respective sets of six unfamiliar- and familiar-city factor scores. Although the factors are not in identical order, the dominant weights in each row and column indicate that the unfamiliar-city factor scores generally had substantial overlaps with those for the familiar-city factor scores ($r > 0.52$, $p < 0.001$). The ordering is not important as it only represents the relative importance of the various feature patterns that are expected to vary between unfamiliar and familiar cities. Correspondence requires only moderate substantial correlations between similar feature patterns.

Table 12. Cross-correlations between unfamiliar-city and familiar-city factor scores of the feature patterns.

	UNFAMILIAR CITY					
FAMILIAR CITY	Basic Map	Voice	Text/Icon	Coordination of Travel	Map Simplification	Monitoring & Emergency Response
Voice	-0.06	0.83**	-0.08	-0.09	-0.03	0.08
Basic Map	0.52**	-0.09	0.013	-0.05	-0.20	-0.13
Text/Icon	-0.05	-0.07	0.82**	-0.02	-0.02	-0.01
Map Simplification	0.40**	-0.14	-0.11	-0.17	0.57**	0.30
Coordination of Travel	-0.02	0.03	0.04	0.73**	0.14	0.01
Monitoring & Emergency Response	0.21	0.06	0.16	0.13	-0.08	0.67**

** $p < 0.001$.

Further, with the exception of the first of the unfamiliar-city feature patterns (*Basic Map*) that is somewhat split between the *Familiar-city Basic Map* (Feature Pattern I) and *Map Simplification* (Feature Pattern V), it is clear that the individual unfamiliar-city feature patterns typically are uniquely identified by single, familiar-city patterns. The split was consistent with drivers desiring simplified feature patterns in a familiar-city (when traversing familiar streets). These results generally support the validity of unfamiliar-city patterns as representative for both desired familiar- and unfamiliar-city feature patterns.

Composite Variable Evaluations

Composite variables were evaluated in two stages. First, using factor analytic methods, composite variables were derived from the following six sets of relevant questionnaire responses:

- *Fidelity* (appendix B, pp. 188-189, items 2, 4, 5, 8, 9).
- *Attention* (appendix B, pp. 188-189, items 1, 3, 6, 7).
- *Capabilities Understanding* (appendix B, pp. 178-182, 4 sets of items and total).
- *System Trust* (appendix B, pp. 192-195, items 1a-7a).
- *Self-Confidence* (appendix B, pp. 192-195, items 1b-7b) .
- *Tolerance Patterns* (appendix B, pp. 190-191, all but item 1).

Second, the first-order relationships among the derived composites were then explored in terms of the model shown in figure 9. The factor analyses and correlations are described in the following subsections.

Derivation of the Composite Variables

Table 13 summarizes the method used for deriving the composite variable factors. This method is analogous to that employed earlier to derive the feature patterns.

Table 13. Method for determination of composite variables.

STEPS USED TO DETERMINE COMPOSITE VARIABLES
Principal factor analysis (PFA) was performed using the SPSS/PC+ software package.
Data were 34 variables from various sections of the TravTek system questionnaire.
A total of 109 drivers provided responses after each of two video presentations (218 cases).
If more than one *eigenvalue* was greater than 1.0, a Scree-test cutoff was performed.
If more than one factor occurred, Varimax rotation was used.

Results of applying this method to each of the six sets of composite variables are summarized in the following:

- *Fidelity*—The PFA of the five *fidelity* questionnaire items revealed a single factor variable, with an eigenvalue greater than unity, that explained 65.6 percent of the total variation. This composite variable was given the short title *FIDELITY* for identification purposes in the analyses that follow.
- *Attention*—The PFA of the four *attention* questionnaire items revealed a single factor variable, with an eigenvalue substantially greater than unity, that explained 64.2 percent of the total variation. This composite variable was given the short title *ATTENT*.

- *Capabilities Understanding*—The PFA of the summary scores for the four sections of *capabilities understanding* questionnaire items revealed two factor variables, with eigenvalues greater than unity (i.e., 1.5 and 1.1) that together explained 64.8 percent of the total variation. The first of these reflected a general understanding of all but the safety-related items, while the second reflected safety-related items. These composite variables were given the short titles *UNDRSTD1* and *UNDRSTD2*, respectively.
- *System Trust*—The PFA of the seven *system trust* questionnaire items revealed a single factor variable, with an eigenvalue greater than unity, that explained 49.7 percent of the total item variation. This composite variable was given the short title *SYSTRUST*.
- *Self-Confidence*—The PFA of the seven *self-confidence* questionnaire items resulted in a single factor, with an eigenvalue greater than unity, that explained 51.9 percent of the total variation. This composite variable was given the short title *SELFCON*.
- *Tolerance Patterns*—The PFA of the seven *tolerance* questionnaire items revealed two factor variables, with eigenvalues greater than unity (i.e., 2.1 and 1.5), that together explained 51.1 percent of the total item variation. The first of these was related to the proportions of trips that prediction failures could be tolerated, whereas the second was related to tolerances for various errors in the arrival times. These composite variables were given the short titles *TOLPAT1* and *TOLPAT2*, respectively.

These PFA results were generally in keeping with the conceptual expectations, although two feature patterns occasionally emerged where one might have been expected (e.g., with regard to UNDRSTD1 and UNDRSTD2). The results, however, were consistent with somewhat broadened concepts (e.g., some older drivers give relatively greater attention to safety-related information). This theoretical consistency pointed toward the evaluation of the first-order correlations among the various composite variables and the multivariate evaluation of their relationships with feature patterns. The results of these evaluations are described below.

Composite Variable First-Order Relationships

Table 14 summarizes the first-order correlations among the factor scores for the feature patterns computed for the eight composite variables. The correlations between the variables indicate that they tend to be only moderately related (i.e., $r > 0.54$). However, these first-order correlations point out relationships that impact driver judgments of the desirability of various feature patterns.

Table 14. Composite variable correlations.

VARIABLE	FIDELITY	ATTENT	UNDRSTD1	UNDRSTD2	SYSTRUST	SELFCON	TOLPAT1	TOLPAT2
FIDELITY	1.000	0.535**	-0.105	0.062	0.396**	0.151*	-0.000	0.060
ATTENT	0.535**	1.000	-0.037	-0.038	0.155	0.007	-0.017	-0.133*
UNDRSTD1	-0.105	-0.037	1.000	0.000	-0.199*	0.045	0.112	-0.099
UNDRSTD2	0.062	-0.038	0.000	1.000	-0.030	-0.004	0.212*	0.023
SYSTRUST	0.396**	0.155*	-0.199*	-0.030	1.000	0.178*	-0.001	0.105
SELFCON	0.151*	0.007	0.045	-0.004	0.178*	1.000	0.088	-0.311**
TOLPAT1	0.000	-0.017	0.112	0.212*	-0.001	0.088	1.000	0.000
TOLPAT2	0.060	0.133	-0.099	0.023	0.105	-0.311**	0.000	1.000

* $p < 0.01$ and ** $p < 0.001$ 2-tailed significance.

Relationships of Feature Patterns with Specified Variables

The third step was directed at the overall relationships among each of the six feature patterns and the selected variables shown in figure 9. Hence, six multiple correlation analyses were conducted that evaluated the joint relationships of each of the feature "patterns" scores with the following:

- Demographic variables (*AGE*, *GENDER*, and their interaction *AGExGEN*).
- Capabilities understanding variables (*UNDRSTD1* and *UNDRSTD2*).
- System trust variable (*SYSTRUST*).
- Self-confidence variable (*SELFCON*).
- Tolerance pattern variables (*TOLPAT1* and *TOLPAT2*).
- *VIDEO* (whether after first or second video presentation).

First, an initial multiple correlation was performed to identify relationships among the feature pattern's scores and all of the previously listed variables. Each of these initial analyses will be shown in a table. Then, the initial multiple correlation models were evaluated using a step-down procedure. Each of these final correlation models will also be shown in a table. A description of the table headings is given below:

- VARIABLE = the variable name.
- "B" = the raw weight of the variable in the model.
- "SE B" = its standard error.
- "BETA" = the standard score model weight.
- "T" = the *t*-test value for the term (T).
- "SIG T" = the significance (*p*) value.

"B" is the raw weight of the variable in the regression equation:

$$y_i = \text{constant(additive)} + \Sigma_j B_j x_{ji}$$

where Y_i is the driver's score on a variable, B_j is the *j*th variable's "B" weight, and X_{ji} is the *i*th driver's score on variable j.

Results for the six feature patterns are presented below in the order of their earlier numbering (i.e., Factors I to VI).

<u>Basic Map Feature Pattern (Factor I)</u>

The initial analysis revealed a very highly significant ($p < 10^{-6}$) multiple correlation among the 10 independent variables and the *Basic Map feature pattern*: $R = 0.489$. Table 15 summarizes the model resulting from this analysis in terms of the raw weight of a term in the model (B); its standard error (SE B); the standard score model weight (BETA), the *t*-test value for the term (T) and its associated significance (*p*) value (SIG T). In addition to the additive constant (Constant), several model variables were initially significant (*p*s < 0.05): *UNDRSTD2*, *UNDRSTD1*, and

AGE. Others (e.g., *SYSTRUST*) approach significance ($p < 0.06$) and some appeared clearly unrelated to the model (e.g., *VIDEO* with $p > 0.7$). These results suggested the examination of simplified multiple correlation models that might better reveal the relationships with the *Basic Map feature pattern*.

Table 15. Basic map feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.161819	0.064796	0.163853	2.497	0.0133
UNDRSTD1	0.193596	0.069841	0.192061	2.772	0.0061
SELFCON	0.125680	0.071854	0.126476	1.749	0.0818
VIDEO	-0.048018	0.128304	-0.023948	-0.374	0.7086
GENDER	-0.548440	0.388990	-0.273449	-1.410	0.1602
TOLPAT1	-0.041113	0.065027	-0.040971	-0.632	0.5280
SYSTRUST	0.125371	0.065538	0.126428	1.913	0.0572
TOLPAT2	-0.016235	0.070098	-0.016004	-0.232	0.8171
AGE	-1.204491	0.412366	-0.593952	-2.921	0.0039
AGExGEN	0.457114	0.258032	0.475602	1.772	0.0780
(Constant)	1.639820	0.663482		2.472	0.0143

Simplified multiple correlation models were evaluated using a step-down procedure that progressively eliminated variables with the largest significance levels, those greater than $p = 0.10$ (Norysis, 1992). This procedure revealed a very highly significant ($p < 10^{-6}$) multiple correlation among the five remaining independent variables and the *Basic Map feature pattern*: $R = 0.472$. Table 16 summarizes the model resulting for this analysis and shows that, in addition to the additive constant (Constant), significant ($p < 0.05$) model variables included *UNDRSTD2*, *UNDRSTD1*, *SYSTRUST*, and *AGE*.

Table 16. Basic map feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.155404	0.062441	0.157358	2.489	0.0136
UNDRSTD1	0.200025	0.068157	0.198439	2.935	0.0037
SELFCON	0.112347	0.067928	0.113058	1.654	0.0997
SYSTRUST	0.128496	0.064477	0.129579	1.993	0.0476
AGE	-0.532424	0.145545	-0.262546	-3.658	0.0003
(Constant)	0.761724	0.215940		3.527	0.0005

Figure 32 illustrates the relationships among these variables in the context of the other potential influences. By multiplying the B weight of *AGE* by the *AGE* code, these results indicate that the *Basic Map feature pattern* was seen by older drivers, as a whole (*AGE* = 2 *x* -0.53 = -1), to be less desirable than by younger drivers (*AGE* = 1 *x* -0.53 = -0.53). However, *AGE* effects can be offset with greater understandings of the system features (as indicated by positive B weights for *UNDRSTD2* = 0.16 and *UNDRSTD1* = 0.20). Increases in *SYSTRUST* would also add to the desirability of this basic pattern (as indicated by a positive B weight = 0.13). These results point out the importance of education and experience for enhancing the desirability of the *Basic Map feature pattern*.

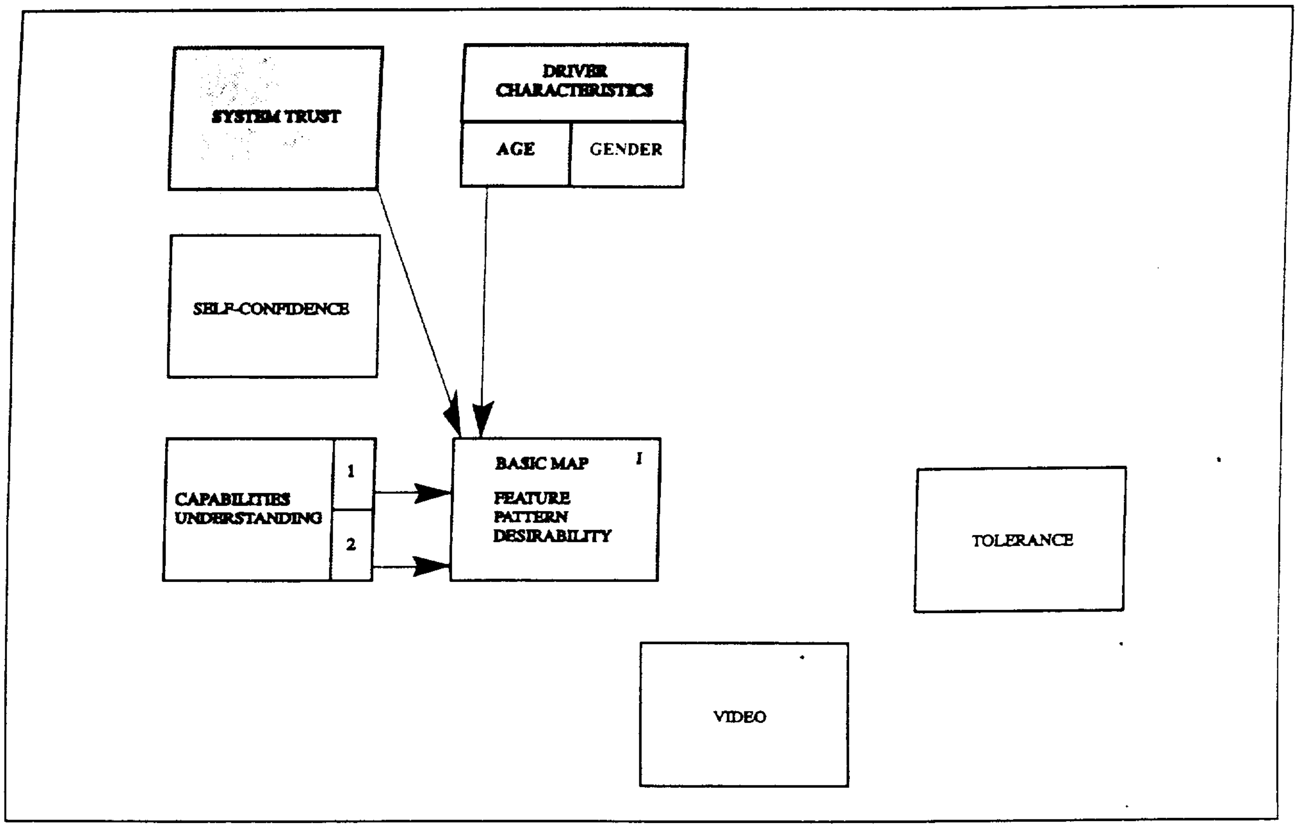


Figure 32. Basic map feature pattern desirability.

Voice Feature Pattern (Factor II)

Initial analysis revealed a very highly significant ($p < 10^{-5}$) multiple correlation among the 10 independent variables and the *Voice feature pattern*: $R = 0.445$. Table 17 summarizes the model resulting from this analysis in the same terms as described above. In addition to the additive constant (Constant), significant ($p < 0.05$) model variables initially included *VIDEO* and *SELFCON*. Others (e.g., *UNDRSTD2*) range from the suggestive ($p < 0.09$) to the clearly unrelated (e.g., *UNDRSTD1* with $p > 0.7$). These results also suggested the examination of simplified multiple correlation models for the *Voice feature pattern*.

Table 17. Voice feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.114205	0.065628	0.117217	1.740	0.0834
UNDRSTD1	-0.025470	0.070737	-0.025612	-0.360	0.7192
SELFCON	-0.219402	0.072776	-0.223800	-3.015	0.0029
VIDEO	0.717494	0.129950	0.362714	5.521	$>10^{-6}$
GENDER	0.134681	0.393981	0.068066	0.342	0.7328
TOLPAT1	-0.081280	0.065861	-0.082102	-1.234	0.2186
SYSTRUST	-0.056271	0.066379	-0.057519	-0.848	0.3976
TOLPAT2	0.032344	0.070997	0.032318	0.456	0.6492
AGE	0.009541	0.417657	0.004769	0.023	0.9818
AGExGEN	-0.137898	0.261342	-0.145430	-0.528	0.5983
(Constant)	-0.974165	0.671995		-1.450	0.1488

Simplified multiple correlation models were evaluated using the same (Norysis, 1992) step-down procedure described earlier. This procedure revealed a highly significant ($p < 10^{-5}$) multiple correlation among three remaining independent variables and the *Voice feature pattern*: $R = 0.424$. Table 18 summarizes the model resulting for this analysis and shows that, in addition to the additive constant (Constant), significant (ps < 0.001) model variables included *VIDEO* and *SELFCON*.

Table 18. Voice feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.114709	0.061961	0.117734	1.851	0.0656
SELFCON	-0.208148	0.062352	-0.212320	-3.338	0.0010
VIDEO	0.706012	0.125846	0.356910	5.610	$<10^{-6}$
(Constant)	-1.033043	0.198707		-5.199	$<10^{-6}$

Figure 33 illustrates the relationships among these variables in the context of the other potential influences. Safety understanding (*UNDRSTD2*) remained insignificant albeit suggestive ($p < 0.07$) that enhancing the TravTek system safety feature understanding (B = 0.11) would increase the desirability of the *Voice feature pattern*. Contrasting with this, the results indicate that drivers with high levels of *SELFCON* tend to find the *Voice feature pattern* less desirable (B = -0.21). However, strongly overriding both of these is the strong influence (B = 0.71) of video 2 over video 1 in increasing the desirability of the *Voice feature pattern*. This influence, as indicated by post-study driver comments, resulted from the strong illustration of voice guidance in video 2 (Orlando trip). This result points out the importance of a specific voice illustration for increasing the perceived desirability of the *Voice feature pattern*.

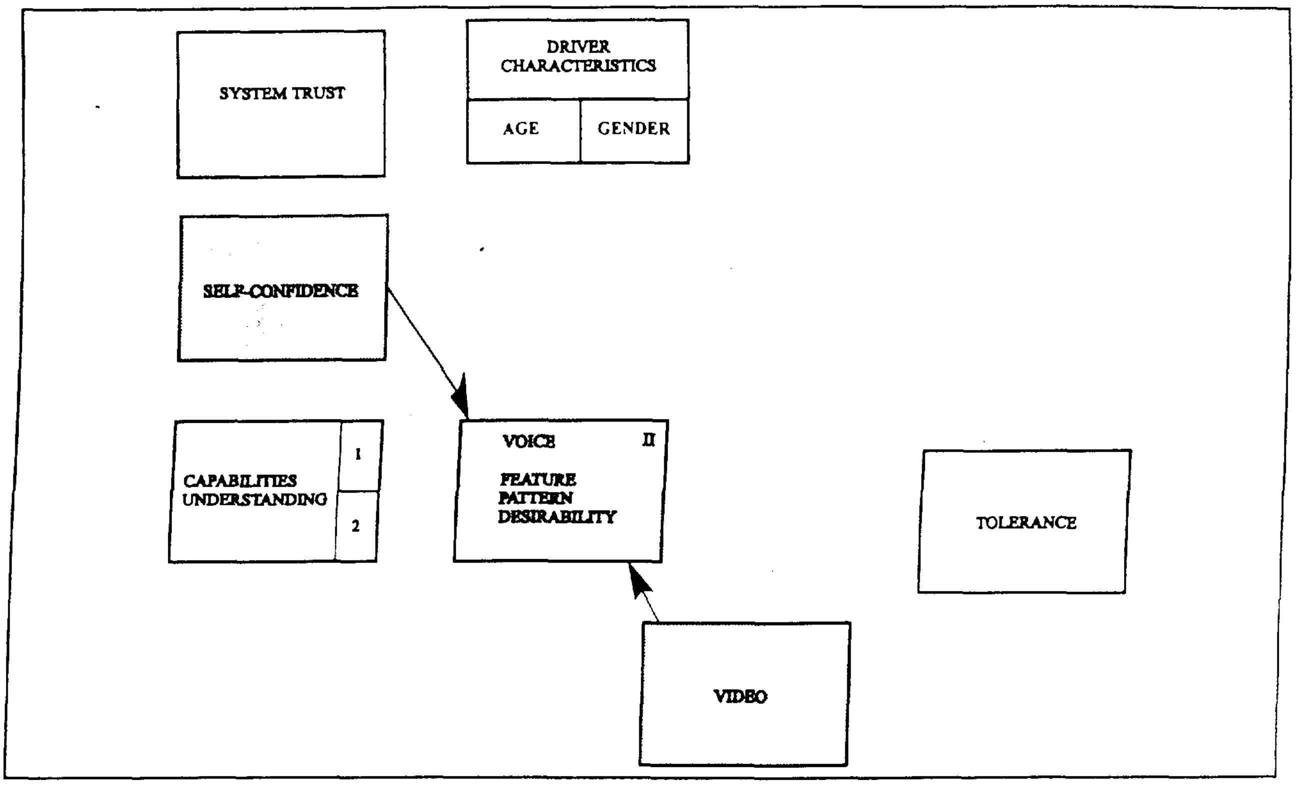


Figure 33. Voice feature pattern desirability.

Text/Icon Feature Pattern (Factor III)

The initial analysis revealed a highly significant ($p < 0.001$) multiple correlation among the 10 independent variables and *Text/Icon feature pattern*: $R = 0.376$. Table 19 summarizes the model resulting from this analysis. Significant ($p < 0.03$) model variables initially included *SELFCON*, *GENDER*, *AGExGEN*, and *SYSTRUST*. Others (e.g., *AGE*) ranged from the nearly significant ($p < 0.06$) to the clearly unrelated (e.g., *VIDEO* with $p > 0.69$). These results also suggested examination of simplified multiple correlation models for the *Text/Icon feature pattern*.

Table 19. Text/Icon feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.173239	0.069290	0.174288	2.500	0.0132
UNDRSTD1	0.115623	0.074685	0.113968	1.548	0.1232
SELFCON	-0.208695	0.076838	-0.208664	-2.716	0.0072
VIDEO	0.053615	0.137202	0.026567	0.391	0.6964
GENDER	1.110326	0.415967	0.550038	2.669	0.0082
TOLPAT1	0.056736	0.069537	0.056176	0.816	0.4155
SYSTRUST	0.154068	0.070083	0.154366	2.198	0.0291
TOLPAT2	-0.121641	0.074960	-0.119140	-1.623	0.1062
AGE	0.849321	0.440964	0.416117	1.926	0.0555
AGExGEN	-0.768081	0.275927	-0.794002	-2.784	0.0059
(Constant)	-1.331378	0.709496		-1.877	0.0621

Simplified multiple correlation models were evaluated using the same (Norysis, 1992) step-down procedure described earlier. This procedure revealed a very highly significant ($p < 0.001$) multiple correlation among three remaining independent variables and the *Text/Icon Feature Pattern*: $R = 0.356$. Table 20 summarizes the model resulting for this analysis.

Table 20. Text/Icon feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.174520	0.067660	0.175576	2.579	0.0106
SELFCON	-0.212390	0.076504	-0.212358	-2.776	0.0060
GENDER	0.995791	0.411663	0.493299	2.419	0.0165
SYSTRUST	0.132286	0.068644	0.132542	1.927	0.0554
TOLPAT2	-0.129278	0.073683	-0.126620	-1.755	0.0809
AGE	0.665720	0.429789	0.326163	1.549	0.1230
AGE *X* GEN	-0.702281	0.273830	-0.725982	-2.565	0.0111
(Constant)	-0.960404	0.653132		-1.470	0.1430

Figure 34 illustrates the relationships among these variables in the context of the other potential influences.

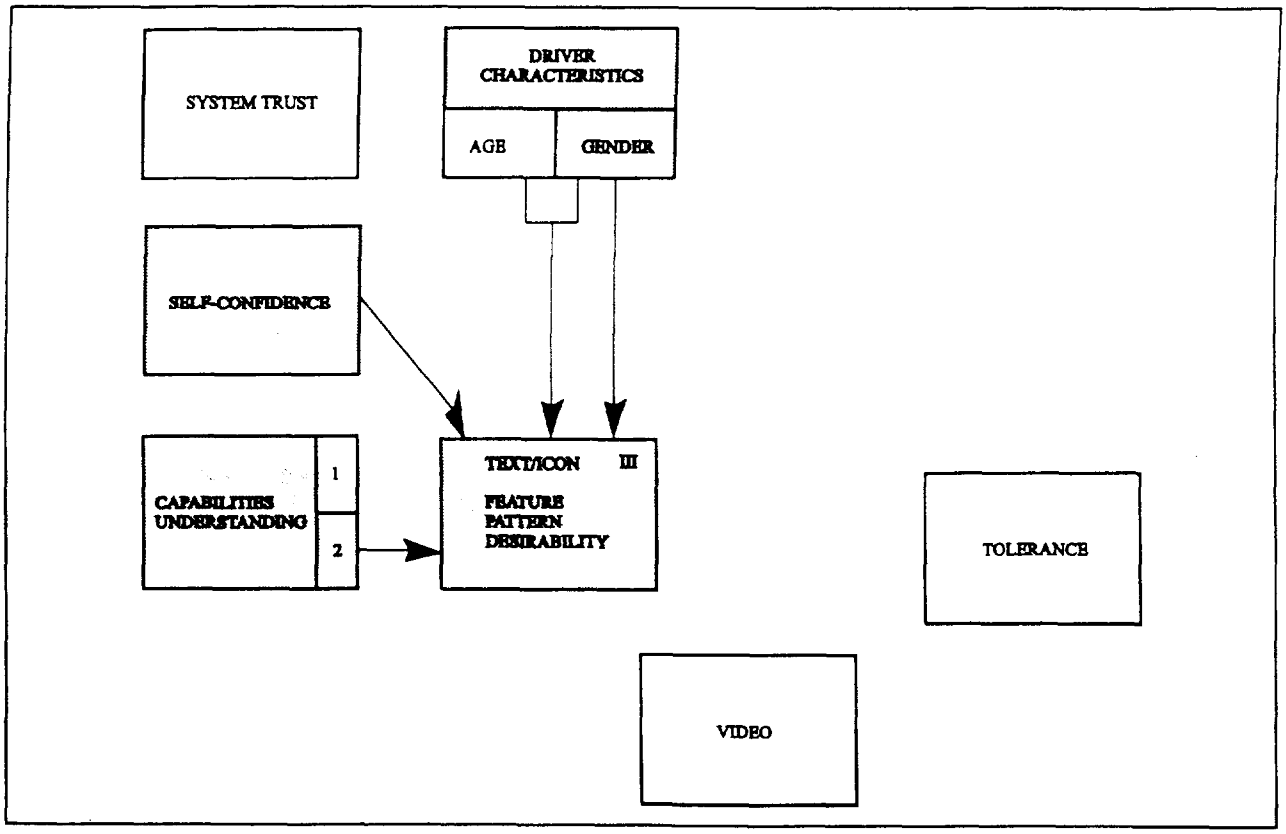


Figure 34. Text/Icon feature pattern desirability.

Significant ($p < 0.02$) model variables included *UNDRSTD2*, *SELFCON*, *GENDER*, and *AGExGEN*. Of these, greater *SELFCON* was associated with decreased desirability for the *Text/Icon feature pattern* (B = -0.21), while greater understanding of system safety features (*UNDRSTD2*) was associated with enhanced desirability (B = 0.17). There was also a tendency for increased desirability for the *Text/Icon feature pattern* with increased *SYSTRUST* ($p = 0.06$). More striking than these, however, are the compound effects of *GENDER* (1 = male and 2 = female), *AGE* (1 = younger and 2 = older), and *AGExGEN*. Taking these and the additive constant (Constant) into account, the net effects are as shown in table 21. Because *AGE* and *GENDER* are fixed, these results point out the importance of increasing system safety understanding (*UNDRSTD2*) and *SYSTRUST* to increase the desirability of the *Text/Icon feature pattern*, particularly for older females.

Table 21. Gender and age interaction on desirability.

GENDER	AGE	
	Younger	Older
Male	0.000	-0.036
Female	0.294	-0.444

Coordination of Travel Information Feature Pattern (Factor IV)

Initial analysis revealed a very highly significant ($p < 0.003$) multiple correlation among the 10 independent variables and the *Coordination of Travel Information feature pattern*: $R = 0.390$. Table 22 summarizes the model resulting from this analysis in the same terms described above. Significant ($ps < 0.02$) model variables initially included *UNDRSTD1*, *SYSTRUST*, and *VIDEO*. Many other variables appeared clearly unrelated (e.g., *TOLPAT1* with $p > 0.9$). These results also suggested examination of simplified multiple correlation models for the *Coordination of Travel Information feature pattern*.

Table 22. Coordination of travel information feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	-0.100310	0.069330	-0.100204	-1.4470	0.1495
UNDRSTD1	-0.261379	0.074728	-0.255816	-3.4980	0.0006
SELFCON	0.046395	0.076882	0.046060	0.6030	0.5469
VIDEO	-0.338219	0.137281	-0.166411	-2.4640	0.0146
GENDER	0.486608	0.416207	0.239354	1.1690	0.2438
TOLPAT1	-0.002533	0.069577	-0.022490	-0.0360	0.9710
SYSTRUST	0.180911	0.070123	0.179980	2.5800	0.0106
TOLPAT2	-0.021678	0.075003	-0.021082	-0.2890	0.7729
AGE	0.311263	0.441219	0.151423	0.7050	0.4814
AGExGEN	-0.314101	0.276086	-0.322406	-1.1380	0.2566
(Constant)	0.016318	0.709906		0.0230	0.9817

Simplified multiple correlation models were evaluated using the same (Norysis, 1992) step-down procedure described earlier. This procedure revealed a significant ($p < 0.0003$) multiple correlation between the three remaining independent variables and the *Coordination of Travel Information feature pattern*: $R = 0.353$. Table 23 summarizes the model resulting for this analysis and shows that *UNDRSTD1*, *VIDEO*, and *SYSTRUST* were significantly associated with the *Coordination of Travel Information feature pattern.*

Table 23. Coordination of travel information feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD1	-0.236610	0.069170	-0.231574	-3.421	0.0008
VIDEO	-0.318441	0.134385	-0.156680	-2.370	0.0187
SYSTRUST	0.193429	0.067610	0.192434	2.861	0.0047
(Constant)	0.489820	0.211960		2.311	0.0218

Figure 35 illustrates the relationships among these variables in the context of the other potential influences. The first two of these results shows a decreased desirability with increased general understandings of features (*UNDRSTD1*, B = -0.24) and video 2 (Orlando trip) (B = -0.32).

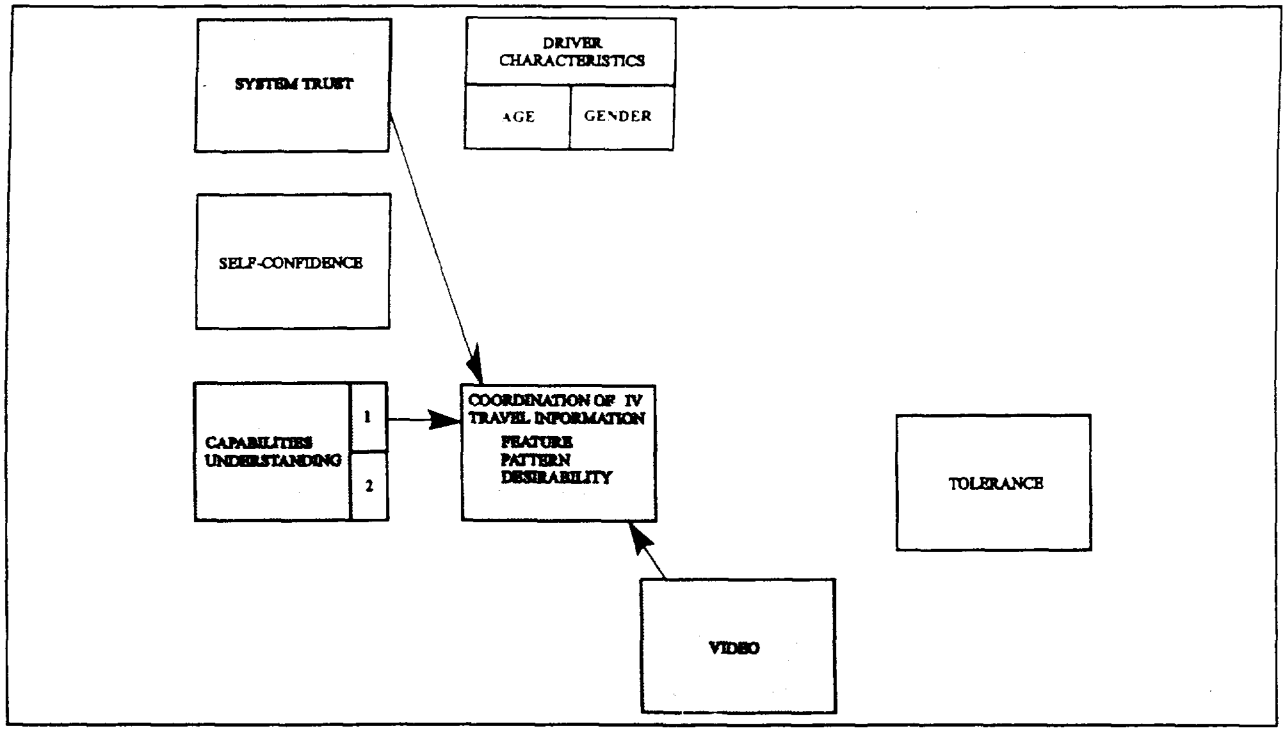


Figure 35. Coordination of travel information feature pattern desirability.

The decreased desirability after video 2 can be posited as due to undemonstrated features (associated with the *Coordination of Travel Information feature pattern*) being obscured by the features that were demonstrated. This explanation is consistent with earlier results indicating the desirability for the *Voice feature pattern* increased after the associated features were demonstrated in video 2. Of course, higher levels of *SYSTRUST* could offset the obscuring effects of the demonstrated features. Salient demonstrations of the *Coordination of Travel Information feature pattern* might increase the desirability, although this remains to be verified in later research.

Map Simplification Feature Pattern (Factor V)

Initial analysis revealed a significant ($p < 0.03$) multiple correlation among the 10 independent variables and the *Map Simplification feature pattern*: $R = 0.309$. Table 24 summarizes the model resulting from this analysis in the same terms as described above. In addition to the additive constant (Constant), model variables initially included *UNDRSTD1* and *TOLPAT1*. Others (e.g., *VIDEO*) ranged from the suggestive ($p < 0.09$) to the clearly unrelated (e.g., *GENDER* with $p > 0.8$). These results also suggested examination of simplified multiple correlation models for the *Map Simplification feature pattern*.

Table 24. Map simplification feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.047333	0.070194	0.048244	0.674	0.5009
UNDRSTD1	-0.161460	0.075659	-0.161234	-2.134	0.0341
SELFCON	-0.050552	0.077840	-0.051207	-0.649	0.5168
VIDEO	-0.242017	0.138992	-0.121497	-1.741	0.0832
GENDER	-0.078256	0.421392	-0.039275	-0.186	0.8529
TOLPAT1	0.149853	0.070443	0.150317	2.127	0.0346
SYSTRUST	0.051727	0.070997	0.052506	0.729	0.4671
TOLPAT2	-0.042100	0.075937	-0.041775	-0.554	0.5799
AGE	0.178915	0.446715	0.088806	0.401	0.6892
AGEXGEN	0.074723	0.279525	0.078257	0.267	0.7895
(Constant)	0.090783	0.718749		0.126	0.8996

Simplified multiple correlation models were evaluated using the same (Norysis, 1992) step-down procedure described earlier. This procedure revealed a significant ($p < 0.03$) multiple correlation among four remaining independent variables and the *Map Simplification feature pattern*: $R = 0.298$). Table 25 summarizes the model resulting for this analysis and shows that *UNDRSTD1*, *TOLPAT1*, and *AGE* were significantly associated with the *Map Simplification feature pattern*.

Table 25. Map simplification feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD1	-0.170038	0.071868	-0.169800	-2.366	0.0189
VIDEO	-0.233172	0.134828	-0.117056	-1.729	0.0853
TOLPAT1	0.158113	0.067614	0.158602	2.338	0.0203
AGE	0.294579	0.143322	0.146218	2.055	0.0411
(Constant)	-0.045256	0.299327		-0.151	0.8800

Figure 36 illustrates the relationships among the variables in the context of the other potential influences. These results show a decreased desirability with increased general understandings of features (*UNDRSTD1*, B = -0.17), perhaps as the advantages of a fuller spectrum of features become apparent. Simplification could have advantages for the older drivers (*AGE*) or others who would have a greater tolerance for system prediction failures (*TOLPAT1*). These results point to the importance of education to promote appreciation for a greater spectrum of features. Also, the results show the importance of the *Map Simplification feature pattern* for older and more prediction-tolerant drivers.

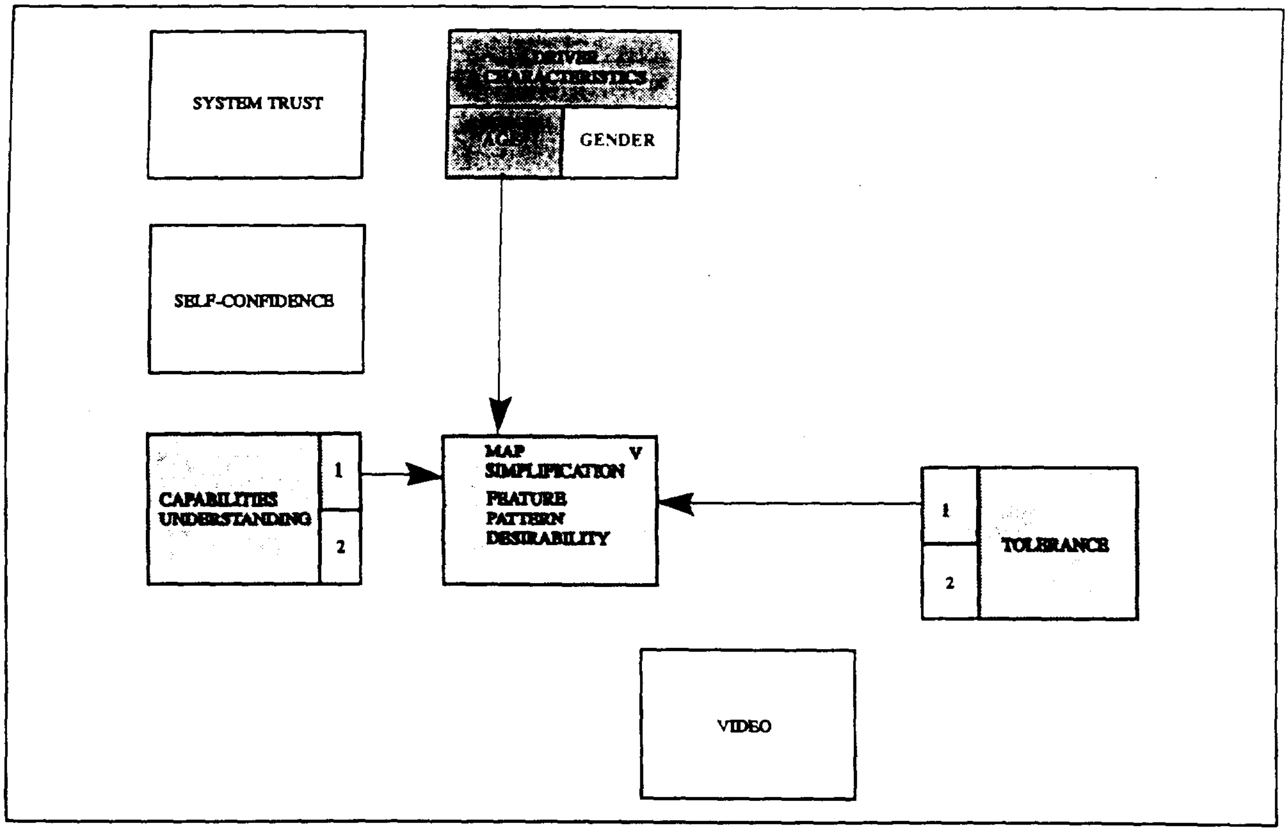


Figure 36. Map simplification pattern desirability.

Monitoring & Emergency Response Feature Pattern (Factor VI)

The initial analysis revealed a marginally nonsignificant ($p = 0.08$) multiple correlation among the 10 independent variables and the *Monitoring & Emergency Response feature pattern*: $R = 0.283$. Table 26 summarizes the model resulting from this analysis. Examining this table, it was apparent that *VIDEO* was very highly significant ($p < 0.0012$), although the overall model was not significant. This, together with the body of clearly unrelated variables (e.g., *SYSTRUST* with $p > 0.9$), suggested the examination of a simplified multiple correlation model.

Table 26. Monitoring & emergency response feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
UNDRSTD2	0.033471	0.071933	0.033570	0.465	0.6422
UNDRSTD1	0.062748	0.077533	0.061660	0.809	0.4193
SELFCON	0.031043	0.079768	0.030944	0.389	0.6976
VIDEO	-0.469942	0.142435	-0.232155	-3.299	0.0012
GENDER	0.476200	0.431833	0.235180	1.103	0.2715
TOLPAT1	-0.057703	0.072189	-0.056958	-0.799	0.4251
SYSTRUST	-0.007554	0.072756	-0.007545	-0.104	0.9174
TOLPAT2	0.044173	0.077819	0.043132	0.568	0.5709
AGE	0.334763	0.457783	0.163512	0.731	0.4655
AGEXGEN	-0.195960	0.286451	-0.201953	-0.684	0.4947
(Constant)	-0.071405	0.736558		-0.097	0.9229

Simplified multiple correlation models were evaluated using the step-down procedure described earlier (Norysis, 1992). This procedure revealed a significant ($p < 0.0003$) multiple correlation between *VIDEO* and the *Monitoring & Emergency Response feature pattern*: $R = 0.248$. Table 27 summarizes the model resulting for this analysis and shows that *VIDEO* is negatively associated (B = -0.50) with the *Monitoring & Emergency Response feature pattern*, indicating a decreased desirability after video 2.

Table 27. Monitoring & emergency response feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
VIDEO	-0.502405	0.136957	-0.248192	-3.668	0.0003
(Constant)	0.747015	0.216234		3.455	0.0007

Figure 37 illustrates the relationships between the variables in the context of the other potential influences. This decreased desirability can be posited as due to undemonstrated features (associated with the *Monitoring & Emergency Response feature pattern*) being obscured by the demonstrated features. Subsequently, the *Monitoring & Emergency Response feature pattern* desirability might be increased by salient demonstrations (as suggested earlier for the *Coordination of Travel Information feature pattern*).

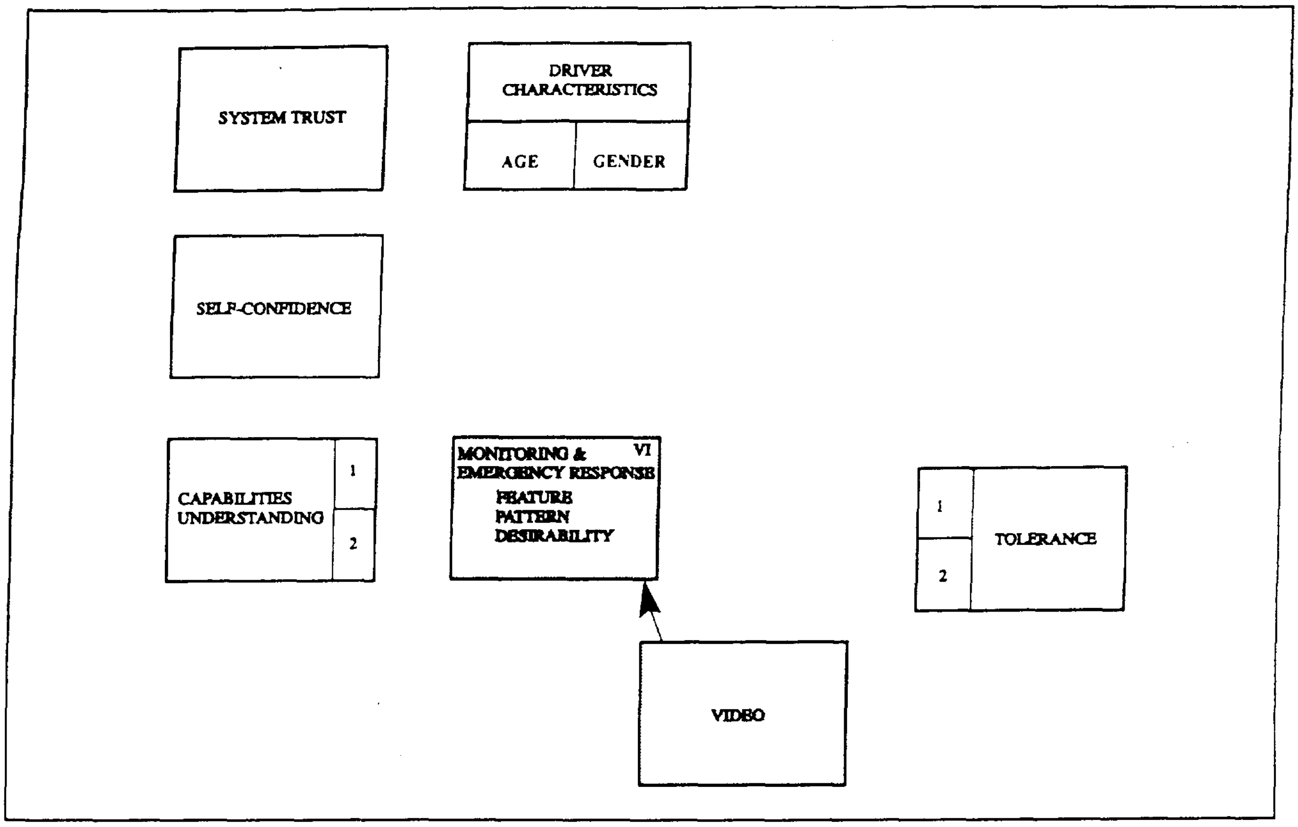


Figure 37. Monitoring & emergency response feature pattern desirability.

Fidelity and Attention

The relationships among *FIDELITY, ATTENT, CAPABILITIES UNDERSTANDING, SELFCON* and *SYSTRUST* were not directly considered in the section that describes the Relationships of Feature Patterns with Specified Variables. This was, as may be recalled, because these variables were posited as only influencing the results through other variables. Therefore, only the direct relationships required analysis. Table 14 showed correlations among these variables. Of the five relationships predicted in figure 9, only the following three relationships were significant: 1) *FIDELITY* and *ATTENT* ($r = 0.535$, $p < 0.001$), 2) *FIDELITY* and *SYSTRUST* ($r = 0.396$, $p < 0.001$), and 3) *FIDELITY* and *SELFCON* ($r = 0.151$, $p < 0.01$). Figure 38 illustrates these relationships. Contrary to links hypothesized in figure 9, *FIDELITY* and *ATTENT* do not drive *CAPABILITIES UNDERSTANDING*.

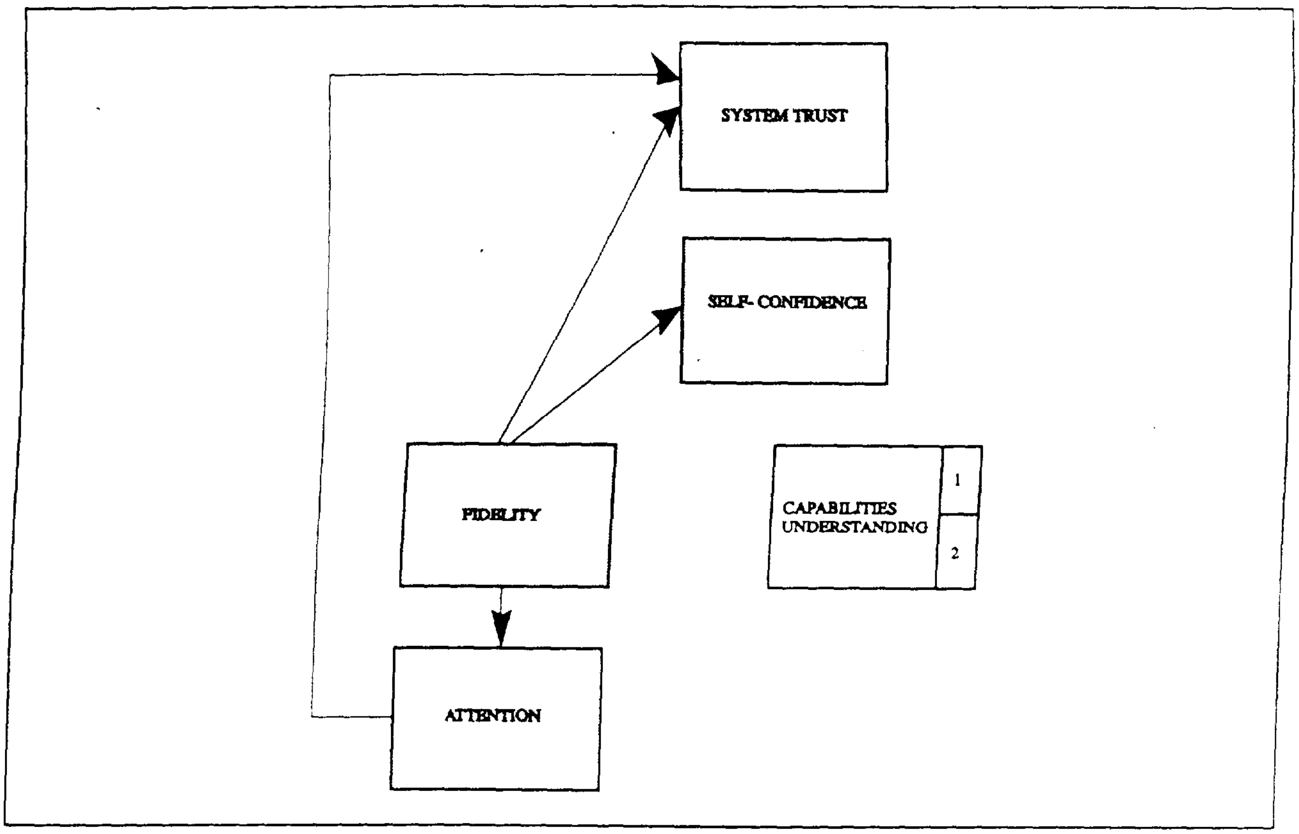


Figure 38. Indirect relationships of feature patterns.

EXPERIMENT 1B RESULTS

Examined in the analyses were 1 objective rating dependent variable and 93 subjective rating dependent variables. The objective dependent variable was the percent correct score for the CityGuide system capabilities items (appendix B, p. 213). This score indicated the drivers' understanding of the CityGuide system. The 93 subjective rating variables were factor analyzed as related groups of questionnaire items and used to create 8 composite variables.

The analyses was conducted in three phases using the SPSS/PC+, version 5.0, software package. In the first phase, descriptive statistics and ANOVA's were calculated for items (appendix B, p. 236) that paralleled the *TravTek User Test Questions* reported in experiment 1. In the next phase, an ANOVA was used to examine the relationships between *AGE, GENDER*, and *DRIVER TYPE*, and the total percent correct score for the CityGuide system capabilities items. In the third phase of the analyses, three parts aimed at identifying the relationships among the variables shown in figure 39. Results from each phase of the analyses are described below. ANOVA tables are presented in appendix C (pp. 261-268).

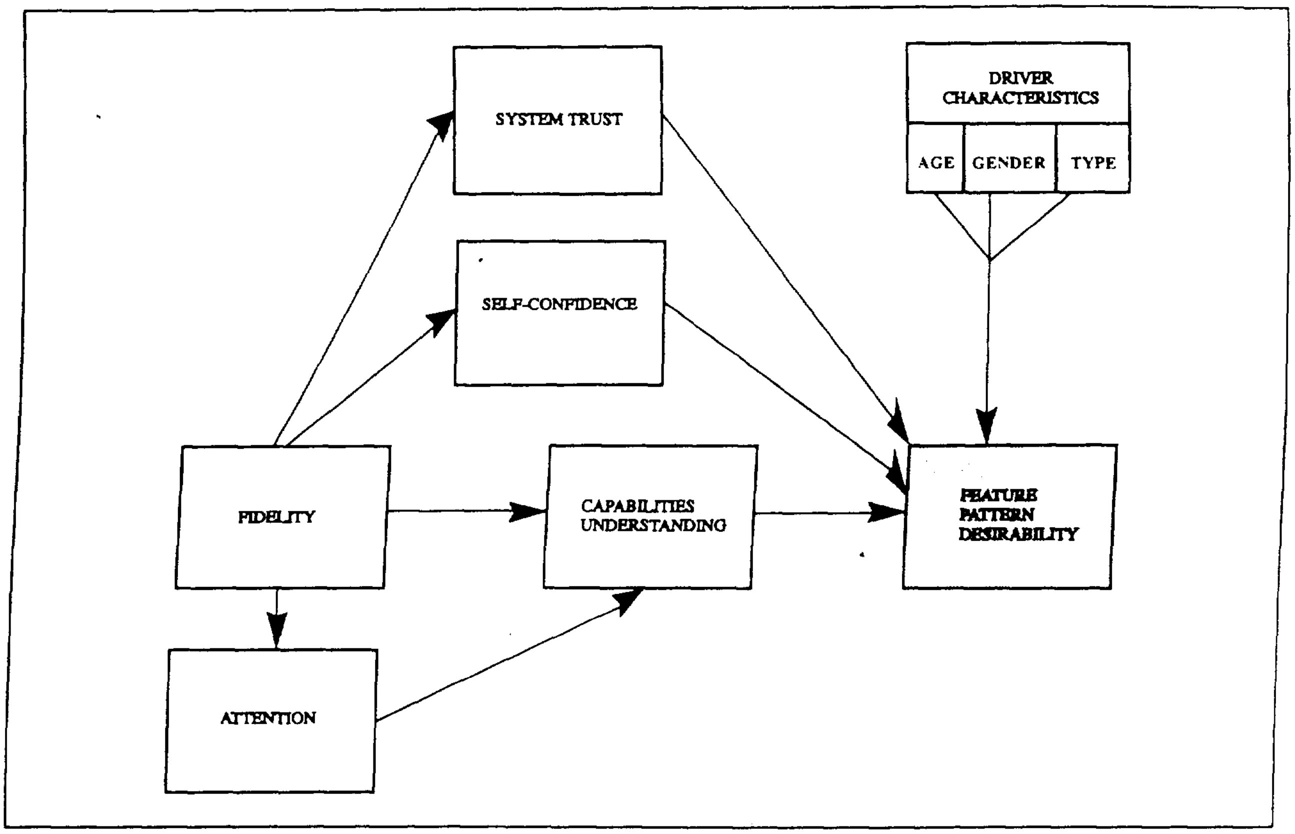


Figure 39. Relationships among composite variables.

Phase 1. CityGuide System User Test Questions - Descriptive Statistics

In the first phase of the analyses, a subset of questionnaire items that paralleled the *TravTek User Test Questions* was analyzed with descriptive statistics and ANOVA for *AGE* (younger = 18-54 years, older = 55-85 years), *GENDER* (male, female) and *DRIVER TYPE* (private, commercial). *DRIVER TYPE* was a covariate in the analyses rather than a separate factor since all commercial drivers were younger and male. The CityGuide system questionnaire items are listed in table 28 and are shown in appendix B under the heading *CityGuide User Test Questions* (p. 236). The items are related to information presentation formats (i.e. map display, text instructions) and overall ease of use and learning. Relevant means for these items are shown in figure 40 through figure 49 as a function of *AGE*. Then a repeated-measures analysis was performed for each of these items.

Table 28. CityGuide system user test questions.

TEST QUESTIONS	
CityGuide system's map display was easy to learn.	CGTEST1A
CityGuide system's map display was easy to use.	CGTEST1B
CityGuide system's map display was useful.	CGTEST1C
CityGuide system's text instructions were easy to learn.	CGTEST2A
CityGuide system's text instructions were easy to use.	CGTEST2B
CityGuide system's text instructions were useful.	CGTEST2C
Of the two routing options, map display, and text instructions, which do you prefer?	CGTEST3
Overall, CityGuide system was easy to learn.	CGTEST4A
Overall, CityGuide system was easy to use.	CGTEST4B
Overall, CityGuide system was useful.	CGTEST4C

Figure 40 (CGTEST1A) shows mean ratings for the CityGuide system's map display ease of learning as a function of *AGE*. Error bars in this and subsequent figures indicate standard deviations. The ANOVA resulted in a significant main effect for *AGE*, $F(1,122) = 9.09$, $p < 0.003$. Younger drivers' ratings (mean = 4.4) indicate that they thought the map display was easier to learn than older drivers (mean = 3.9).

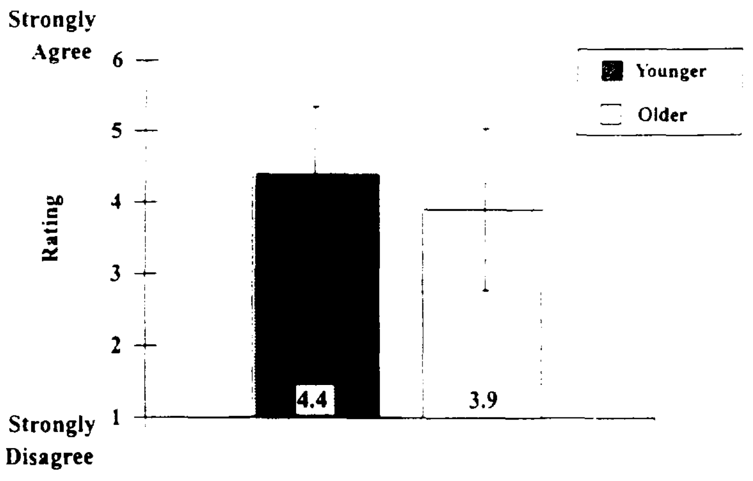


Figure 40. CityGuide system's map display was easy to learn. (CGTEST1A)

Figure 41 (CGTEST1B) shows mean ratings for the CityGuide system's map display ease of use as a function of *AGE*. A significant main effect occurred for *AGE*, $F(1,120) = 10.9$, $p < 0.001$.

Younger drivers' ratings (mean = 4.4) indicated that they thought the map display was easier to use than older drivers (mean = 3.8).

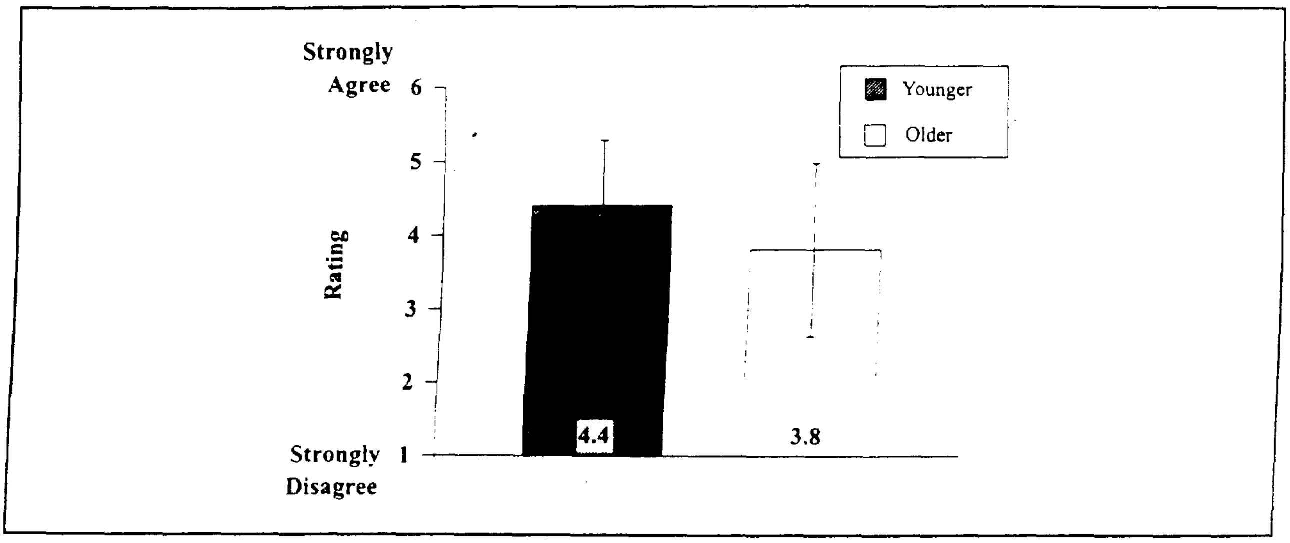


Figure 41. CityGuide system's map display was easy to use. (CGTEST1B)

Figure 42 (CGTEST1C) shows mean ratings for the CityGuide system's map display usefulness as a function of *AGE*. A significant main effect occurred for *AGE*, $F(1,121) = 11.4$, $p < 0.001$. Younger drivers' ratings (mean = 4.6) indicate that they thought the map display was more useful than older drivers (mean = 4.0).

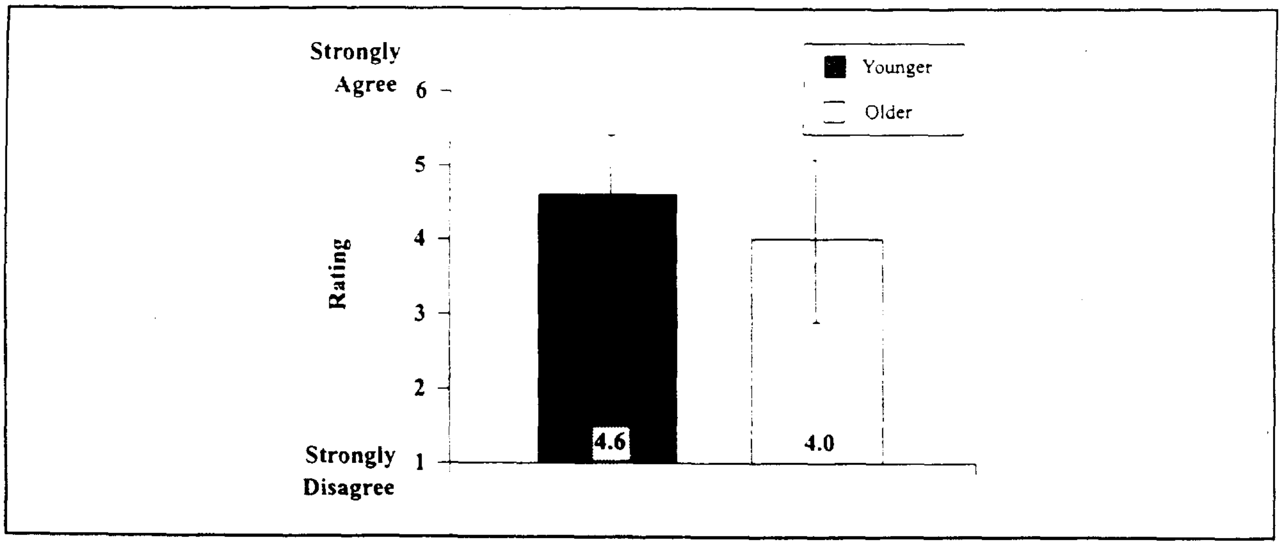


Figure 42. CityGuide system's map display was useful. (CGTEST1C)

Figure 43 (CGTEST2A) shows mean ratings for the CityGuide system's text instructions ease of learning as a function of *AGE*. A significant main effect occurred for *AGE*, $F(1,120) = 27.3$, $p < 0.001$. Younger drivers' ratings (mean = 4.4) indicated that they thought the text instructions were easier to learn than older drivers (mean = 3.4).

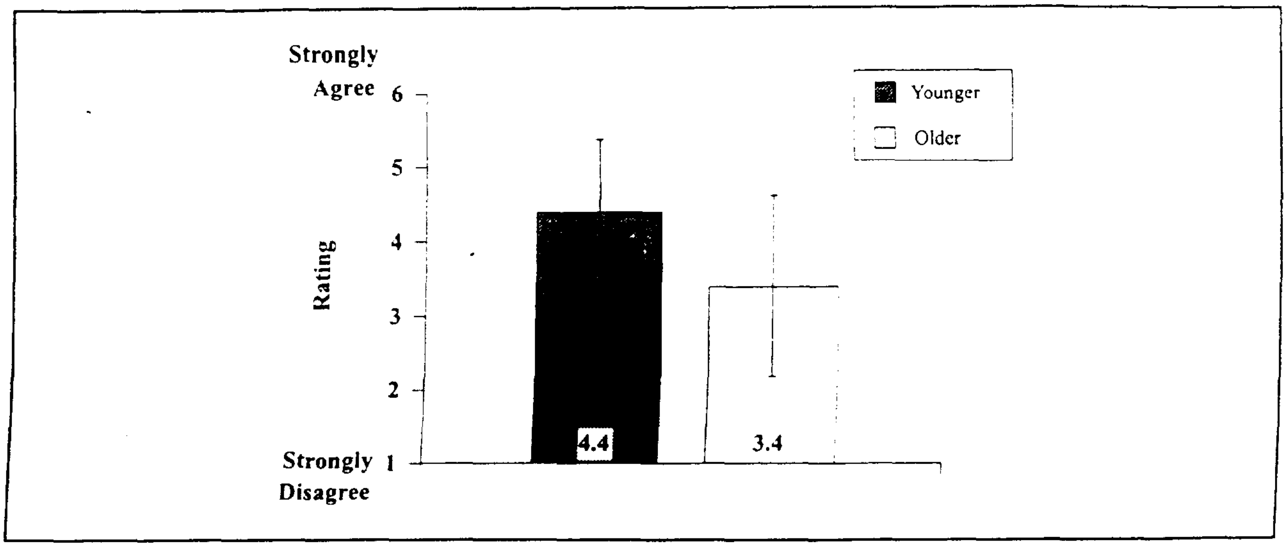


Figure 43. CityGuide system's text instructions were easy to learn. (CGTEST2A)

Figure 44 (CGTEST2B) shows mean ratings for the CityGuide system's text instructions ease of use. A significant main effect occurred for *AGE*, $F(1,118) = 21.4$, $p < 0.001$. Younger drivers' ratings (mean = 4.3) indicate that they thought the text instructions were easier to use than older drivers (mean = 3.4).

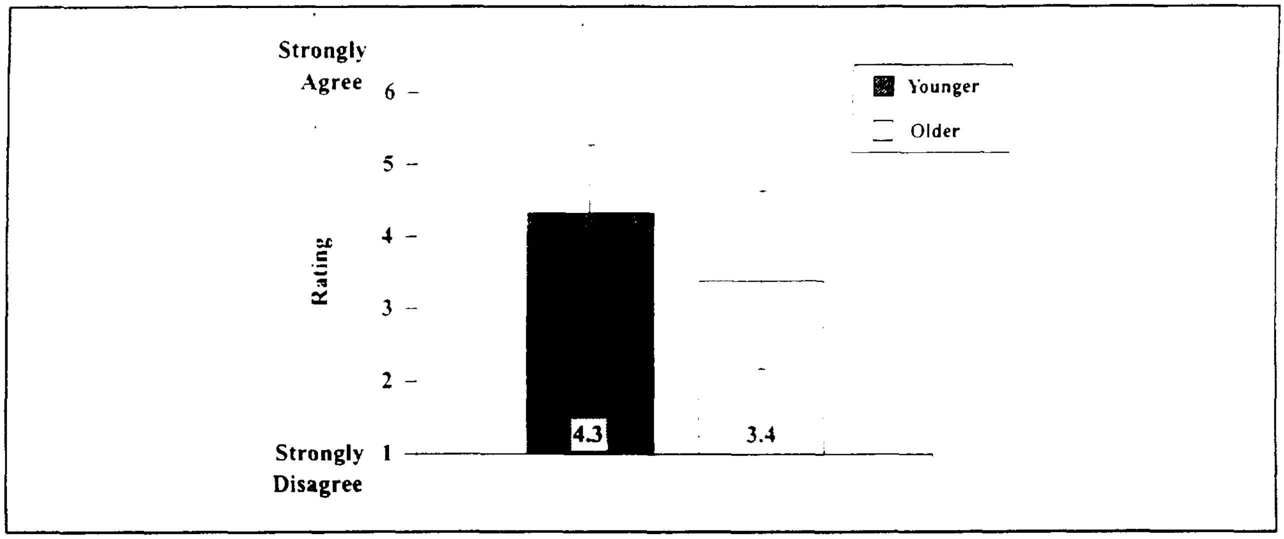


Figure 44. CityGuide system's text instructions were easy to use. (CGTEST2B)

Figure 45 (CGTEST2C) shows mean ratings the CityGuide system's text instructions usefulness as a function of *AGE*. A significant main effect occurred for *AGE*, $F(1,120) = 23.8$, $p < 0.001$. Younger drivers' ratings (mean = 4.6) indicated that they thought the text instructions were more useful than older drivers (mean = 3.6).

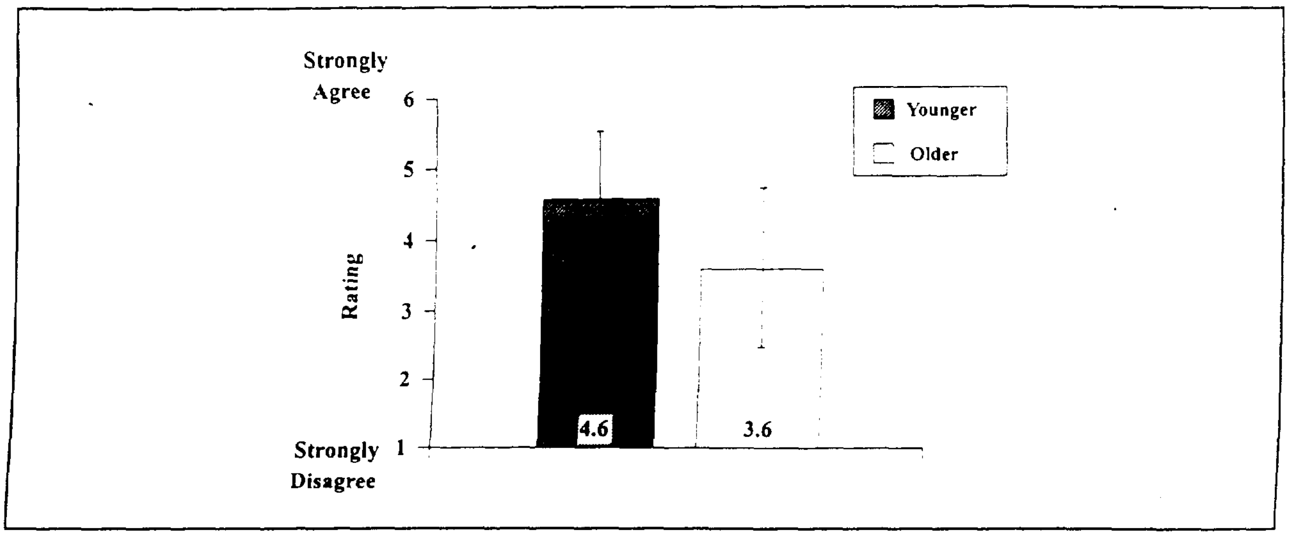


Figure 45. CityGuide system's text instructions were useful. (CGTEST2C)

Figure 46 (CGTEST3) shows mean ratings for display preference. Younger drivers' mean rating was 2.6, while older drivers mean rating was 3.0.

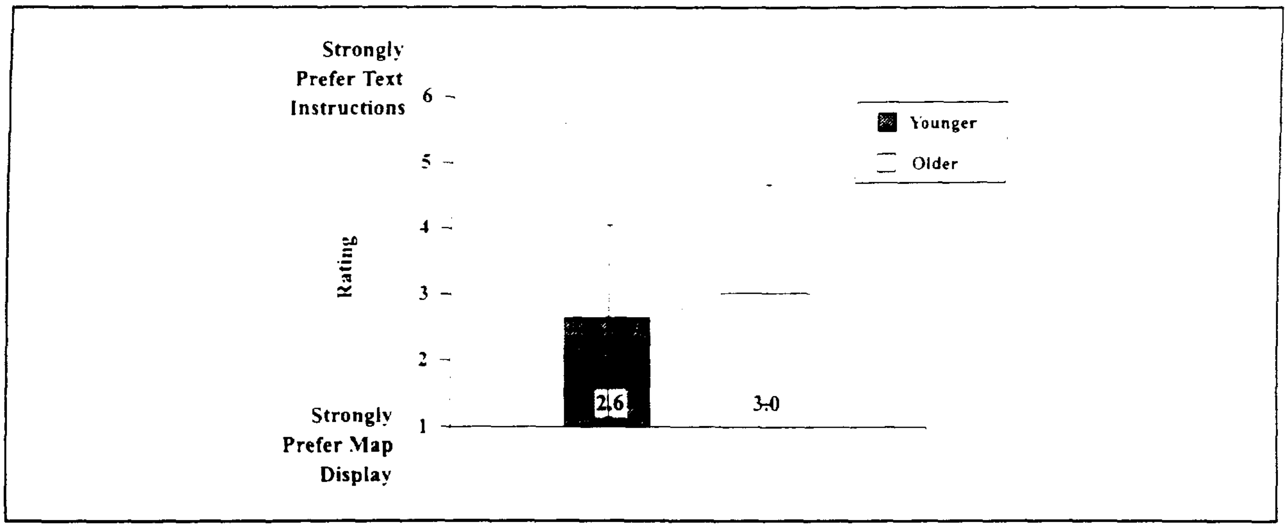


Figure 46. Of the two routing options, map display, and text instructions, which do you prefer? (CGTEST3)

Figure 47 (CGTEST4A) shows mean ratings the CityGuide system's overall ease of learning. A significant main effect occurred for the covariate, *DRIVER TYPE*, $F(1,118) = 4.53$, $p < 0.035$. Commercial drivers, all younger and male, rated the ease of learning (mean = 3.7) the same as the older, private male drivers (mean = 3.7). Commercial drivers' mean rating was less than that of private male drivers in the same age group. Overall, there was a significant main effect for *AGE*, $F(1,118) = 11.4$, $p < 0.001$. Younger drivers' ratings (mean = 4.3) indicate that they thought the CityGuide system was easier to learn than older drivers (mean = 3.8).

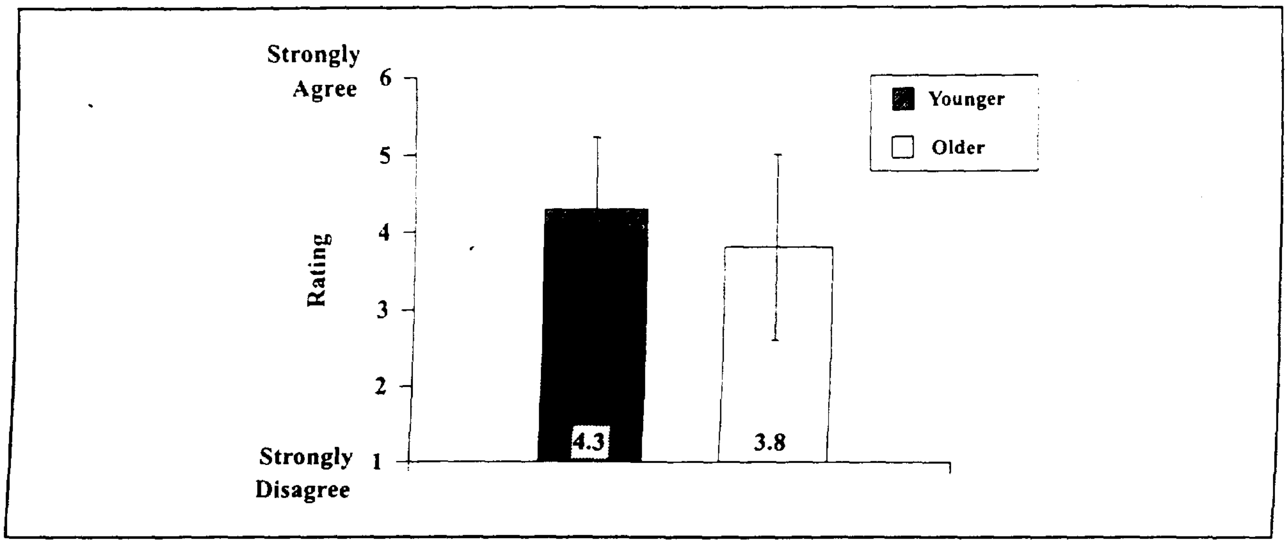


Figure 47. Overall, CityGuide system was easy to learn. (CGTEST4A)

Figure 48 (CGTEST4B) shows mean ratings for the CityGuide system's overall ease of use. A significant main effect occurred for *AGE* $F(1,116) = 11.2, p < 0.001$. Younger drivers' ratings for ease of use (mean = 4.4) were higher than older drivers' ratings (mean = 3.9).

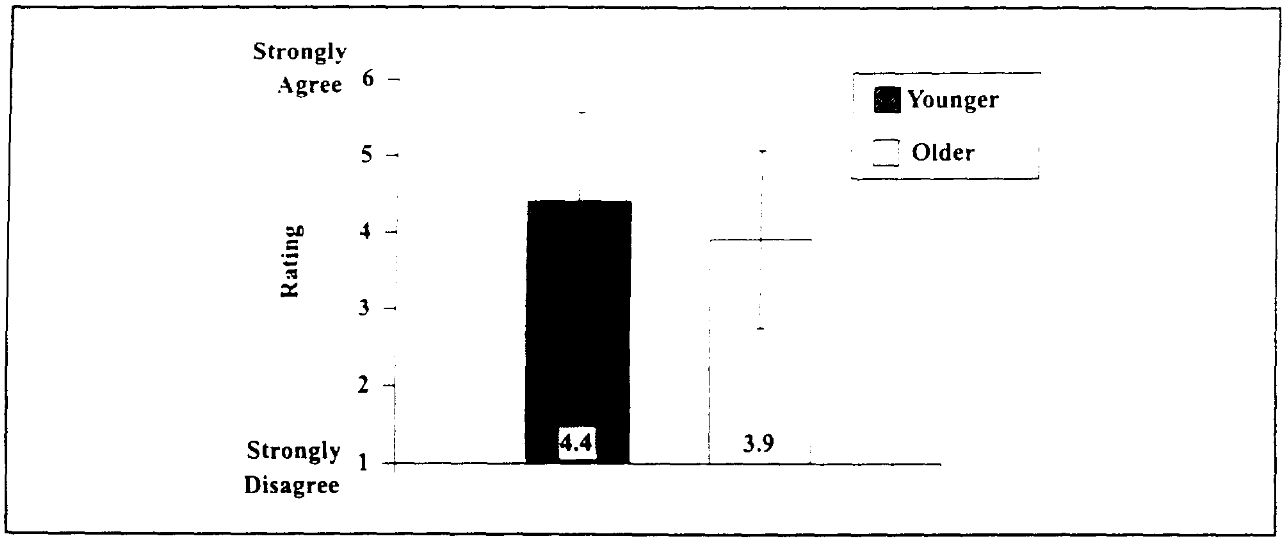


Figure 48. Overall, CityGuide system was easy to use. (CGTEST4B)

Figure 49 (CGTEST4C) shows mean ratings for the CityGuide system's overall usefulness. Younger drivers' mean ratings were 4.3 while older drivers' mean ratings were 4.1.

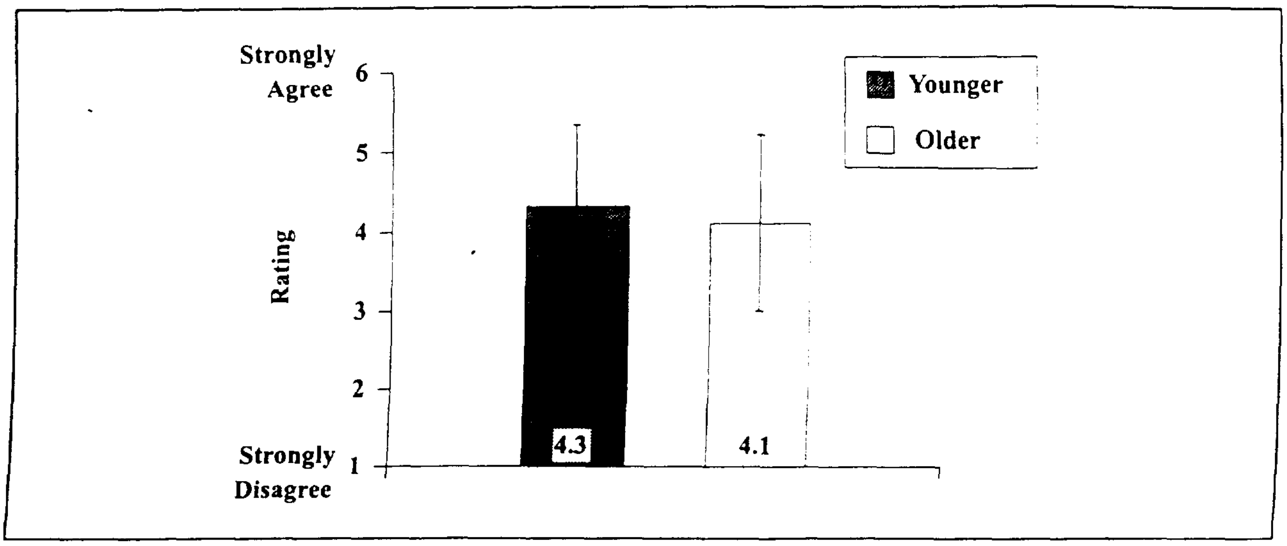


Figure 49. Overall, CityGuide system was useful. (CGTEST4C)

Phase 2. Age, Gender, Driver Type, and Mean Percent Correct Scores on the CityGuide System User Test

The second phase of the analyses examined *AGE*, *GENDER*, and *DRIVER TYPE* relationships for the overall percent correct score for the CityGuide system capabilities items. An ANOVA indicated that a significant main effect occurred for *AGE*, $F(1,123) = 30.1$, $p < 0.001$. Figure 50 shows that younger drivers had a higher mean percent correct score (mean = 77.6 percent) than older drivers (mean = 69.6 percent).

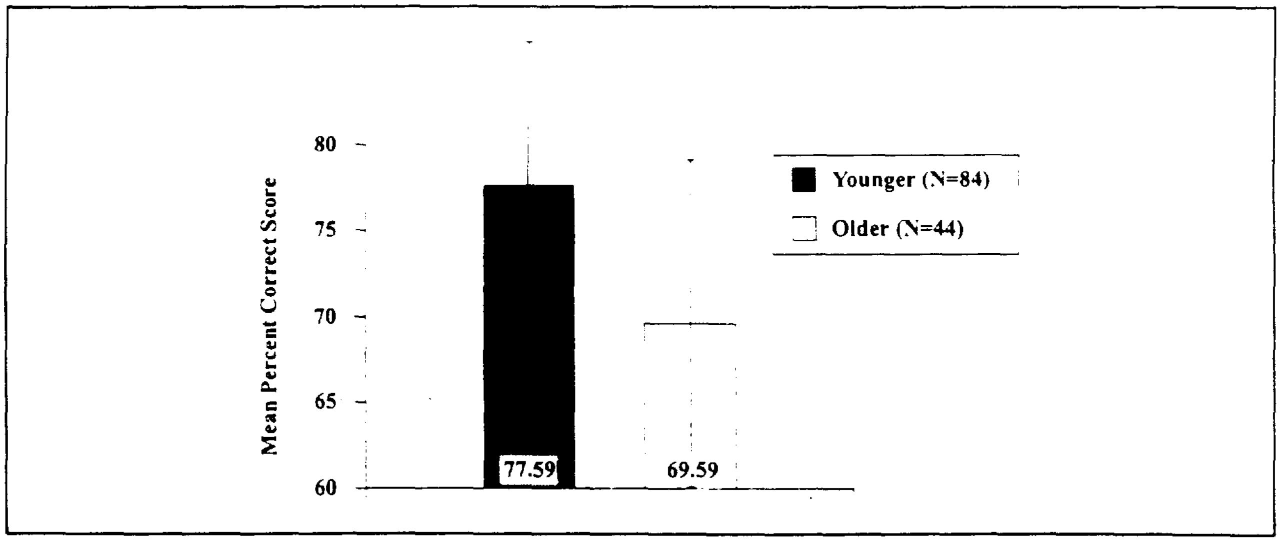


Figure 50. Mean percent correct scores for CityGuide system's capabilities.

Phase 3. Identifying Relationships Among Variables

As with the results of experiment 1, the last phase of the analyses was conducted in three steps aimed at identifying relationships among the variables shown in figure 39. During the first step, the feature patterns were determined via a factor analysis of driver responses on the *CityGuide System Features Desirability* questionnaire. Mean values and other descriptive results for individual features were also developed. During the second step, composite variables were developed from the individual questionnaire items. The first-order relationships among these composite variables were then explored correlationally. The results of this second step supported the regression-analysis evaluation of the relationships among the individual desired feature patterns and other variables during the third phase. The third step resulted in an understanding of the connection between the feature patterns, demographic variables (*AGE*, *GENDER*, and *DRIVER TYPE*), and the derived composite variables (i.e. *system trust, self-confidence*, etc.). Results of the three steps of the analyses are described below.

Feature Patterns

The feature patterns were derived and verified from the results of the respective factor analyses of 34 unfamiliar and 34 familiar-city responses on the *CityGuide System Feature Desirability* questionnaire (appendix B, p. 216). Three items were dropped from the analyses as they were added to the survey after the first 20 subjects. The primary focus was on the unfamiliar-city features because of expectations that drivers would require the most comprehensive sets of features in unfamiliar cities (and unfamiliar portions of familiar cities). The derivation and verification processes are described in the following subsections.

<u>Deriving the Feature Patterns</u>

As a first step in the analyses to derive the feature patterns, the mean values for the CityGuide system feature desirability items were calculated. Features with mean desirability ratings greater than or equal to 1.5 made up the most desired features category. Table 29 lists these 27 features.

Table 29. CityGuide system most desired features.

UNFAMILIAR CITY	CITYGUIDE SYSTEM FEATURE DESIRABILITY	ITEM NO.
1.7	Position/location shown on an electronic map: hotels	1
1.7	Map: restaurants	2
1.7	Map: landmark/tourist attractions	3
1.6	Map: theaters/shows/movies	4
1.6	Map: museums	7
1.6	Map: parks	8
1.7	Map: specific address	9
1.8	Text information about: hotels	10
1.7	Text information about: restaurants	11
1.6	Text information about: landmark/tourist attractions	12
1.5	Text information about: theaters/shows/movies	14
1.5	Text information about: museums	17
1.5	Route distance based on: using fewest roads possible	20
1.7	Route distance based on: shortest route distance	21
1.7	Route guidance: outlined on an electronic map on the computer screen	22
1.6	Route guidance: map printed on a piece of paper (for use in car)	23
1.6	Route guidance: written directions displayed on the computer screen	24
1.5	Route guidance: written direction printed on a piece of paper (for use in car)	25
1.8	General travel information: identification of places represented on the map	27
1.6	General travel information: information about prices	28
1.5	Parking information: locations shown on map display	31
1.6	Other routing information: calculates route to avoid congestion	33
1.5	Other routing information: calculates mileage, time, and cost estimates	34
1.6	Other routing information: route selection preference for main highways or local access roads	35
1.6	Other routing information: multi-destination trip planning function	36
1.6	Other routing information: one-way streets shown on the electronic map	37
1.5	Other routing information: notification of road closures or detours	38

NOTE: All of the most desired CityGuide system feature patterns are for unfamiliar-city applications.

Features with mean desirability ratings less than or equal to 0.5 made up the least desired features category. Table 30 lists these six features. To summarize, the most desired features were *position of interest spots, text information* about these "interest spots", *route distance* and *route guidance* alternatives, and general and other travel/routing information. All of the most desired features were for unfamiliar-city applications. The majority of least desired features related to *text information about shops, coordination of travel with airlines*, and *text information about parking.*

Table 30. CityGuide system least desired features.

FAMILIAR CITY	CITYGUIDE SYSTEM FEATURE DESIRABILITY	ITEM NO.
0.9	Position/location shown on an electronic map: shops.	6
0.8	Text information about: shops.	16
0.9	Text information about: parks.	18
0.8	General travel information: coordination of travel with airlines.	29
0.6	General travel information: restaurant reservations made by the system.	30
0.8	Parking information: text descriptions.	32

NOTES: All of the least desired features are for familiar city applications.
No CityGuide system feature patterns had a desirability rating of less than 0.5.

These results do not explain why certain feature patterns are more or less desirable. More specifically, they do not reveal how variables such as driver characteristics, attitudes, and understanding influence feature pattern desirability. This factor analysis method was used to first identify feature patterns and then identify variables that influence these feature patterns.

This factor analysis approach reduced the numbers of individual analyses from the total number of feature patterns (34 for unfamiliar-city driving and 34 for familiar-city driving) to a more manageable number of feature patterns (four for unfamiliar-city driving). Reducing the number of analyses avoided a large experiment-wide error rate and provided a more parsimonious model for driver acceptance. Moreover, it was expected that these feature patterns would represent integrated functional groupings that drivers would expect in the actual final ATIS design.

Table 31 summarizes the method for determining the feature patterns from the unfamiliar-city responses following an approach, as was the case in experiment 1, featuring a Scree-test cutoff (Harmon, 1976) that typically is more parsimonious than a unity eigenvalue cutoff (hence, the minimum eigenvalue was 1.7 in the present case). Additionally, the Varimax procedure was used to orthogonally rotate the resulting factors to facilitate their interpretation (cf., Harmon, 1976).

Table 31. Method for determination of feature patterns.

STEPS USED TO DETERMINE FEATURE PATTERNS
Principal factor analysis (PFA) was performed using the SPSS/PC+ software package.
Data were 34 unfamiliar-city feature desirability variables from the CityGuide system feature desirability section of the CityGuide system questionnaire.
A total of 128 drivers provided responses (107 private drivers, 21 commercial drivers).
A Scree-test cutoff, with a minimum 1.7 eigenvalue, resulted in four factors.
Varimax rotation was applied to the four factors.

The results of the principal factor analysis were four feature patterns summarized in table 32. It can be seen that two of the feature patterns, *Recreational Information* and *Accommodations Related Information* (Feature Patterns I and III) were respectively defined by recreational and accommodation-related information feature patterns. In contrast, the other two feature patterns, *Routing Assistance* (Feature Pattern II) and *Restaurants and Other Coordination* (Feature Pattern IV) were more assistance-coordination oriented.

Table 32. Desired feature patterns.

FEATURE	NAME	DESCRIPTION
I	*Recreational Information*	Text and map information for parks (.87 and .69), museums (.81 and .64) and six other recreational related items.
II	*Routing Assistance*	Main highway/local access route selection preference (.72), multi-destination (stops) trip planning (.68), and 12 other routing related features.
III	*Accommodation Related Information*	Map and text information for hotels (.84 and .60), restaurants (.82 and .62), and five other related attraction information items (re: theaters, land-marks, etc.).
IV	*Restaurant and Other Coordination*	Restaurant reservations by system (.80), coordination of travel with airlines (.65), parking text description (.62) and map location (.62), and four other related items.

Verifying the Feature Patterns

The derived feature patterns were "verified" for the familiar-city responses by comparison of unfamiliar- and familiar-city feature pattern scores. The results of the familiar-city responses were first factor analyzed following the unfamiliar-city approach described in table 31. The familiar-city factor analysis revealed four factors that appeared to be largely consistent with those summarized in table 32.

To more conservatively evaluate this consistency, the separate feature pattern scores of unfamiliar- and familiar-city results were cross-correlated. Table 33 summarizes the results of the cross-correlation of the respective sets of four unfamiliar- and familiar-city factor scores. The dominant weights in each row and column indicate that the unfamiliar-city feature pattern scores generally had substantial overlap with those for the familiar-city. More specifically, the table shows that the familiar-city feature patterns, *Recreational Information, Routing Assistance, Accommodation Related Information* and *Restaurant and Other Coordination*, were most identified by respective unfamiliar-city feature patterns *Routing Assistance, Recreational Information, Accommodation Related Information*, and *Restaurant and Other Coordination* (respective correlations of 0.59, 0.53, 0.52, and 0.63). For example, some elements of the unfamiliar-city Feature Pattern III, *Accommodation Related Information*, are associated with the familiar-city Feature Pattern I, *Recreational Information*. Likewise, somewhat de-emphasized (-0.30) in familiar-city Feature Pattern III, *Accommodation Related Information*, are some elements of unfamiliar-city Feature Pattern IV, *Restaurant and Other Coordination*, e.g., Yellow Pages. The results show that the unfamiliar-city feature patterns are generally verified by the familiar-city results, with differences representing relatively minor fine tunings.

Table 33. Cross-correlations between unfamiliar-city and familiar-city factor scores of the feature patterns.

	UNFAMILIAR CITY FACTORS			
FAMILIAR CITY FACTORS	RECREATIONAL INFORMATION	ROUTING ASSISTANCE	ACCOMMODATION RELATED INFORMATION	RESTAURANT AND OTHER COORDINATION
RECREATIONAL INFORMATION	0.064	0.592**	0.276*	0.017
ROUTING ASSISTANCE	0.528**	0.060	-0.002	-0.054
ACCOMMODATION RELATED INFORMATION	0.033	-0.019	0.519**	-0.297**
RESTAURANT AND OTHER COORDINATION	0.117	0.059	0.168	0.627**

* $p < 0.01$ and ** $p < 0.001$ 2-tailed significance.

Composite Variable Evaluations

Composite variables were evaluated in two stages. First, using factor analytic methods, composite variables were derived from the four sets of relevant questionnaire responses:

- *Fidelity* (appendix B, pp. 219-220, items 1, 3, 6, 7)
- *Attention* (appendix B, pp. 219-220, items 2, 4, 5, 8, 9)
- *System trust* (appendix B, pp. 221-224, items 1a-8a)
- *Self-confidence* (appendix B, pp. 221-224, items 1b-8b)

Due to less clearly defined system components than the TravTek system, the overall percent correct score for the CityGuide system capabilities items was used rather than factor scores on correct percent scores for system components. *Tolerance pattern* items were not asked during this study because they were not addressed by the CityGuide system functions. Second, the first-order relationships among the derived feature pattern variables were then explored in terms of the model shown in figure 39. The factor analyses and correlations are described in the following subsections.

Derivation of the Composite Variables

Table-34 summarizes the common method used for deriving the composite variable factors. This method is analogous to that employed earlier to derive the feature patterns.

Table 34. Method for determination of composite variables.

STEPS USED TO DETERMINE COMPOSITE VARIABLES
Principal factor analysis (PFA) was performed using the SPSS/PC+ software package.
Data were 25 variables (e.g., *fidelity, attention*, etc., items as appropriate).
A total of 128 drivers provided responses (107 private vehicle drivers and 21 commercial vehicle operators).
Numbers of factors were identified by numbers determined in experiment 1 (the TravTek study), if more than one *eigenvalue* was greater than 1.0, for comparability.
If more than one factor occurred, Varimax rotation was used.

Results of applying this method to each of the four sets of composite variables are summarized in the following:

- *Fidelity*—The PFA of the five fidelity questionnaire items resulted in a single factor variable with an eigenvalue greater than unity (i.e. 3.32) that explained 66.5 percent of the total variation. This composite variable was termed "*FIDELTYC*".
- *Attention*—The PFA of the four attention questionnaire items resulted in a single factor variable (2.28 eigenvalue) that explained 57.0 percent of the total variation. This composite variable was termed "*ATTENTC*".
- *System Trust*—The PFA of the eight system trust questionnaire items resulted in a single factor variable (3.1 eigenvalue) that explained 38.9 percent of the total item variation. This composite variables was termed "*SYSTRUSTC*".
- *Self-Confidence*—The PFA of the eight self-confidence questionnaire items resulted in a single factor variable (4.25 eigenvalue) that explained 53.2 percent of the total variation. These composite variables were termed "*SELFCONC*".
- *Capabilities Understanding*—The overall percent correct score was used rather than factor scores on correct percent scores for system components. This variable was given the short title "*UNDRSTDC*".

These PFA results were generally consistent with the earlier analyses conducted in experiment 1. Specifically, the correlations of items with their respective subjective variables (*FIDELITYC, SYSTRUSTC*) were nearly identical with those seen earlier in experiment 1. This consistency supported the evaluation of the first-order correlations between the various composite variables and multivariate evaluations of their relationships with the desired feature patterns.

Composite Variable First-Order Relationships

Table-35 summarizes the first-order correlations among the factor scores for the feature patterns computed for the four composite variables and the *capabilities understanding* variable, percent correct score (*UNDRSTDC*). Examining the correlations between the variables, it is apparent that they are generally consistent with those observed earlier during the evaluations of the TravTek system. For example, it may be seen that the two largest positive correlations are again between the respective *FIDELITYC* and *ATTENTC* (r = .65 vs. 0.54 seen earlier in experiment 1) and the *FIDELITYC* and *SYSTRUSTC* variables (r = 0.40 matching what was seen earlier). These composite variables will be seen to play important roles in predicting the CityGuide system feature patterns seen in the next section.

Table 35. Composite variable correlations.

VARIABLE	FIDELITYC[1]	ATTENTC[1]	SYSTRUSTC[1]	SELFCONC[1]	UNDRSTDC[1]
FIDELITYC	1.0000	0.6548**	0.3972**	0.0950	0.0977
ATTENTC	0.6548**	1.0000	0.2383*	0.0110	0.0332
SYSTRUSTC	0.3972**	0.2383*	1.0000	0.0716	-0.0782
SELFCONC	0.0950	0.0110	0.0716	1.0000	0.1410
UNDRSTDC	0.0977	0.0332	-0.0782	0.1410	1.0000

[1] NOTE: The suffix "C" distinguishes variables in the CityGuide experiment from similar variables in the TravTek experiment.

* $p < 0.01$ and ** $p < 0.001$ 2-tailed significance.

Relationships of Feature Patterns with Specified Variables

The third step was directed at the overall relationships among each of the four feature patterns and the selected variables shown in figure 39. Hence, four multiple correlation analyses were conducted that evaluated the joint relationships of each of the feature patterns scores with the following:

- Demographic variables (*AGE*, *GENDER*, their interaction *AGE X GEN*, and *DRIVER TYPE*, commercial vs. private).
- *Capabilities understanding* variable (*UNDRSTDC*).
- *System trust* variable (*SYSTRUSTC*).
- *Self-confidence* variable (*SELFCONC*).

First, an initial multiple correlation was performed to identify relationships among the feature pattern's scores and all of the previously listed variables. Each of these initial analyses will be shown in a table. Then, the initial multiple correlation models were evaluated using a step-down procedure. Each of these final correlation models will also be shown in a table. A description of the table headings is given below:

- VARIABLE = the variable name.

- "B" = the raw weight of the variable in the model.
- "SE B" = its standard error.
- "BETA" = the standard score model weight.
- "T" = the t-test value for the term (T).
- "SIG T" = the significance (p) value.

"B" is the raw weight of the variable in the regression equation:

$$y_i = \text{constant(additive)} + \Sigma_j B_j x_{ji}$$

where Y_i is the driver's score on a variable, B_j is the jth variable's "B" weight, and X_{ji} is the ith driver's score on variable j.

Results for the four feature patterns are presented below in the order of their earlier numbering (i.e., Factors I to IV).

Recreational Information Feature Pattern (Factor I)

The initial analysis revealed a highly significant ($p < 0.003$) multiple correlation between the seven independent variables and the *Recreational Information feature pattern*: $R = 0.409$. Table 36 summarizes the model resulting from this analysis in terms of the raw weight of a term in the model (B); its standard error (SE B); the standard score model weight (BETA), the t-test value for the term (T); and its associated significance (p) value (SIG T). It is apparent that only one variable is initially significant ($p < 0.003$): *type* (commercial drivers were -0.84 below private). Others are clearly unrelated to the model (e.g., *AGE* with $p > 0.9$). These results suggested examination of simplified multiple correlation models that might better reveal the relationships with the *Recreational Information feature pattern.*

Table 36. Recreational information feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
FIDELITYC	0.125144	0.089412	0.126353	1.400	0.1643
SYSTRUSTC	0.076432	0.085991	0.077070	0.889	0.3759
TYPE	-0.835854	0.268636	-0.313755	-3.111	0.0023
UNDRSTDC	0.015154	0.009958	0.145385	1.522	0.1307
GENDER	0.245263	0.565558	0.119766	0.434	0.6653
AGE	0.063449	0.601116	0.030425	0.106	0.9161
AGExGEN	-0.256151	0.379582	-0.263932	-0.675	0.5011
(Constant)	-0.093822	1.421445		-0.066	0.9475

Simplified multiple correlation models were evaluated using a step-down procedure that progressively eliminated variables with the largest significance levels greater than $p = 0.10$ (Norysis, 1992). This procedure revealed a very highly significant ($p < 0.0003$) multiple correlation among three remaining independent variables and the *Recreational Information* *feature pattern*: $R = 0.378$. Table 37 summarizes the model resulting for this analysis and shows that the significant ($p < 0.04$) model variables included: *SELFCONC*, *TYPE*, and *UNDRSTDC*.

Table 37. Recreational information feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
SELFCONC	0.177161	0.084584	0.178874	2.095	0.0383
TYPE	-0.716368	0.225635	-0.268903	-3.175	0.0019
UNDRSTDC	0.018857	0.008879	0.180911	2.124	0.0357
(Constant)	-0.569220	0.734032		-0.775	0.4396

Figure 51 illustrates the relationships among these variables in the context of the other potential influences. These results indicate that as drivers with higher *SELFCONC* and *UNDRSTDC* find this feature pattern more desirable ($B = 0.18$ and 0.02, respectively). However, not surprisingly, commercial drivers (*TYPE* = 2) find the *Recreational Information feature pattern* substantially less desirable (B = -.72) than do private drivers (*TYPE* = 1). These results point out the considerable disinterest of commercial drivers in the *Recreational Information feature pattern*.

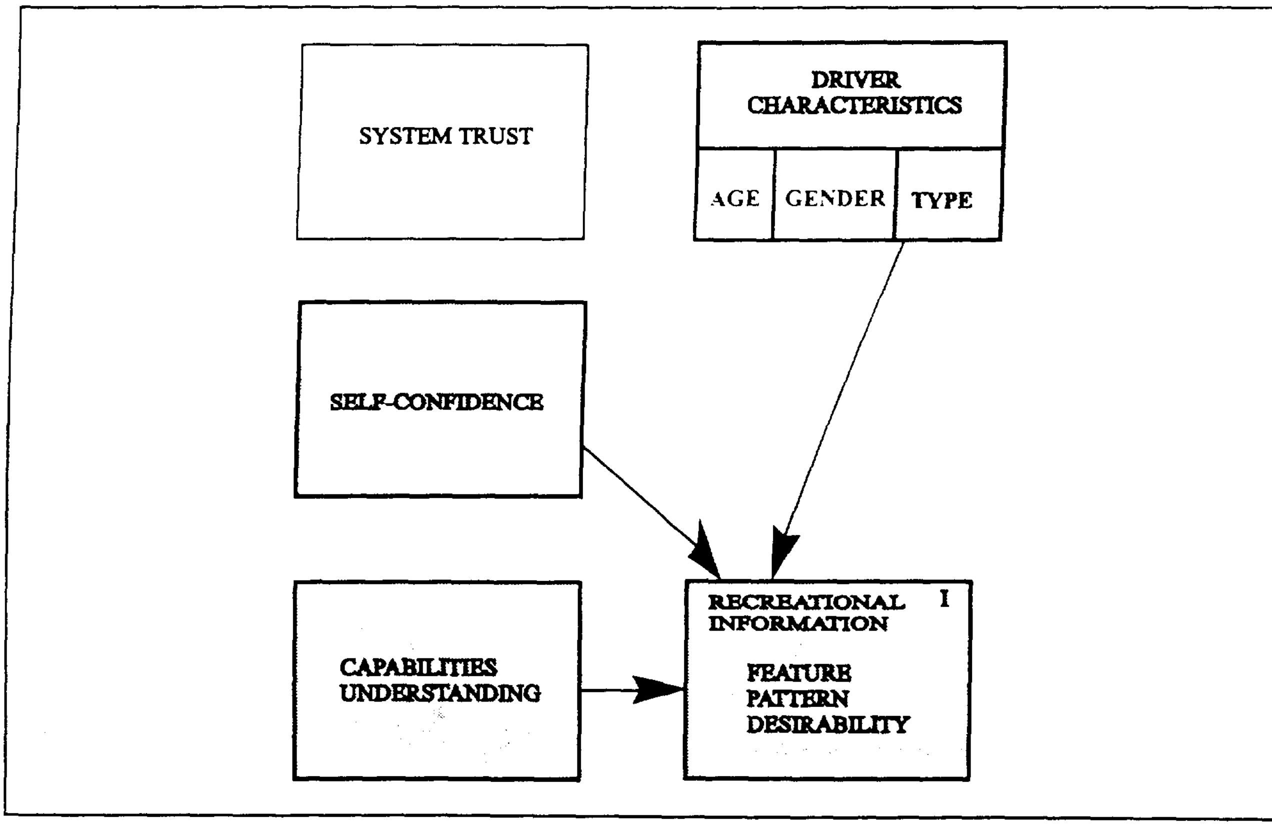


Figure 51. Recreational information feature pattern desirability.

Routing Assistance Feature Pattern (Factor II)

Initial analysis revealed a highly significant ($p < 0.005$) multiple correlation among the seven independent variables and the *Routing Assistance feature pattern*: $R = 0.395$. Table 38 summarizes the model resulting from this analysis. It is apparent that only one variable is initially significant ($p < 0.05$): *UNDRSTDC*. Others are clearly unrelated to the model (e.g., *AGE X GEN* with $p > 0.8$). These results suggested examination of simplified multiple correlation models that might better reveal the relationships with the *Routing Assistance feature pattern*.

Table 38. Routing assistance feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
SELFCONC	0.058344	0.090029	0.058908	0.648	0.5182
SYSTRUSTC	0.070259	0.086584	0.070846	0.811	0.4188
TYPE	0.382054	0.270489	0.143412	1.412	0.1605
UNDRSTDC	0.020680	0.010026	0.198394	2.063	0.0414
GENDER	-0.186618	0.569460	-0.091128	-0.328	0.7437
AGE	-0.450269	0.605262	-0.215911	-0.744	0.4584
AGExGEN	0.061541	0.382201	0.063411	0.161	0.8724
(Constant)	-1.239382	1.431251		-0.866	0.3883

Simplified multiple correlation models were evaluated using a step-down procedure that progressively eliminated variables with the largest significance levels greater than $p = 0.10$ (Norysis, 1992). This procedure revealed a very highly significant ($p < 0.0003$) multiple correlation among three remaining independent variables and the *Routing Assistance feature pattern*: $R = 0.381$. Table 39 summarizes the model resulting for this analysis and shows that the clearly two-tailed significant ($p < 0.05$) model variables included: *TYPE, UNDRSTDC* and *AGE*.

Table 39. Routing assistance feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
TYPE	0.423711	0.242607	0.159049	1.74	0.0416*
UNDRSTDC	0.019631	0.009725	0.188332	2.019	0.0457
AGE	-0.409058	0.205912	-0.196150	-1.987	0.0492
(Constant)	-1.407096	1.006159		-1.398	0.1645

* One-tailed directional test

Figure 52 illustrates the relationships among these variables in the context of the other potential influences. Additionally, based upon an a prior prediction of increased desirability for commercial drivers, *TYPE* was also significant ($p < 0.05$ with a $B = 0.42$). The results also indicate that drivers with greater *UNDRSTDC* find this feature pattern more desirable but again older drivers find it less desirable than younger (respective $B = 0.02$ and -0.41). The *Routing Assistance feature pattern* desirability can be enhanced somewhat with education to increase *UNDRSTDC*, but it appears that much would be required to meaningfully offset the relatively large negative effects of *AGE* and positive effects of *TYPE*.

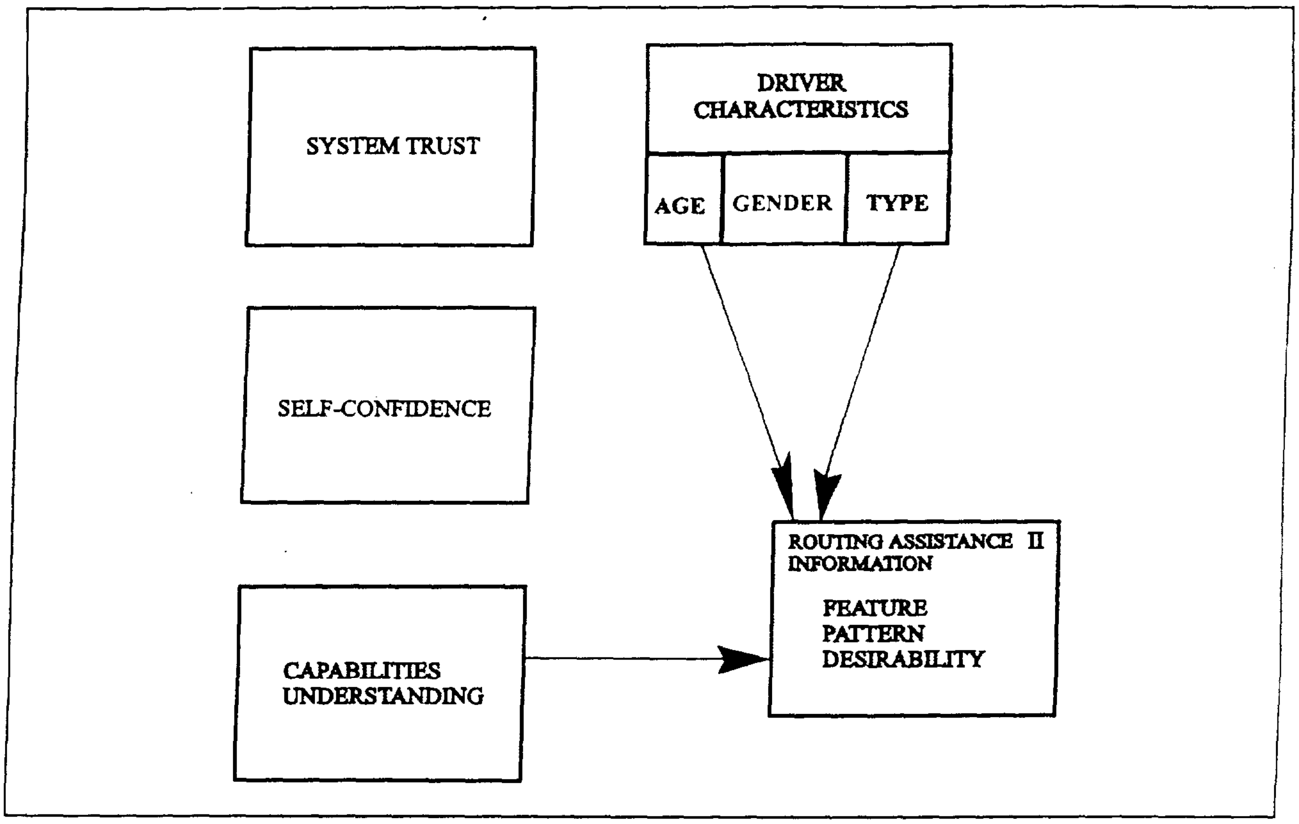


Figure 52. Routing assistance feature pattern desirability.

Accommodation-Related Information Feature Pattern (Factor III)

Initial analysis revealed a highly significant ($p < 0.0001$) multiple correlation among the seven independent variables and the *Accommodation-Related Information feature pattern*: $R = 0.478$. Table 40 summarizes the model resulting from this analysis. Examining this table, it is apparent that two variables are initially significant ($p < 0.007$): *SYSTRUSTC* and *TYPE*. Others range from the suggestive (*AGE* with $p = 0.075$) to the unrelated (e.g., *AGExGEN* with $p > 0.4$). These results suggested examination of simplified multiple correlation models that might better reveal the relationships with the *Accommodation-Related Information feature pattern*.

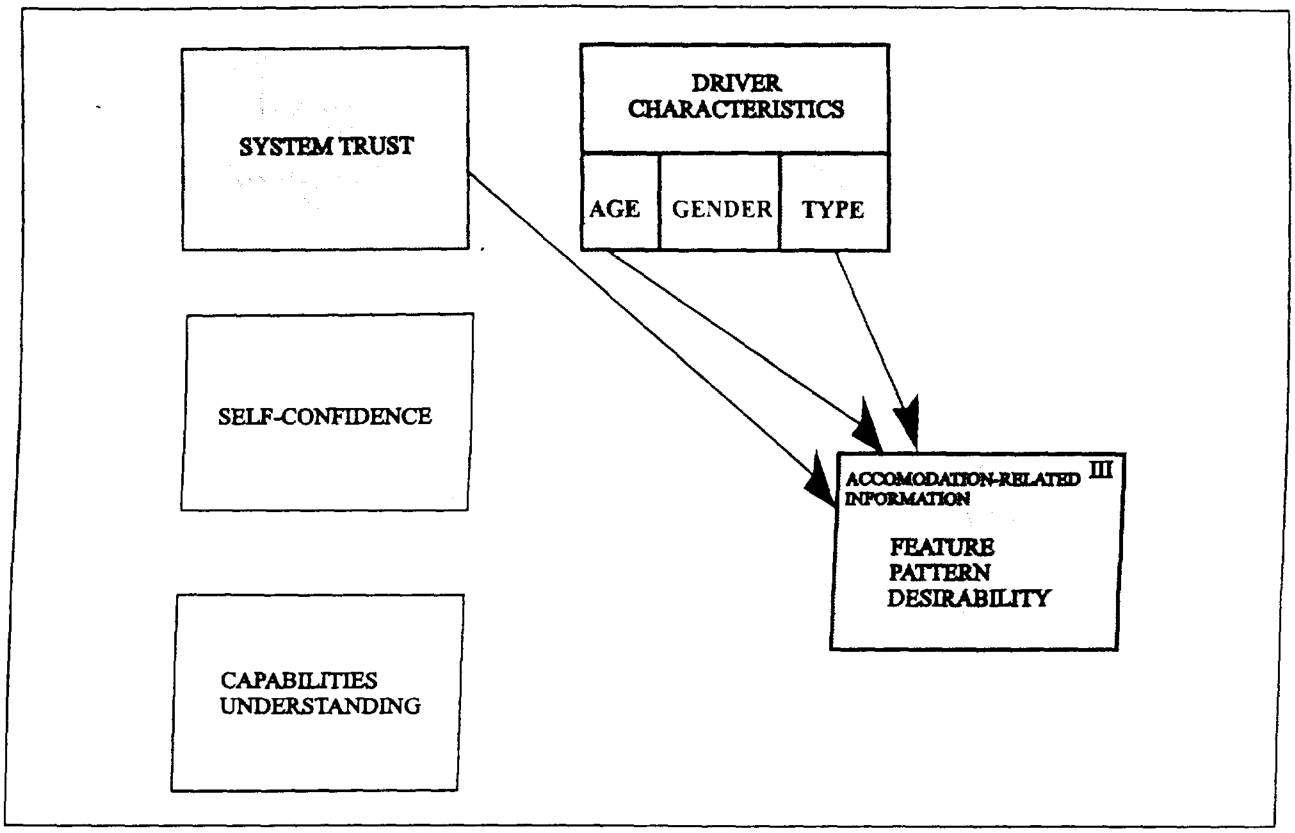


Figure 53. Accommodation related information feature pattern desirability.

Restaurant and Other Coordinations Feature Pattern (Factor IV)

Initial analysis revealed a nonsignificant ($p = 0.09$) multiple correlation among the seven independent variables and the *Restaurant and Other Coordinations feature pattern*: $R = 0.312$. However, as indicated in table 42 that summarizes the individual variable results, *SYSTRUSTC* appears highly significant ($p < 0.006$) and *TYPE* appears marginally insignificant ($p = 0.06$). Still others appear clearly unrelated (e.g., *UNDRSTDC* with $p > 0.8$). These results suggested examination of simplified multiple correlation models that might better reveal the relationships with the *Restaurant and Other Coordinations Pattern*.

Table 42. Restaurant and other coordinations feature pattern initial analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
SELFCONC	0.048319	0.093098	0.048786	0.519	0.6047
SYSTRUSTC	0.250941	0.089535	0.253038	2.803	0.0059
TYPE	0.517333	0.279708	0.194192	1.850	0.0669
UNDRSTDC	-0.001618	0.010368	-0.015524	-0.156	0.8762
GENDER	0.404758	0.588869	0.197649	0.687	0.4932
AGE	0.558137	0.625892	0.267636	0.892	0.3744
AGExGEN	-0.219989	0.395228	-0.226672	-0.557	0.5789
(Constant)	-1.382463	1.480033		-0.934	0.3522

Simplified multiple correlation models were evaluated using a step-down procedure that progressively eliminated variables with the largest significance levels greater than $p = 0.10$ (Norysis, 1992). This procedure revealed a highly significant ($p < 0.005$) multiple correlation between the only remaining variable, *SYSTRUSTC*, and the *Restaurant and Other Coordinations feature pattern*: $R = 0.254$. Table 43 summarizes the model resulting for this analysis and shows that increased *SYSTRUSTC* is associated with higher desirability for the *Restaurant and Other Coordinations feature pattern* (B = 0.25).

Table 43. Restaurant and other coordinations feature pattern final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
SYSTRUSTC	0.252254	0.086479	0.254362	2.917	0.0042
(Constant)	-0.001750	0.086854		-0.020	0.9840

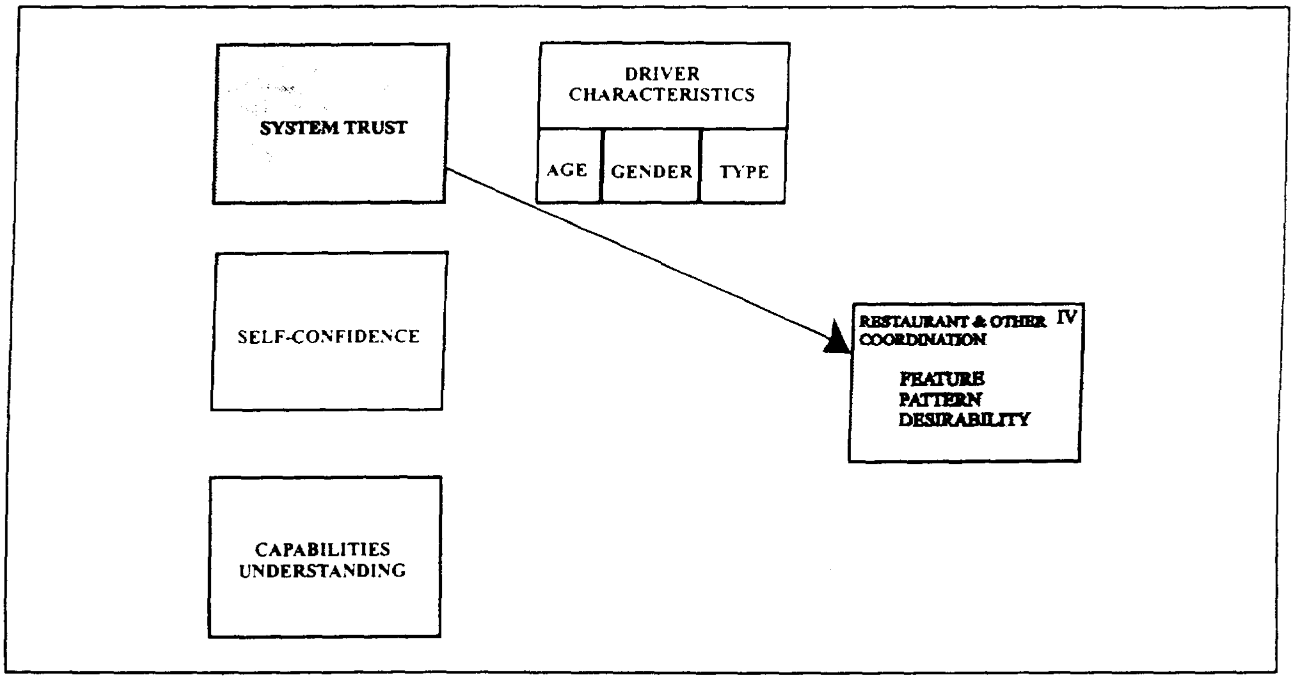


Figure 54. Restaurant and other coordinations feature pattern desirability.

Figure 54 illustrates the relationships among these variables in the context of the other potential influences. Here, it is noteworthy, *SYSTRUSTC* likely plays a moderating influence for much the same reasons it did above for the *Accommodation Related Information feature pattern*. The desirability of information and coordination is strongly dependent on *SYSTRUSTC* when it can vary widely in quality. Hence, perhaps the only way of enhancing the desirability of the *Restaurant and Other Coordinations feature pattern* would be to increase the *FIDELTYC*, as it can be significantly related ($r = 0.40$) to *SYSTRUSTC* as shown earlier in table 35.

Fidelity and Attention

The relationships among *FIDELITYC, ATTENTC, UNDRSTDC, SYSTRUSTC,* and *SELFCONC* were not directly considered in the section that describes the relationships of feature patterns with specified variables. This was, as may be recalled, because these variables were posited as only influencing the results through other variables. Therefore, only the direct relationships required analysis. Table 35 shows the correlations among the indirect variables. Of the five relationships predicted in figure 39, only the following two relationships were significant: 1) *FIDELITYC* and *ATTENTC* ($r = 0.6548$, $p < 0.001$) and 2) *FIDELITYC* and *SYSTRUSTC* ($r = 0.3972$, $p < 0.001$). Figure 55 illustrates these relationships.

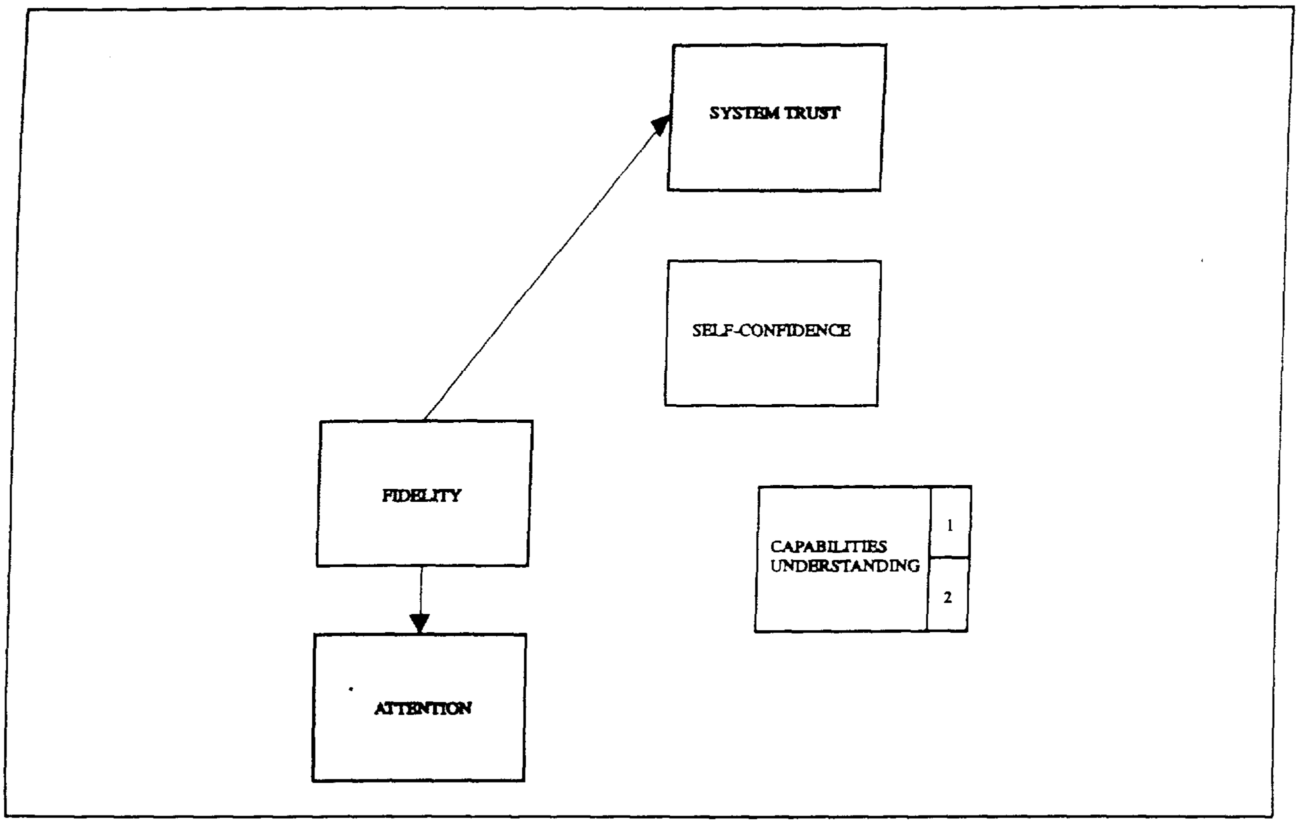


Figure 55. Indirect relationships of feature patterns.

DISCUSSION

Experiments 1 and 1B are part of an integrated series of studies directed at exploring questions of user acceptance and evaluation methodology. Initially discussed in this section are the individual results for examinations of two ATIS related systems: the TravTek system and the CityGuide system. This discussion addresses the effect of driver attitudes and system understanding on feature pattern desirability. In addition, it considers how driver characteristics influence feature pattern desirability, and how simulation fidelity influences driver understanding and preferences. The final section considers the integrated results of these experiments with regard to the broader questions concerning (1) feature pattern influence on user acceptance and (2) issues involved with evaluation methodology.

TravTek System Feature Pattern Desirability, Driver Attitudes, and System Understanding

A critical issue of user acceptance concerns the combinations of ATIS feature patterns that drivers would like to have. This experiment successfully determined the desirable TravTek system feature patterns. Six feature patterns emerged (table 11). These patterns were unrelated to the functional divisions of ATIS (into IRANS, IMSIS etc.) used by human factors professionals (Lee, Morgan, Wheeler, Hulse, & Dingus, 1997; Wheeler et al., 1997). Rather, they involved the: (1) *Basic Map feature pattern*; (2) *Voice feature pattern*; (3) *Text/Icon feature pattern*; (4) *Coordination of Travel Information feature pattern*; (5) *Map Simplification feature pattern*; and (6) *Monitoring and Emergency Response feature pattern*.

Table 44 summarizes the statistical relationships among the six TravTek system feature patterns and the variables that were hypothesized to influence the desired feature patterns (figure 56). This table also considers independent variables of *AGE*, *GENDER*, and *VIDEO*, where *VIDEO* refers to the differential effect of an AAA tutorial videotape and an on-road demonstration videotape. Figure 56 shows this information graphically.

Table 44. Summary of the TravTek system multiple-correlation results.

	TRAVTEK FEATURE PATTERN					
VARIABLE	BASIC MAP	VOICE	TEXT/ICON	COORDINATION OF TRAVEL INFORMATION	MAP SIMPLIFICATION	MONITORING & EMERGENCY RESPONSE
SYSTRUST	++		+	+++		
SELFCON	+	---	--			
UNDRSTD1	+++			---	--	
UNDRSTD2	++	+	++			
VIDEO		+++++		--	-	----
TOLPAT1					++	
TOLPAT2			-			
AGE	----				++	
GENDER			--			
AGExGEN						

Where sign (+ or -) indicates direction of effect:

+/- $p < 0.10$
++/-- $p < 0.05$
+++/--- $p < 0.005$
++++/---- $p < 0.0005$
+++++/----- $p < 0.00005$

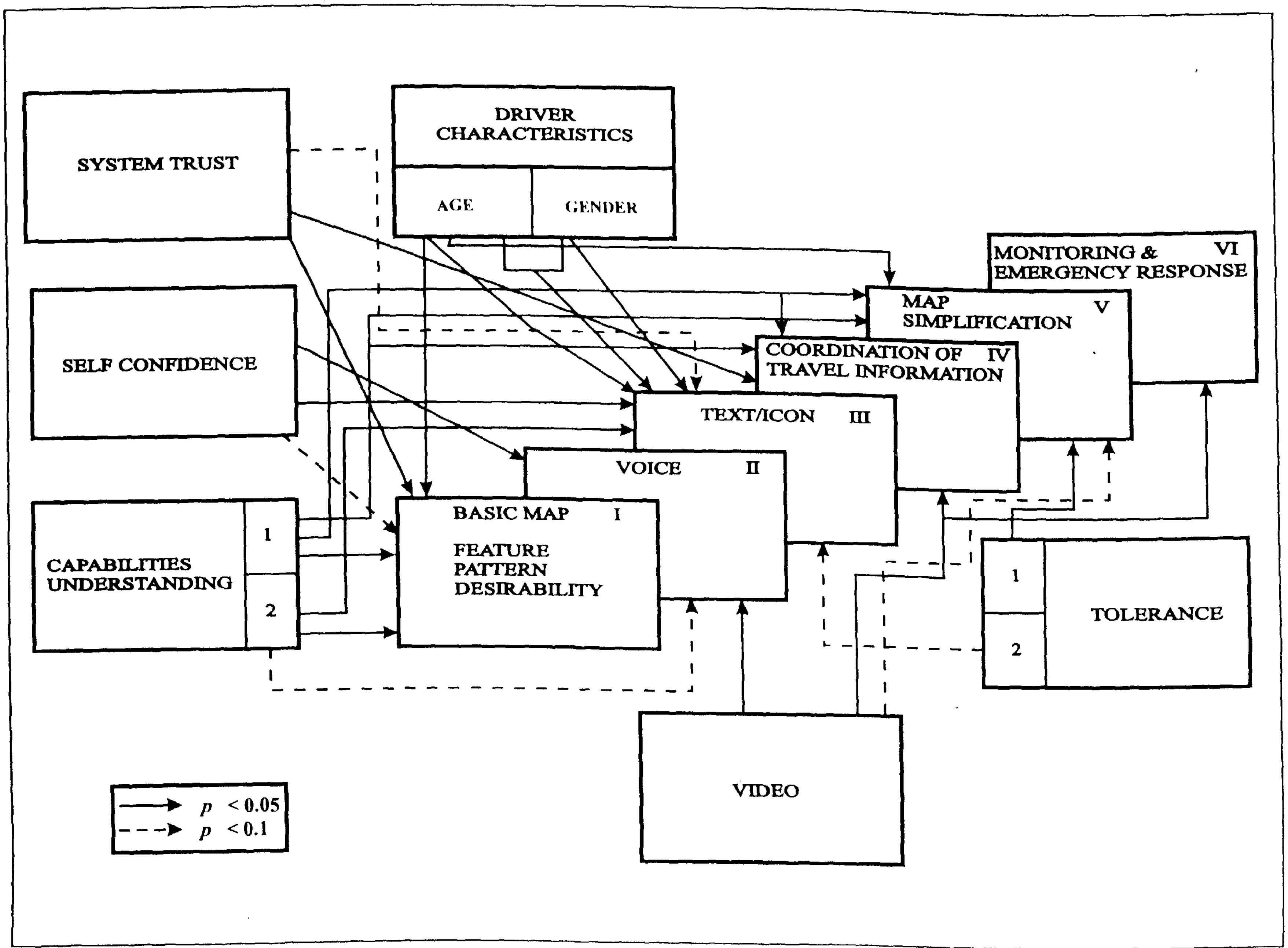


Figure 56. Relationships among composite variables for TravTek system.

The model shown in table 44 and figure 56 demonstrates the importance of subjective variables on feature pattern desirability. It also shows that the importance of various variables depends on the specific feature patterns being considered. For example, *system trust* (*SYSTRUST*) significantly influenced the desirability of three feature patterns, most importantly the *Coordination of Travel Information feature pattern* (Feature Pattern IV). *Self-confidence* (*SELFCON*) also had a weak positive relationship to the *Basic Map feature pattern* (Feature Pattern I), which at first glance appeared to mildly contradict other research on automation (Lee & Moray, 1994; Experiment 2 of this report) that shows a negative relationship between *SELFCON* and the use of automation. In contrast, *SELFCON* was negatively related to two other feature patterns. Drivers with high *SELFCON* do not find voice instructions from ATIS to be as attractive as those with lower *SELFCON*. The apparent paradox of these differences in the influences of *SELFCON* may be the result of perceptions of the value of the feature patterns for promoting driver self-reliance. The *Basic Map feature pattern* (Feature Pattern I) may be perceived as directly supporting *SELFCON* since it reduces the need for stopping for directional assistance, whereas the reverse is true for the other feature patterns. The effects of the prediction failures (*TOLPAT1*) and arrival time mis-estimates (*TOLPAT2*) are consistent with expectations. Older drivers and others with less processing capabilities, who desire the *Map Simplification feature pattern* (Feature Pattern V), might be more tolerant of occasional prediction failure as they tend to have more experience with it in their lives. In contrast, intolerance for arrival time mis-estimates (*TOLPAT2*) is weakly negative related to preferences for the *Text/Icon feature pattern* (Feature Pattern III), perhaps reflecting the personality style of those preferring the exactness of the *Text/Icon feature pattern* (Feature Pattern III) (vs. Map analog). More specifically, the *Text/Icon feature pattern* (Feature Pattern III) is believed to be preferred by people who want to have access to more exact details of the driving situation so as to have greater control of the driving situation. Thus, drivers' tolerance for inaccuracies depends on both the type of inaccuracies (inaccurate predictions compared to inaccurate estimates of arrival times) and the specific feature pattern.

Similar to the differential effect of inaccuracy types, drivers' understanding consists of two factors, one reflecting understanding safety-related features (*UNDRSTD2*) and one reflecting understanding features not related to safety (*UNDRSTD1*). As *UNDRSTD2* increases, so does the desirability of *Basic Map, Voice* and *Text/Icon feature patterns* (Feature Patterns I, II, and III). Additionally, the negative relationship between *UNDRSTD1* and the *Map Simplification feature pattern* (Feature Pattern V) also makes sense, as a greater appreciation of features would be expected to reduce the desirability of a feature pattern which simplifies them (except for older drivers and others who might appreciate the lessened processing load with the *Map Simplification* features). The marginal ($p < 0.0008$) negative relationship between drivers' *UNDRSTD1* and *Coordination of Travel Information* (Feature Pattern IV) may arise because the set of appreciated capabilities may be somewhat overwhelming, thereby reducing the desirability of some of those capabilities that are more tangential.

This discussion demonstrates that a variety of subjective variables influences desirability of feature patterns. These variables cover a broad spectrum of potential influences, and include *SELFCONC, SYSTRUST, TOLPAT1, TOLPAT2, UNDRSTD1* and *UNDRSTD2*. This broad spectrum of variables does not influence the desirability of all features equally. Instead, they affect user acceptance in a complex manner that depends on the specific features being considered.

Driver Characteristics and Feature Pattern Desirability for the TravTek System

Experiment 1 examined the effect of driver characteristics, *AGE* and *GENDER*, on user acceptance. In general, younger drivers were more comfortable with TravTek system ATIS technology. They found the TravTek system easier to learn and saw more value in it than did older drivers (table 45).

Table 45. Age differences in the TravTek system feature acceptance.

TRAVTEK FEATURE	EASY TO LEARN	EASY TO USE	USEFUL
Guidance map	0.9**	0.7**	0.5**
Route map	0.6**	0.5**	0.3*
Voice guide	0.4*	0.5*	0.1
Overall system	0.1**	0.7**	0.4*

Note: Cell entries are mean ratings of younger drivers minus mean ratings of older drivers.
. * $p < 0.05$; ** $p < 0.01$

The model shown in table 44 and figure 56 illustrates the effect of driver characteristics on feature desirability. *AGE* had a strong negative effect on the desirability of the *Basic Map feature pattern* (Feature Pattern I). In part this could be because older drivers are less able to process a full array of map information. Supporting this interpretation, older drivers particularly appreciated the *Coordination of Travel Information feature pattern* (Feature Pattern IV) and *Map Simplification feature pattern* (Feature Pattern V). These results are consistent with other results concerning information processing in the aging driver (Barfield et al., 1993).

Overall, *GENDER* had a modest effect on the desirability of the *Text/Icon feature pattern* (Feature Pattern III). Across younger and older drivers, these features were more desirable for women. However, the interaction of *AGExGENDER* indicated that older female drivers were negatively disposed to the *Text/Icon feature pattern* (Feature Pattern III), whereas younger female drivers found it particularly attractive (table 46). The *Text/Icon feature pattern* (Feature Pattern III) needs to be a selectable option to accommodate both female driver age groups.

Table 46. Text/Icon feature pattern *AGEXGEN* subset of the final analysis summary.

VARIABLE	B	SE B	BETA	T	SIG T
GENDER	0.995791	0.411663	0.493299	2.419	0.0165
AGE	0.665720	0.429789	0.326163	1.549	0.1230
AGExGEN	-0.702281	0.273830	-0.725982	-2.565	0.011
(Constant)	-0.960404	0.653132		-1.470	0.1430

Influence of Demonstration Fidelity for the TravTek System

A fundamental question that guided this experiment addresses the development of empirical methods to study driver acceptance of ATIS. To address this question, experiment 1 included a series of questions from the *TravTek System Evaluation* questionnaire used in the Orlando study. A major goal of including these questions was to compare ratings of drivers who have driven the

TravTek system vehicle in Orlando to the Seattle drivers who have only seen two videos. Such a comparison would reveal how well a simple videotape representation of the TravTek system compares to direct experience with the actual TravTek system. Systematic differences can serve as a guide to future empirical studies of driver acceptance. However, this comparison must be deferred until either these data are made available to the TravTek System Project team or until the Orlando TravTek System data are made available to the Battelle team.

In lieu of comparing the actual TravTek system and videotape experiences, this experiment examined the effect of watching two different videotapes. The first videotape (edited version of the AAA instructional tape) provided a static tutorial of the TravTek system functions and features. The second videotape (a driver's view of a trip through Orlando) provided a dynamic, on-road demonstration of the TravTek system being used to select a destination and then guiding the driver through the city. The differences between the two videotapes seemed to influence driver acceptance. Specifically, *voice* and other specific system features received higher ratings after drivers had seen video 2 (Orlando trip). However, perhaps reflecting the difficulty of a global evaluation, ratings of the overall TravTek system did not increase after video 2. Drivers may have considered video 1 (AAA instructional tape) to be a sufficient learning experience. Supporting this, video 2 did not reliably increase the dollar amount drivers were willing to pay for a TravTek system.

The two videotapes did not influence ratings of ease of use or dollar amount drivers were willing to pay, but did produce the strongest effect across the feature patterns. Reflecting this, the desirability of the *Text Icon feature pattern* (Feature Pattern III) increased considerably when drivers viewed video 2. This result suggests that drivers may require a concrete demonstration of system features before they fully appreciate the associated benefits. At the same time, desirability of several feature patterns decreased after seeing video 2. The type of data collected from these experiments matches that collected during the TravTek System Demonstration Project in Orlando, and so it supports future analyses revealing how actual driving experience compares to relatively crude simulations of the same ATIS. The immediate results of experiments 1 and 1B revealed strong effects of different types of ATIS simulations. Experiment 1 showed that subjective perception of simulation *FIDELITY* influenced several important user acceptance variables. These effects were fully delineated in the model-based approach adopted in experiments 1 and 1B. This same explanation may hold for the diminishing effect of video 2 on the *Map Simplification feature pattern* (Feature Pattern V). Alternatively, the desirability of the *Map Simplification feature pattern* (Feature Pattern V) may have been reduced by a growing appreciation of a fuller set of features with video 2.

In addition to the effect of the two videotapes, subjective ratings of the videotapes played an important role in understanding driver acceptance. Subjective ratings of *FIDELITY* and *ATTENT* devoted to the experiment were used to gauge how well the "simulation" of the TravTek system, created by the videotapes, conveyed the "feel" of the actual system to the subjects. Although *FIDELITY* and *ATTENT* are not listed in table 44, they played important roles because *FIDELITY* strongly influenced *ATTENT* and both together influenced *SYSTRUST* and subsequent desirability of feature patterns. Of note, *FIDELITY* and *ATTENT* were not seen to influence driver understanding of the TravTek system (or later the CityGuide system), as posited earlier (figure 9). This may have resulted because enhanced *FIDELITY* can focus driver *ATTENT* on the more global "feel" of a system than on the specific technical details (thus enhancing *SYSTRUST*, but reducing detailed technical understanding). This phenomenon is not uncommon in simulator research where driver acceptance is the appropriate focus and knowledge of system functionality is of secondary importance.

In summary, the model presented in figure 56 was successful in explaining driver acceptance of the TravTek system features. This model addresses different user dimensions (e.g., *SYSTRUST*) than either the Mackie-Wylie MIAT model discussed earlier in chapter 1 or alternatives such as the Technology Acceptance Model (TAM). This experiment shows that these other variables are important factors and that this simpler model provides a basis for assessing and controlling them in future research and design activities.

CityGuide System Feature Desirability, Driver Attitudes, and System Understanding

Experiment 1B examined the factors affecting driver acceptance using the CityGuide system. The CityGuide experiment was successful in determining the feature patterns drivers would like to have (analogous to the results for TravTek). The four feature patterns that emerged were the: (1) *Recreational Information feature pattern* (Feature Pattern I); (2) *Routing Assistance feature pattern* (Feature Pattern II); (3) *Accommodation Related feature pattern* (Feature Pattern III); (4) *Restaurant and Other Coordination feature pattern* (Feature Pattern IV).

Table 47 summarizes the statistical relationships among these feature patterns and the variables that were hypothesized to influence the feature patterns (figure 57). This table also considers independent variables of *AGE*, *GENDER*, and *DRIVER TYPE* (commercial drivers vs. private drivers).

Table 47. Summary of the CityGuide system multiple-correlation results.

	CITYGUIDE FEATURE PATTERN			
VARIABLE [1]	RECREATIONAL INFORMATION	ROUTING ASSISTANCE	ACCOMMODATION RELATED INFORMATION	RESTAURANT AND OTHER COORDINATION
SYSTRUSTC			+++	+++
SELFCONC	++			
UNDRSTDC	++	++		
TYPE	---	++	---	
AGE		--	----	
GENDER				
AGExGEN				

[1] NOTE: The suffix "C" distinguishes variables in the CityGuide experiment from similar variables in the TravTek experiment.

Where sign (+ or -) indicates direction of effect:

+/-	$p < 0.10$
++/--	$p < 0.05$
+++/---	$p < 0.005$
++++/----	$p < 0.0005$
+++++/-----	$p < 0.00005$

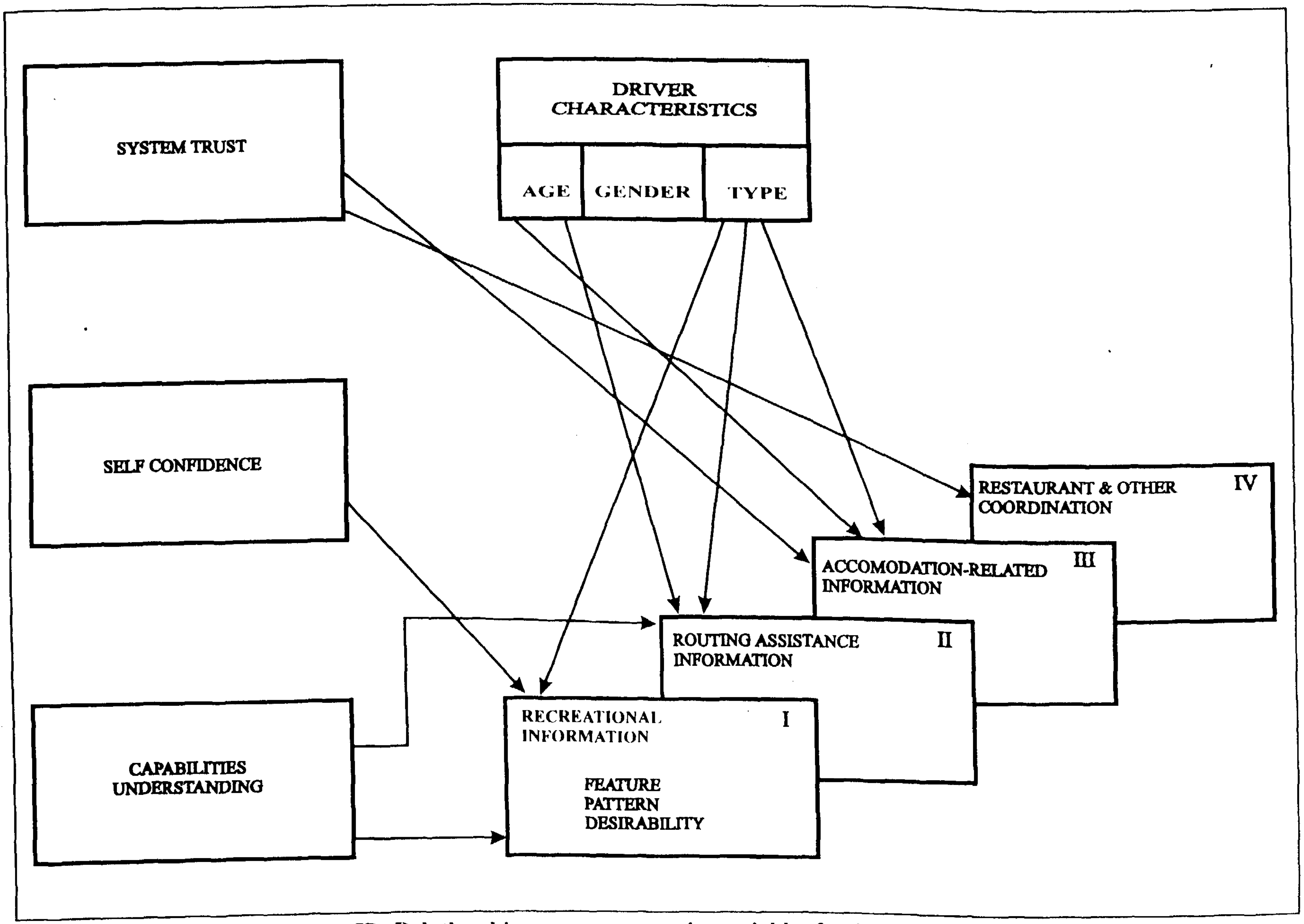


Figure 57. Relationships among composite variables for CityGuide system.

As with the TravTek system, *SYSTRUSTC* significantly influenced the desirability of feature patterns. Specifically, *SYSTRUSTC* affected the *Accommodation Related Information feature pattern* (Feature Pattern III) and the *Restaurant and Other Coordination feature pattern* (Feature Pattern IV). These two positive relationships are consistent with the three positive TravTek system relationships seen earlier. *SELFCONC* also had a positive relationship with the *Recreational Information Pattern feature pattern* (Feature Pattern I). This, similar to the positive relationship identified for the TravTek system *Basic Map feature pattern* (Feature Pattern I) appeared to mildly contradict other research on automation (Lee & Moray, 1994; Experiment 2 this report) that has shown a negative relationship between *SELFCONC* and the use of automation. However, the apparent paradox of these differences in the influences of *SELFCONC* may be the result of perceptions of the value of the patterns for promoting driver self-reliance. *Recreational Information* (Feature Pattern I) may be perceived as directly supporting self-reliance and requiring the associated high levels of *SELFCONC* since they reduce the need for asking other guidance. For the other feature patterns, the reverse is true.

Finally, the positive relationships between *UNDRSTDC* and two feature patterns also makes sense. Increasing *UNDRSTDC* corresponds to increasing desirability of *Recreational Information feature pattern* and *Routing Assistance feature pattern* (Feature Patterns I and II). These results and the others point out the similarity of results for the CityGuide and the TravTek systems.

Driver Characteristics and Feature Pattern Desirability for the CityGuide System

Reflecting the same kind of result seen in the TravTek system analysis, younger drivers again were generally more comfortable than older drivers with the CityGuide system. Within the younger group, the private and commercial drivers were generally equivalent in their ratings. (The one exception was with regard to specific ratings of the "ease of learning" where the commercial drivers were more like older than younger private drivers). The CityGuide system overall was judged by the younger drivers to be easier to learn, use, and to have more value than by older drivers (table 48). Younger drivers overall also gave higher ratings to the map display features, text instructions, and the overall system (analogous to TravTek feature results).

Table 48. Age differences in the CityGuide system feature acceptance.

CITYGUIDE FEATURE	EASY TO LEARN	EASY TO USE	USEFUL
Map display	0.5**	0.6**	0.6**
Text instructions	1.0**	0.9**	1.0**
Overall system	0.5*	0.5**	0.2

NOTE: Cell entries are mean ratings of younger drivers minus mean ratings of older drivers.
* $p < 0.05$; ** $p < 0.01$

In the context of the model of driver acceptance, figure 57 and table 47, the strongest effect across the feature patterns was exerted by the *DRIVER TYPE* (commercial driver vs. private driver). As would be expected, the desirability of *Recreational Information* (Feature Pattern I) was less for commercial drivers than for private drivers. Likewise, the commercial drivers valued *Routing Assistance* (Feature Pattern II) less compared to private drivers. Also, not inconsistent with expectations, *Routing Assistance* (Feature Pattern II) was somewhat more appreciated by commercial drivers than private drivers. The *DRIVER TYPE* effects were generally in keeping with expectations based on the differing concerns of commercial drivers and private drivers.

AGE also had negative effects on the desirability of both *Routing Assistance* and *Accommodation Related Information* (Feature Pattern II and III). With regard to the first of these, this could be because older drivers are less able to process the full array of routing assistance provided by the CityGuide system. Supporting this interpretation, older drivers particularly appreciated *Map Simplification* (Feature Pattern V) for the TravTek system. This first result would also be consistent with other results on information processing in the aging driver (Barfield et al., 1993). The second result was also not surprising given the expectation that older drivers might have less need for such information due to greater experience and lifestyle differences. *AGE* effects were generally in keeping with expectations, based on concerns that differed from those of younger drivers.

Influence of Demonstration Fidelity of the CityGuide System

Using the CityGuide system provided a second opportunity to examine the influence of demonstration fidelity (*FIDELITYC*) that complimented our first study of the TravTek system (experiment 1). Hence, this study also addressed the same fundamental concerns that guided experiment 1, (1) identification of feature patterns that influence driver acceptance; (2) development of empirical methods to study driver acceptance. Contrasting with the two videotape presentations used in the TravTek system study, the CityGuide system was a physically operational system that was demonstrated to the drivers. Of particular concern was the impact that this difference would have on driver acceptance, particularly with regard to the subjective ratings, e.g., *FIDELITYC* and *ATTENTC*. Specific results are discussed, followed by a discussion of the broader implications of demonstration *FIDELITYC*, in the context of the CityGuide system and the TravTek system results.

As with experiment 1, subjective ratings of the "simulation" played an important role in understanding how the feature patterns influenced driver acceptance. In experiment 1B, the "simulation" consisted of a computer-based demonstration of the CityGuide system compared to the videotapes of the TravTek system presented in experiment 1. Ratings of the degree of *FIDELITYC* were important because they influence how much attention the simulation commands. In addition, *FIDELITYC* and *ATTENTC* both influence system trust (*SYSTRUSTC*) and the subsequent desirability of various feature patterns. Similar to the results of experiment 1, the ratings of *FIDELITYC* and *ATTENTC* did not influence driver understanding (*UNDRSTDC*) of the CityGuide system feature patterns. These results also support the view that the influence of enhanced *FIDELITYC* may be to focus driver attention on the more global "feel" of a system (vs. on technical details). This CityGuide system experiment consequently served to support the general finding of experiment 1 that the acceptance model (figure 57) provides a basis for future research and design activities.

Broader Implications of Experiments 1 and 1B

Experiments 1 and 1B are part of an integrated series of studies directed at exploring both questions of users' acceptance and evaluation methodology. Taken together, the results of experiments 1 and 1B also begin to provide a basis for the broader considerations of user acceptance and evaluation methodology. This final section begins the consideration of the integrated results of these experiments with regard to the general questions of user acceptance and evaluation methodology.

User Acceptance

The TravTek system and CityGuide system results together indicate some broad user acceptance trends in the three areas delineated below. The first broad user acceptance finding regarding *AGE* found that younger drivers were generally more comfortable with the TravTek system and the CityGuide system technology. They found the TravTek system and the CityGuide system easier to learn and having more value than did older drivers. With regard to several specific patterns of the TravTek system and the CityGuide system feature patterns, *AGE* was also often found to have negative effects on the desirability. In part, this may be because older drivers have more experience and a different lifestyle than younger drivers (as suggested for aspects of the CityGuide system). More often this difference may be because older drivers tend to be less able to process information than younger drivers. Supporting this interpretation were 1) the finding that older drivers particularly appreciated the *Map Simplification feature pattern* (Feature Pattern V) for the TravTek system and 2) other general results on information processing in the aging driver (Barfield et al., 1993).

A second broad user acceptance finding was the generally positive relationships between *UNDRSTD1*, *UNDRSTD2*, and *UNDRSTDC* variables and the desirability of feature patterns (six positive results across the TravTek system and the CityGuide system). These results show that the better features are understood, the more they are appreciated and desired. Even the one significant exception to this finding, the negative relationship between *UNDRSTD2* and *Map Simplification* (Feature Pattern V) supports the view as greater appreciation of features would be expected to tend to reduce the desirability of a feature pattern which simplifies them. The general result supports the view that better understanding of system capabilities will tend to enhance desirability.

The third and final broad user acceptance finding concerns *FIDELITY*, *ATTENT* and *SYSTRUST* for both the TravTek system and the CityGuide system, *FIDELITY* was found to strongly influence *ATTENT* and both together were found to tend to positively influence *SYSTRUST*. *SYSTRUST* was subsequently positively associated with desirability of five different feature patterns, across results for the CityGuide system and the TravTek system. *FIDELITY* and *ATTENT* were not seen to influence *UNDRSTDC* of the CityGuide system for the same reasons as were posited earlier and addressed in the experiment 1 portion of this discussion.

Each of these three broad findings reflect a growing understanding of user acceptance that will be useful in future system development activities. The next section touches on several of these during its consideration of the evaluation methodology used during the course of the experiments 1 and 1B.

Evaluation Methodology

A general question of developing methodologies to evaluate driver acceptance concerns how well data collected in laboratory conditions, using simulations of ATIS, will generalize to actual systems. Experiments 1 and 1B provide a basis to examine effects of different types of ATIS simulations on the evaluation of driver acceptance. These experiments used quite crude simulations of ATIS (videotapes and a demonstration on a computer-based system). Neither of these "simulations" supported interaction with the system and neither placed subjects in an actual driving situation.

The model-based experimental method used across experiments 1 and 1B proved highly productive both practically and theoretically. Practically, experiments 1 and 1B were successful in revealing both distinct patterns of respective TravTek and CityGuide features that drivers would like to have, and driver characteristics and other factors that influenced their acceptance. These results, among other uses, provide a basis for the grouping of features in respective initial and enhanced Advanced Traveler Information Systems. In turn, the correlational analyses revealed factors that could influence acceptance and point toward methods for practically increasing such acceptance. For example, the positive influence of perceived *FIDELITY* on user acceptance and its subsequent positive impact on the acceptance of both TravTek and CityGuide feature patterns suggests its systematic examination to variously (1) increase the *FIDELITY* of the presentations of systems being introduced to the public and (2) control for its impact in studies of user acceptance. These are among the most obvious examples pointing out the practical utility of the model-based approach employed in experiments 1 and 1B.

The model-based methodology also proved productive with regard to advancing our theoretical understanding of user acceptance in two broad respects. First, as noted above, the structural model presented in figure 39 proved a successful basis for explaining the driver acceptance of the TravTek and CityGuide systems (confirming much of its structure). [In itself, this result would recommend continuing to use such a theory in future evaluations of user-acceptance.] Second, as seen earlier in the individual TravTek and CityGuide system results, there were some surprises. System understanding(s), for example, were not influenced by *ATTENT* in either experiments 1 or 1B. This may have been because the influence of *FIDELITY* on *ATTENT* with respect to the more "global" aspects of the way a system works, and not on detailed verbal understanding (i.e., like the results of a flight simulator that teaches the skill of flying but not ground-school details). Of course, together with the other suggested modifications to the structural-model, this posited attentional relationship is an area for future theoretical consideration. Model-based methodology similar to that used herein is consequently expected to continue to be productive in future investigations.

CHAPTER 3. EXPERIMENT 2

METHOD

Subjects

Forty-eight subjects, ranging from 18 to 75+ years of age, participated in this experiment (table 49). There were an equal number of males and females in each category. Each participant was paid $10 per hour, plus a cash bonus. All subjects were licensed drivers and familiar with driving in the Seattle area. Younger subjects were recruited from the University of Washington, while older subjects were recruited from local school, church, volunteer, and retirement groups. Only subjects who were deemed to be "familiar" or "very familiar" with common traffic routes in Seattle participated in the experiment. Also, subjects were required to have an active driver's license, and drive at least once per week.

To determine subjects' driving experience, data was collected on the years living and driving in Seattle and on the mean miles driven annually. Table 49 shows that mean years living in Seattle ranged from 10.1 years for the 18 to 24 age group to 50 years for the over 75 age group. Mean years driving in Seattle ranged from 4.2 years for the 18 to 24 age group to 46.6 years for the 75+ age group. Finally, mean miles driven annually ranged from 8,125 miles for the 75+ age group to 13,125 for the 25 to 54 age group.

Table 49. Age group and number of subjects for experiment 2.

AGE	NUMBER	MEAN YEARS LIVING IN SEATTLE	MEAN YEARS DRIVING IN SEATTLE	MEAN MILES DRIVEN ANNUALLY
18-24	12	10.1	4.2	8,958
25-54	12	23.1	16.8	13,125
55-64	8	31.5	29.5	9,063
65-74	8	44.8	42.1	9,375
75+	8	50.0	46.6	8,125

Apparatus

This experiment used the Battelle Route Guidance Simulator (RGS). This simulator consists of two 486 computers and provides drivers with real-time video information and a schematic map of available routes. This video information is presented as a windshield view of the traffic scene. This allows the driver to experience real-time visual traffic images from the driver's seat perspective. To create the video information, a Sony camcorder was mounted on a tripod fixed beneath the rear view mirror of a 1979 Chevrolet Malibu. The camera recorded traffic scenes as the car drove along various links from the Westlake Center in downtown Seattle to the Bellevue Square Mall in Bellevue. The recorded traffic scenes were digitized and displayed using a Dell

466/T computer equipped with a 508 mm NEC monitor, a Video Logic digital video adapter, an Adaptec SCSI host adapter, three Fujitsu 1.2 gigabyte hard drives, an Ahead VGA adapter, and custom software. The schematic street map and subject input touch buttons were displayed using a second Dell 466/T computer equipped with a 14-inch Zenith VGA monitor, MicroTouch Systems touch screen and bus controller card, digital DECtalk voice synthesizer, and custom software.

In addition to the RGS, the experiment used a variety of other materials. Appendix D includes copies of the eight questionnaires which were administered. The *Subject's Familiarity With Driving in Seattle: Pre-Selection Phone Questionnaire* (p. 267) was given to subjects in order to assess Seattle driving familiarity. Two questionnaires, *Driver Demographic Characteristics Questionnaire (Phone)* (p. 268), and *Driver Demographic Characteristics* (p. 270), were used to collect relevant subject demographic data. A set of questions, *Trust & Self-Confidence in ATIS Technology* (p. 274), collected subjective data pertaining to route guidance technology and self-confidence in one's own ability to navigate through Seattle. A series of questions titled *Inter-Link Questions* (p. 276), administered after each link, assessed subjects' rated trust in the route guidance system, self-confidence in their ability to accurately anticipate traffic conditions, and expectations of the traffic. A questionnaire, *Modifying Your Trip to Avoid Traffic* (p. 277), asked questions pertaining to the level of accuracy required from a navigation device. The questionnaire, *Trust in the Route Guidance System* (p. 279), asked subjects about the navigation system's technological trustworthiness. At the end a final questionnaire, *Demonstration Fidelity* (p. 282), was presented to solicit opinions regarding the simulation and demonstration.

Battelle Route Guidance Simulator

Overview

The Battelle Route Guidance Simulator is a powerful research tool developed in order to investigate driver performance and behavior. The flexibility of the simulator's configuration allows experimenters to adjust and adapt parameters as needed. The simulator is designed to track a variety of performance measures (e.g., time to traverse a route). Subjects use the simulator by selecting a route from a computer-generated map on a touch screen and then view the real-time digitized traffic scene as if they were actually driving the route in their car.

Displays and Controls

The RGS consists of two computers linked to two monitors. One monitor displays real-time digitized video scenarios (figure 58) and the other monitor displays a computer-generated schematic map (figure 59). Together these monitors allow subjects to specify a route and "drive" from their originating location in the Westlake Center to their destination in the Bellevue Square Mall.

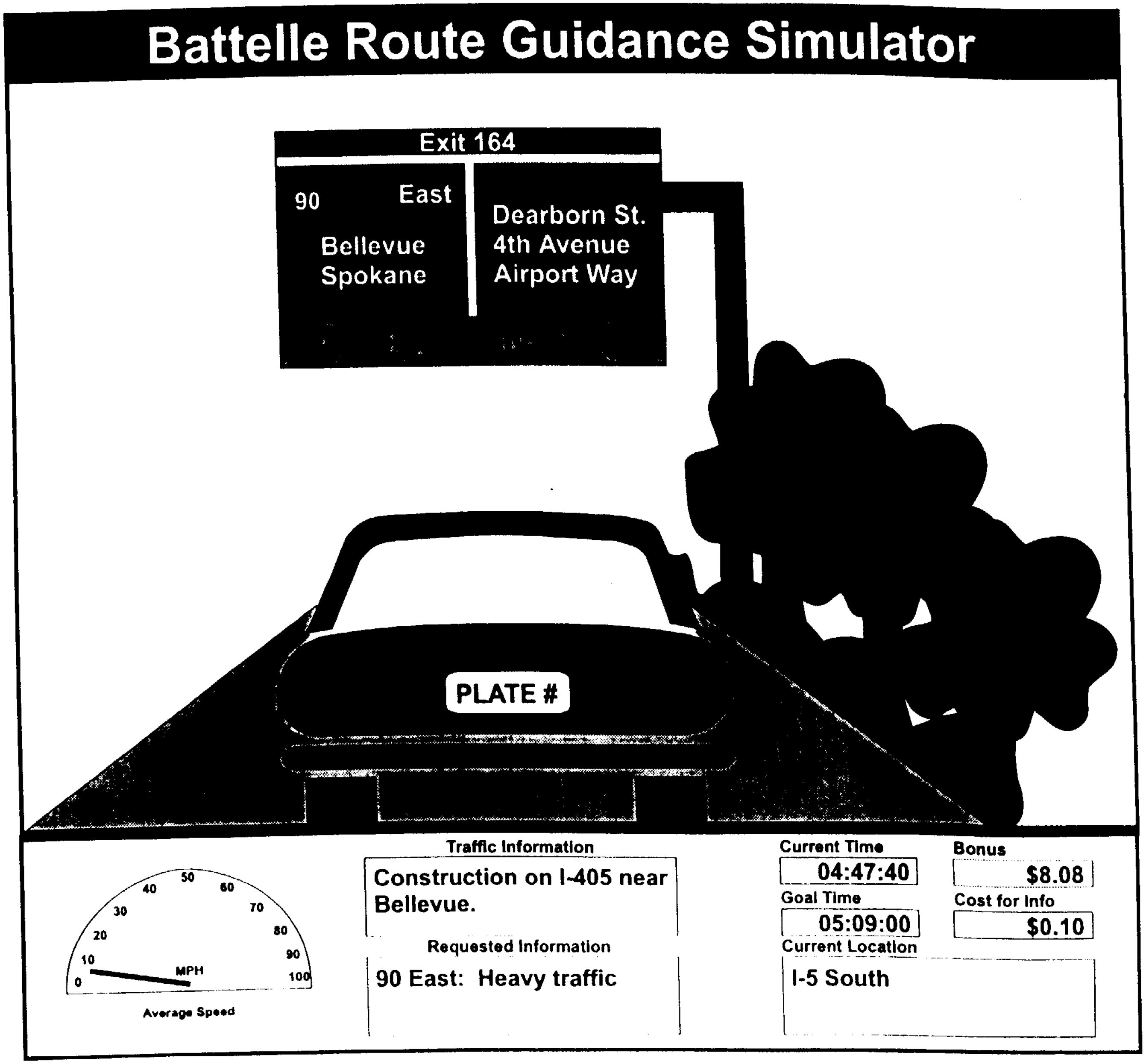


Figure 58. Artist reconstruction of real-time digitized color display.

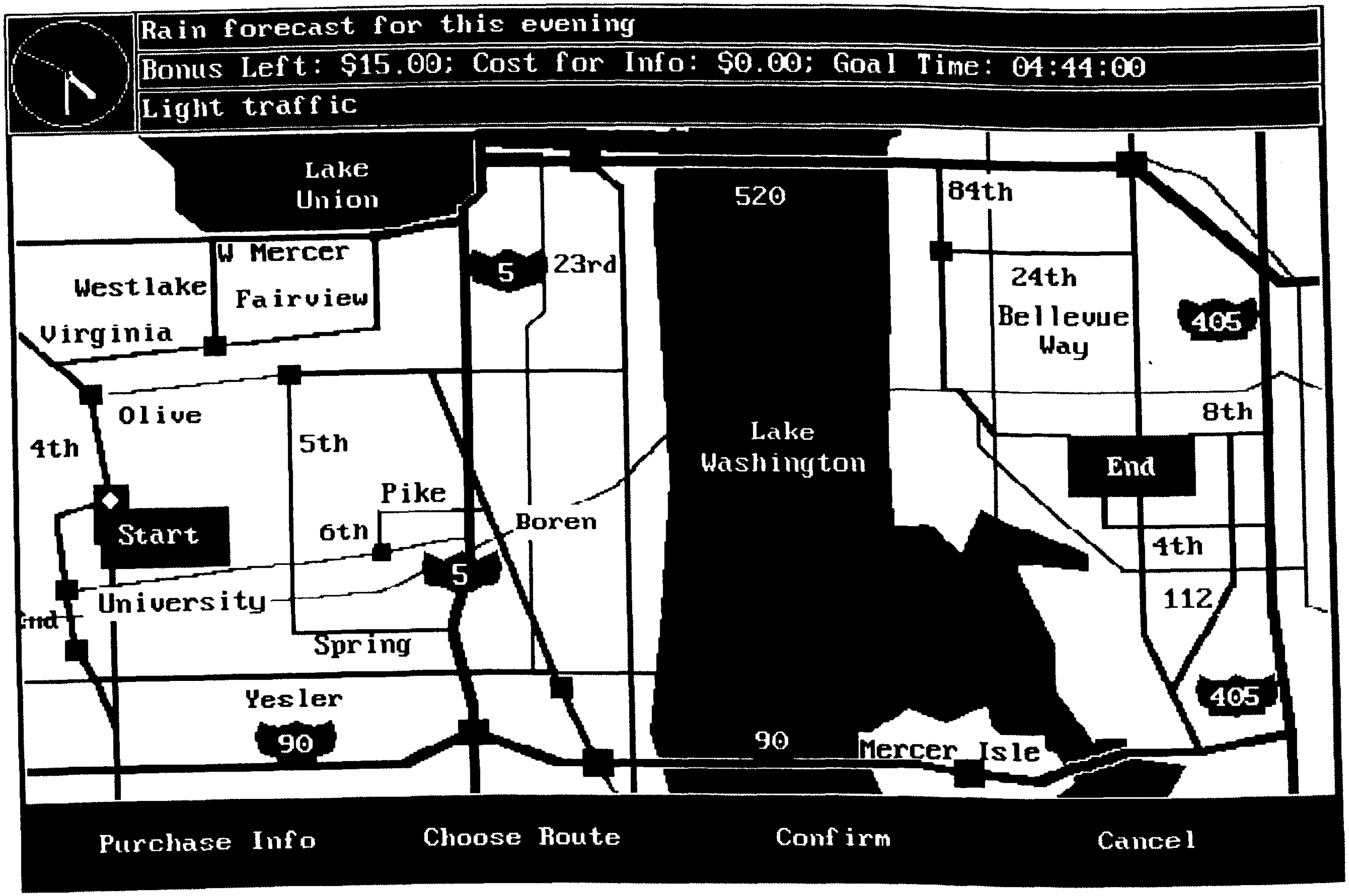


Figure 59. Monitor displaying a computer-generated schematic map.

DISCUSSION

For commercial drivers, there are differences in the perceived job-related value of the 16 ATIS/CVO functions investigated here. Some functions seem to be consistently highly valued, some are consistently judged to be of little or no help on the job, and the ratings for other functions appear to be changed by the presentation of new information. The network analysis identified some of the ways that the functions interconnect in the rating space of job-related value. With these data, we may be able to make some preliminary suggestions about how to configure ATIS/CVO functions for introduction into commercial vehicles and about how to structure training programs.

In the best of all possible worlds, ATIS/CVO technology would be introduced into commercial vehicles, embraced as a good thing, and used successfully and effectively by all drivers. From past product introductions, we know that this will not happen. Commercial drivers will resist some functions that may be inappropriately introduced, like some of the current vehicle tracking systems. For other functions, like the voice communications currently supported by CB radios, there may be instant acceptance of a new mechanism that improves upon a highly valued function. If we follow the general principles that the highest rated functions stand the best chance of being accepted and that the acceptance of less valued functions can be improved by tying them to more highly valued functions, then the data presented here may provide a useful starting point for identifying some of the usable links between functions.

Safety functions received the highest ratings out of all the measures taken here for both driver groups. *Immediate Hazard Warning, Emergency Aid Request*, and *Road Condition Information* are valued functions for both local and long-haul drivers. Therefore, these functions should probably be included in any initial ATIS/CVO release for commercial drivers. From some of the driver comments, the implementation of these functions should be reliable enough so that drivers, for example, do not need to verify road condition information through independent sources. Invalid or stale information will seriously undermine the eventual value of this function. Also, information should be available for any alternative routes that the driver may wish to consider. These drivers pointed out that all drivers approaching traffic congestion would get the same re-routing suggestions which would result in traffic congestion along the alternate route.

Beyond the safety functions, the networks of local and long-haul drivers diverge. Long-haul drivers placed a high value on *Voice/Message Communications* and on *Vehicle/Cargo Condition Monitoring*. These functions are in turn linked to *Route Navigation, Route Selection And Guidance*, and *Route Scheduling*. In many ways, this set of eight functions meets the needs of a long-haul driver who is making his own decisions and managing his own driving schedule over a time span of several days. The safety functions, vehicle monitoring, and navigation functions support the driver in knowing the status of his vehicle and in handling both normal routing and route deviations. The communications function allows contact with others as needed. A training program for long-haul drivers could emphasize these functions and the independence and personal control that they afford. The remaining ATIS functions provide external control over the driver. Company control, customer coordination, and regulatory control could be cast as those necessary evils of commercial driving most of which are buffered through the *Dispatch*

Figure 58 depicts a monitor display of the view one might have driving through Seattle. It shows a real-time video of Seattle roadways that correspond to the route specified by the subject. In addition to the view of the roadway, this monitor also provides a variety of other information. The simulator presents this information at the bottom of the screen (see figure 58) and it includes:

- Average speed of the subject's "car," given as a fixed scale with moving pointer, similar to typical analog automobile speedometers.
- Requested information, both written and oral.
- Traffic information, "free" and extraneous to the route.
- Current time.
- Goal time.
- Bonus amount.
- Current location, the road/highway.

The second monitor displayed the computer-generated schematic map of all permissible routes. Using this map, routes were planned and monitored. Vehicle location en route was represented by the position of a moving blue dot. Since this screen was touch sensitive it also acted as an input device, enabling subjects to request traffic information and control their progress. Four touch-sensitive buttons labeled Purchase Info, Choose Route, Confirm, and Cancel (see figure 59) enabled subjects to collect traffic information about specific links in the street network and "drive" by selecting which links to traverse. Each request for traffic congestion information cost subjects $0.10 and provided them with the traffic density (heavy or light) for the specified link.

Each route was broken into "nodes" and "links." Nodes are located at the beginning of every link and indicate a decision point where a link choice was required. A link is defined as one of several segments that make up a route. At nodes, subjects had the opportunity to select from one to three link choices, with two choices being the most common. On some links, however, decisions at nodes were not required as only one possible link could be selected. Thus, subjects could request traffic information, plan their routes, and select their route using the schematic map. At the same time, they could monitor the roadway, surrounding traffic, and speed on the second monitor just as they might do in an actual car.

Street Network Structure and Bonus Calculation

Figure 60 shows the tree structure of alternate routes. A total set of 26 links was used with each link varying in length from 1 to several streets. Twenty-nine different routes are possible between the origination, Westlake Center, and the destination, Bellevue Square Mall. As Lake Washington is a natural barrier between the origination and destination, the traveler is forced to cross one of two bridges. These routes traverse a variety of roads including congested city streets, four-lane State roads, and Interstates in an urban setting. Table 50 lists the links and corresponding travel times for the entire link set. Trips took approximately 22 min in light traffic and 37 min in heavy traffic.

Origin - 4th & Pine, Seattle
Destination - Bellevue Square Mall, Bellevue

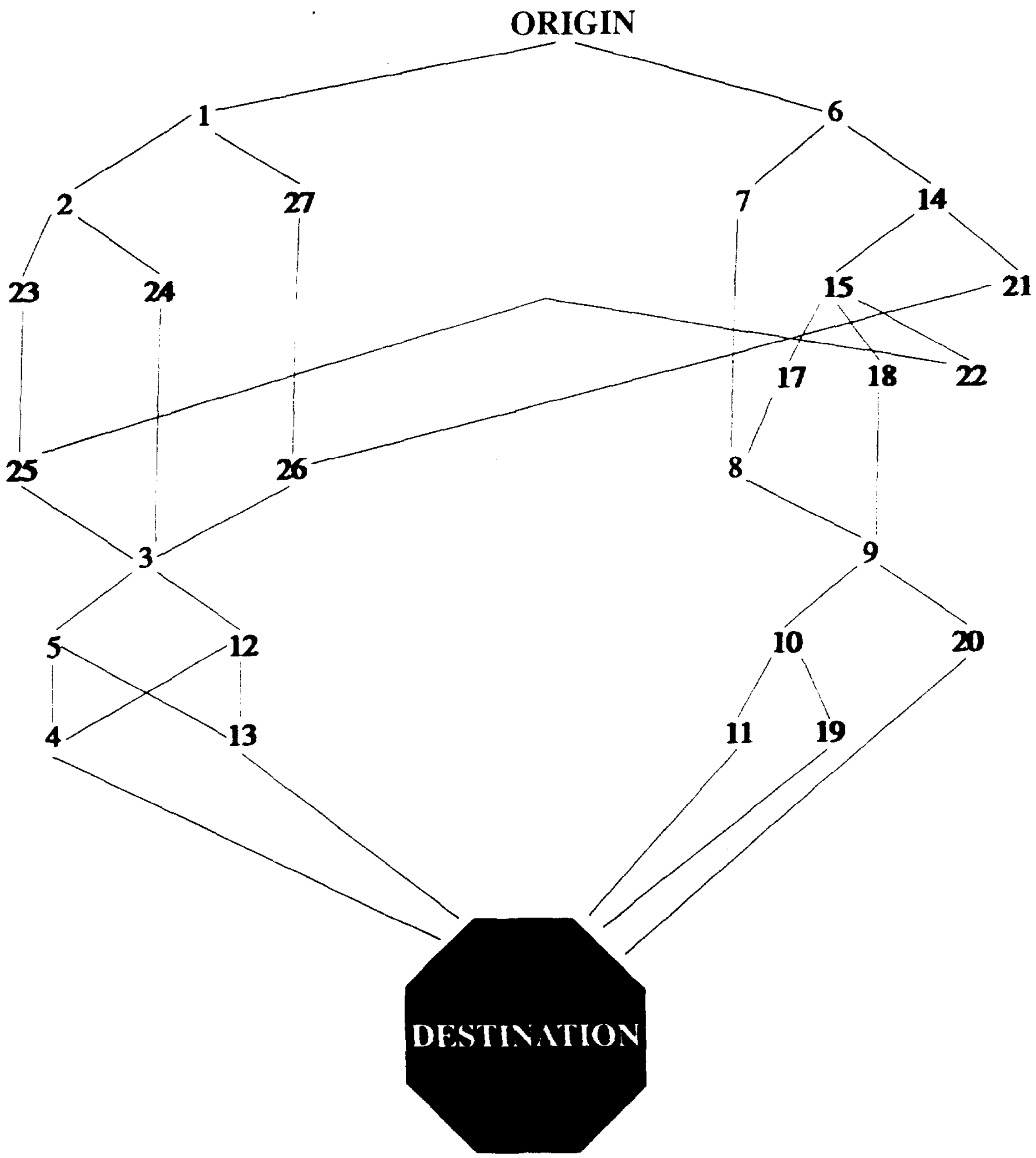


Figure 60. Link tree diagram (actual links used).

Table 50. Link segments for experiment 2.

ORIGIN: Westlake Center, 4th Avenue and Pine Street
DESTINATION: Bellevue Square Mall, N.E. 8th & 100 Avenue N.E.

LINK #	LINK REFERENCE	TIME TO TRAVERSE	BONUS DECREMENT
1	4th Ave. to Pine St. to 2nd Ave.	3:37	0.48
2	2nd Ave. (Cherry St. to Yesler Way)	0:24	0.04
3	I-90 (Boren Ave. to 24th St. exit)	3:49	0.01[1]
4	Bellevue Way (I-90 to N.E. 45th St.)	7:43	0
5	I-90 (24th St. exit to Bellevue Way)	3:04	0
6	4th Ave. (Pine St. to Olive Way)	0:30	0
7	4th Ave. to Fairview Ave. N. to W. Mercer	5:51	1.4
8	I-5 (W. Mercer to SR 520)	12:08	1.72[1]
9	SR 520 (Montlake St. exit to 84th Ave. N.E. exit)	5:16	0.76
10	SR 520 (84th Ave. N.E. exit to Bellevue Way)	1:33	0.32
11	Bellevue Way (SR 520 to N.E. 8th St.)	4:47	0.92
12	W. Mercer to 24th St. to Island Crest Way to S.E. 40th St. to Gallagher St. to I-90	9:04	3.24
13	I-90 to I-405 to N.E. 4th St.	9:55	1.20
14	Olive Way (4th Ave. to 5th Ave.)	0:43	0
15	Olive Way (5th Ave. to Boren Ave.)	2:24	0.48
16	Olive Way to I-5	1:21	0.20
17	Olive Way to John St. to 23rd Ave. E. to 24th Ave. E.	13:06	1.96
18	SR 520 to I-405 to N.E. 8th St.	6:12	2.52
19	SR 520 to 84th Ave N.E. to N.E. 12th St.	5:24	0.76
20	Olive Way to 5th Ave. to Spring St. to I-5	4:28	0
21	Olive Way to Boren Ave.	3:33	0.68
22	Yesler Way (2nd Ave. to Boren Ave.)	3:21	0.76
23	2nd Ave. to 4th Ave. to I-90	5:43	0.76
24	Boren Ave. to Rainier to I-90	3:41	0.72
25	I-5 to I-90	1:39	0
26	2nd Ave. to Cherry St. to 6th Ave. to I-5	8:44	3.12[1]

[1] Bonus decrement after 50 percent deduction applied.

The goal of subjects in this experiment was to maximize the bonus awarded to them. This bonus depended on their ability to minimize the duration of the journey and avoid congestion. Delays associated with a poor route selection or the failure to avoid a congested link decreased the subject's bonus. At the beginning of the driving simulation, the maximum bonus amount was displayed to the subject. If the subject chose the shortest (optimal) route to the destination (and did not select any "heavy" traffic links), the bonus amount displayed reflected the starting bonus minus any amount spent to purchase link information. If the subject deviated from the shortest route, the bonus would decrease.

Each link had an associated cost factor (see table 50). When a link was traversed, this cost factor was subtracted from the bonus amount. For links along the shortest route, these cost factors were zero.. The overall effect was such that longer driving times from start to finish would yield a lower bonus amount.

The cost factors were determined as follows. First, an arbitrary bonus amount was assigned to the longest time route. The difference between this bonus amount and the maximum bonus amount was divided by the time difference between the longest and quickest routes to yield a cost-per-delay time factor. The time for each route was determined. The difference between it and the shortest time route was multiplied by the cost-per-delay time factor to yield a penalty amount. This penalty amount was then divided up proportionally among its associated links (excluding any links belonging to the shortest time route). This proportional penalty was the cost factor.

In addition to the penalty associated with selecting a non-optimal route, the bonus decreased when subjects encountered heavy traffic. Anytime a subject traversed a "heavy" traffic link, the remaining bonus amount was divided by two. This penalty was assessed after first subtracting the cost factor for that particular link.

The bonus available at the start was $20. The cost factors were calculated so that taking the longest time route would cause the bonus amount to drop to $12 if no heavy traffic was encountered. Although a bonus was calculated for each of the four trials, only the highest bonus achieved was actually awarded to the subject.

Traffic Congestion

In order to examine driver behavior in various traffic situations, the RGS was designed with the capability to portray "light" traffic and "heavy" traffic, as well as intermediate levels of congestion. These were defined in terms of *level-of-service* (Transportation Research Board [TRB], 1992). Light traffic, *level-of-service A*, represents a free flow of traffic where individual drivers are unaffected by others present in the traffic stream. Heavy traffic was defined as *level-of-service E* or *level-of-service F*. *Level-of-service E* refers to operating conditions at or near capacity level in which all speeds are reduced to a low, though relatively uniform value. In *level-of-service F*, there is a forced breakdown of traffic flow. Queues occur and operations within a queue are characterized by extremely unstable stop-and-go waves.

Three links of the street network contained "heavy" traffic. One link was a street leading up to a major thoroughfare. The second heavy traffic link was a stretch of road leading to one of the bridges. The third heavy traffic link was the other bridge. The presence of heavy traffic served two primary purposes. First, congested streets added reality to the traffic scenario. As in all major cities in the United States, Seattle is not without heavy traffic and traffic jams. Second, with the knowledge that heavy traffic may confront them, subjects were compelled to utilize the traffic information system. By accessing the up-to-date traffic information, drivers could potentially avoid links with heavy traffic, thereby minimizing their travel time.

Independent Variables

A mixed design with two between-subjects variables (*AGE, GENDER*) and three within-subjects variables (*accuracy of traffic information, repetition of trials, link position*) was used (table 51). Five age groups were recruited, as were equal numbers of males and females.

Table 51. Summary of the independent variables.

INDEPENDENT VARIABLES	LEVELS
Age (Categories)	(1) 18-24
	(2) 25-54
	(3) 55-64
	(4) 65-74
	(5) >75
Gender	(1) Male
	(2) Female
Accuracy Level of Traffic Information	(1) 100% accurate
	(2) 77% accurate
Repetition	(1) First repetition
	(2) Second repetition
Link Position	(1) First link
	(2) Second link
	(3) Middle link
	(4) Second to last link
	(5) Last link

Each driver traveled from Seattle to Bellevue four times. Drivers selected links and had the option of purchasing traffic information for any desired link. This information was manipulated to be accurate (i.e., heavy traffic reported and heavy traffic encountered or light traffic reported and light traffic encountered) or inaccurate (i.e., light traffic reported and heavy traffic encountered or heavy traffic reported and light traffic encountered). In the first two journeys (trials), subjects received traffic information from the navigation system that was 100 percent accurate. That is, 26 of the 26 available pieces of link information were accurate. In the third and fourth trials, only 77 percent of the information provided was accurate. In other words, only 20 of the 26 available pieces of information were accurate. However, as subjects controlled the path of the car, the actual accuracy that each subject experienced varied. *Link position* refers to the number and order of links selected in traversing the route. Subjects completed a minimum of five links and a maximum of eight links. Where subjects required more than five links to traverse the route, the middle links were averaged. Thus the term "middle link" in some cases may refer to just the third link if five links were selected, or the average of links three, four, five, and six if eight links were selected.

Dependent Variables

Table 52 summarizes the objective and subjective dependent variables measured throughout the experiment. A record of the links selected at each node was made in order to determine the route chosen. At each node, decision times were recorded for purchasing information, link selection, and link travel duration. Whether or not information was purchased for any given link was also logged. The bonus that subjects received for quick route completion refers to the end bonus achieved when penalties and information costs were subtracted. Both the total trip penalty costs and the information costs were recorded independently. The time to complete the route was the total time to get from origination to destination. This total time included decision, route selection, and travel times. Finally, calculated percent convergence with the baseline route refers to the amount of similarity between the links in the route traveled and the links in the baseline route. As a baseline, drivers indicated their preferred route prior to beginning the first of the four trials. The links for each route of the four trials were compared to the links in the baseline route. A calculation of the percent route convergence was made for each trial by counting the number of matching links between the trial and baseline routes. For example, on any given trial, a driver who had no matching links had zero percent route convergence. When there were six baseline links, a driver who had three links had a route convergence of 50 percent. A driver who precisely followed the baseline route had a route convergence of 100 percent.

Table 52. List of dependent variables for experiment 2.

OBJECTIVE DEPENDENT VARIABLES	SUBJECTIVE DEPENDENT VARIABLES
Links selected	Trust in the technology
Route selected	Self-confidence in navigating ability
Time selections/decisions were made	Traffic expectations
Occurrence and accuracy of purchased link information	Trust minus self-confidence
Bonus received for route completion	
Penalty costs for non-optimal link selection and traversing heavy traffic links	
Cost for purchasing information	
Time to complete route	
Convergence to baseline route	

Trust in technology, self-confidence in navigation ability and traffic expectations were measured after each link via the questionnaire, *Inter-link Questions* (appendix D, p. 276). The three questions were rated on a 0-100 scale, and administered after every link. A new variable, *trust minus self-confidence*, was calculated from each inter-link administration by subtracting rated *self-confidence* from rated *trust*. This variable was created to examine subject's acceptance of automated control. Lee and Moray (1994) showed that when *trust* exceeds *self-confidence* operators accept automated control. Conversely, when *self-confidence* exceeds *trust* operators use manual control.

Experimental Procedure

In total, eight questionnaires were administered during the experiment. Table 53 shows the sequence in which they were administered.

Table 53. Sequence of questionnaires administered.

QUESTIONNAIRES	TIME ADMINISTERED				
	PHONE	PRE-TEST	INTER-LINK	POST-100% ACCURATE Trial 2	POST-77% ACCURATE Trial 4
Subject's Familiarity With Driving in Seattle Pre-Selection Phone Questionnaire	✓				
Demographic Characteristics Questionnaire (Phone)	✓				
Driver Demographic Characteristics		✓			
Trust & Self-Confidence in ATIS Technology		✓			
Inter-Link Questions (Trust, Self-Confidence and Expectations)			✓		
Modifying Your Trip to Avoid Traffic				✓	✓
Trust in the Route Guidance System				✓	✓
Demonstration Fidelity					✓

Background Questions and Instructions

The initial screening of participant suitability was done by telephone. The *Subject's Familiarity With Driving in Seattle: Pre-Selection Phone Questionnaire* (appendix D, p. 267) and the *Demographic Characteristics Questionnaire (Phone)* (appendix D, p. 268) were administered at that time. The purpose of the Seattle driving familiarity questions was to ensure a homogeneous subject population in terms of Seattle driving knowledge and experience. Potential subjects who either did not have an active driver's license, were unfamiliar with driving in Seattle, or drove less than once per week in Seattle were eliminated from the subject pool. Those individuals who did have sufficient Seattle driving familiarity were asked a series of demographic characteristics questions and scheduled for a testing time. The demographic questionnaire was given during the telephone interview to reduce the amount of questions asked during the testing session.

At the testing site, subjects filled out a written consent form and completed the questionnaire *Driver Demographic Characteristics* (appendix D, p. 270). The demographic information solicited at this time was of a sensitive nature (e.g., income) and, therefore, was not asked over the phone. The questionnaire *Trust & Self-Confidence in ATIS Technology* (appendix D, p. 274) was completed next.

Subjects began the experiment by listening to instructions about their goal, task, computers, route choice, rewards, and costs. The drivers were instructed to plan and execute a trip from the Westlake Center to the Bellevue Square Mall on a Friday afternoon at 4:30 pm so as to arrive in the least amount of time possible. Subjects were told that heavier traffic density (congestion) typically resulted in longer driving times. Brief instructions were given about the computers and how to choose routes and purchase information. In addition to being paid $10 per hour, subjects had the opportunity to earn bonus money for quick route completion. This served to motivate subjects to use the route guidance system in order to avoid heavy traffic. Subjects could also incur travel expenses, which were deducted from a starting maximum bonus of $20. The expenses included purchasing information ($0.10); choosing a non-optimal link (approximately $1.50); and selecting a link with "heavy" traffic (existing bonus cut in half).

After listening to the instructions, the two computer screens were presented. An explanation was given of the digitized windshield roadway view and of the schematic map with the four touch screen buttons labeled Purchase Info, Choose Route, Confirm, and Cancel. It was explained that Purchase Info allowed the subject to buy traffic information on the various links, and despite reducing the bonus, it might be beneficial to purchase information pertaining to upcoming links. In this way, heavily congested links might be avoided and those where the traffic was light could be selected.

Prior to starting the simulation, drivers were given a conventional paper map. The map contained all possible route options that would be available during the driving simulator portion of the experiment and corresponded to the computer-generated map that would be used during the experiment. The experimenter pointed out the start (Westlake Center) and end points (Bellevue Square Mall), and the available route options were highlighted in orange. Using a red marker, subjects traced the route that they would prefer to take (baseline) at 4:30 pm on a Friday afternoon. No extra traffic information was provided during this baseline segment.

The purpose of having subjects indicate their baseline preference route was twofold. First, providing a map helped to orient drivers with the area to be traveled. Second, this baseline data would later be compared to the actual routes traversed (i.e., *percent convergence*).

Route and Link Selection

Once the baseline route was recorded, subjects began the practice trial(s) to become familiar with the simulator. This practice trial was repeated until two criteria had been met. First, the subject, when asked, must have stated that he or she felt comfortable using the simulator, purchasing information, and choosing routes. Second, the subject must have demonstrated an ability to purchase information correctly, to choose a route successfully three consecutive times, and to complete at least one practice trial from start to finish. Having satisfied practice criteria, the four experimental trials were presented to each subject in the same order. Trials 1 and 2 presented 100 percent accurate purchased traffic information, while trials 3 and 4 presented 77 percent

Sequence of Experimental Trials

All drivers were involved in four trials. No breaks or pauses were taken at the completion of the first trial. At the end of the second trial, the simulation was paused and drivers were administered the questionnaires titled *Modifying Your Trip to Avoid Traffic* (appendix D, p. 277) and *Trust in the Route Guidance System* (appendix D, p. 279). At the completion of the third trial, no breaks or pauses were taken. At the end of the fourth trial, in addition to the questionnaires *Modifying Your Trip to Avoid Traffic* and *Trust in the Route Guidance System*, the questionnaire *Demonstration Fidelity* (appendix D, p. 282) was given. Each trial lasted approximately 30 min. All subjects completed the entire experiment in under 3 h. Breaks taken for personal reasons (e.g., restroom) were allowed between trials. Upon completion of the final questionnaire, the experimenter reviewed the four bonuses achieved and the highest was documented on a subject payment form. The experimenter then answered any questions the drivers had, the total payment for participation was calculated, and the drivers were escorted out of the building.

RESULTS

Three objective dependent variables (*information cost, penalty cost, and percent convergence of links traversed compared to the baseline route*) and four subjective ratings dependent variables (*trust in the route guidance system, self-confidence, expectations of traffic conditions*, and a variable created from subtracting the self-confidence rating from the trust rating - *trust minus self-confidence*) were examined in the analyses. ANOVA tables are presented in appendix E (pp. 293-297). Drivers could traverse the route by selecting from five to eight links (most trips used six or seven links). In order to examine these routes collectively, the middle links for routes with six, seven and eight links were combined. In this way, all routes could be analyzed together as if there were five link positions for all routes. Additional analyses, not presented here, were also conducted separately for each route without combining middle links; no additional insights were revealed.

Information Cost

The four successive trials for each driver were analyzed as a 2 x 2 combination of *accuracy* and *repetition* (see table 54).

Table 54. Analysis of trials: Cell entries are trial ordinal position.

	REPETITION	
ACCURACY	1	2
100%	1	2
77%	3	4

Figure 61 shows mean *information cost*, cost averaged across an entire trial, for each level of *information accuracy* as a function of *repetition*. For the 100 percent information accuracy trials, mean information costs were \$0.65 for repetition 1 and \$0.86 for repetition 2. For the 77 percent information accuracy trials, mean information costs were \$0.81 for repetition 1 and \$0.77 for repetition 2. An interaction between *information accuracy* and *repetition* indicates that as drivers went from the 100 percent information accuracy trials to the 77 percent information accuracy trials, the purchasing of information increased for repetition 1 and decreased for repetition 2, $F(1,46) = 9.65, p < 0.01$.

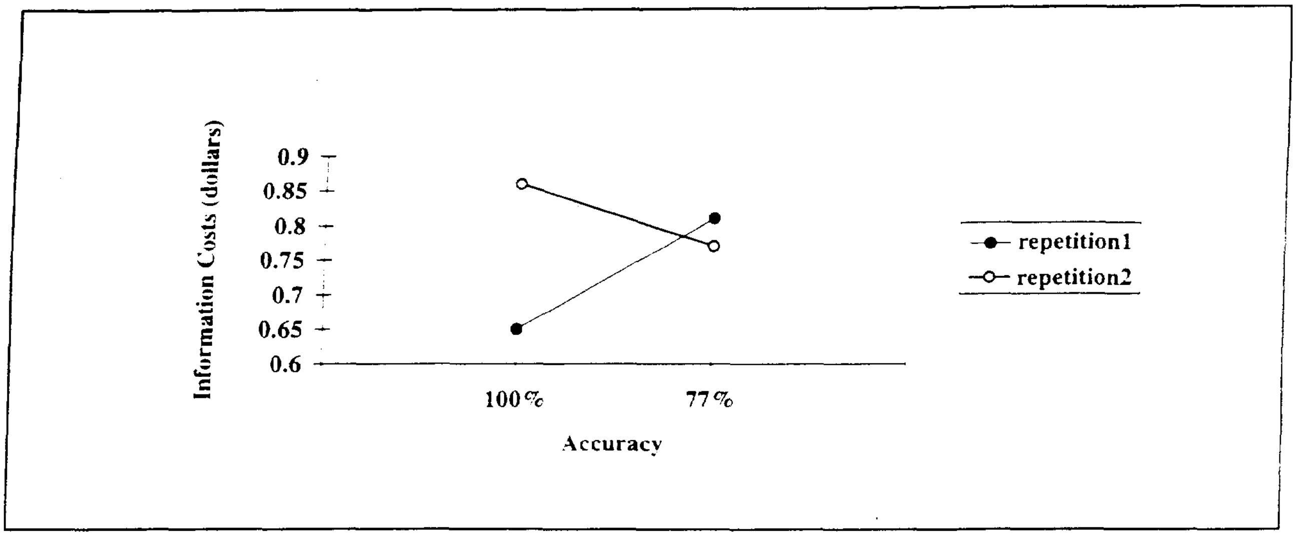


Figure 61. Mean purchased information costs as a function of repetition.

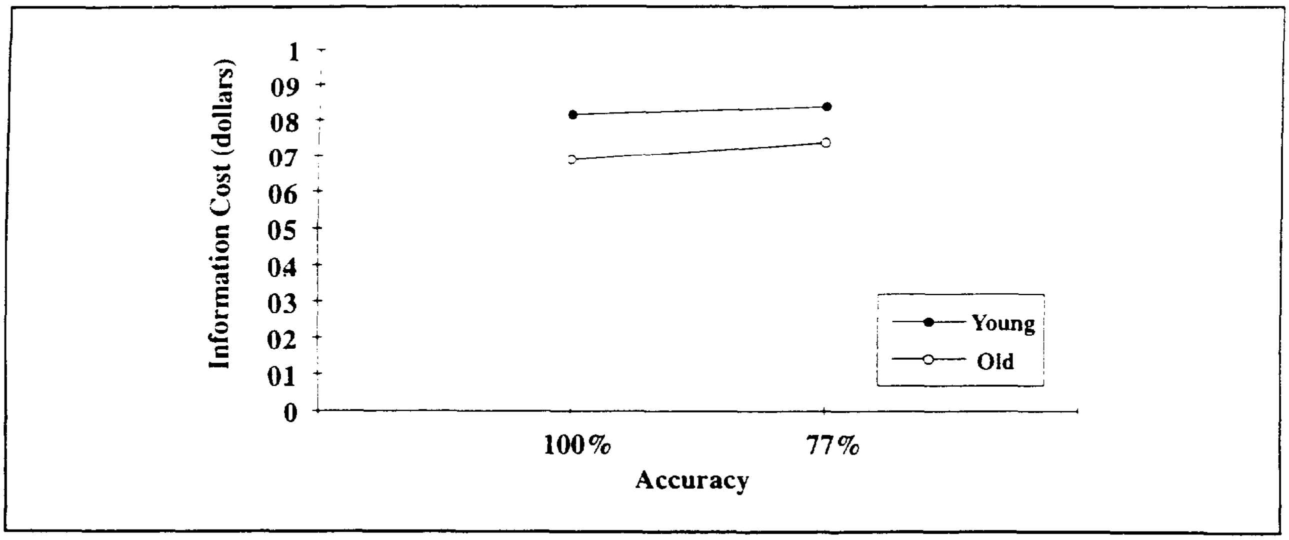


Figure 62. Information cost as a function of age and accuracy.

Figure 62 shows mean information cost for each level of *information accuracy* as a function of *AGE*. As can be seen, the *AGE x information accuracy* interaction did not prove to be significant, $F(1,46) = 0.05$, $p > 0.05$. Additionally, there was no significant effect of *AGE*, $F(1,46) = 1.41$, $p > 0.05$. This shows that older drivers purchased information as much as younger drivers. Therefore, any *AGE* effects cannot be attributed to the older drivers' lack of use of ATIS technologies.

Penalty Costs

Figure 63 shows mean *penalty costs* for each level of *information accuracy* as a function of *AGE*. For the 100 percent information accuracy trials, mean penalty costs were $8.48 for younger drivers and $10.86 for older drivers. For the 77 percent information accuracy trials, mean penalty costs were $12.37 for younger drivers and $11.92 for older drivers. An ANOVA indicated four significant results. First, older drivers incurred higher penalty costs than younger drivers, $F(1,46) = 4.53$, $p < 0.05$. Second, penalty costs increased when drivers received inaccurate information, $F(1,46) = 32.42$, $p < 0.001$. Third, an interaction between *AGE* and *information accuracy* shows that younger drivers incurred lower penalty costs during the 100 percent information accuracy trials, $F(1,46) = 10.56$, $p < 0.01$.

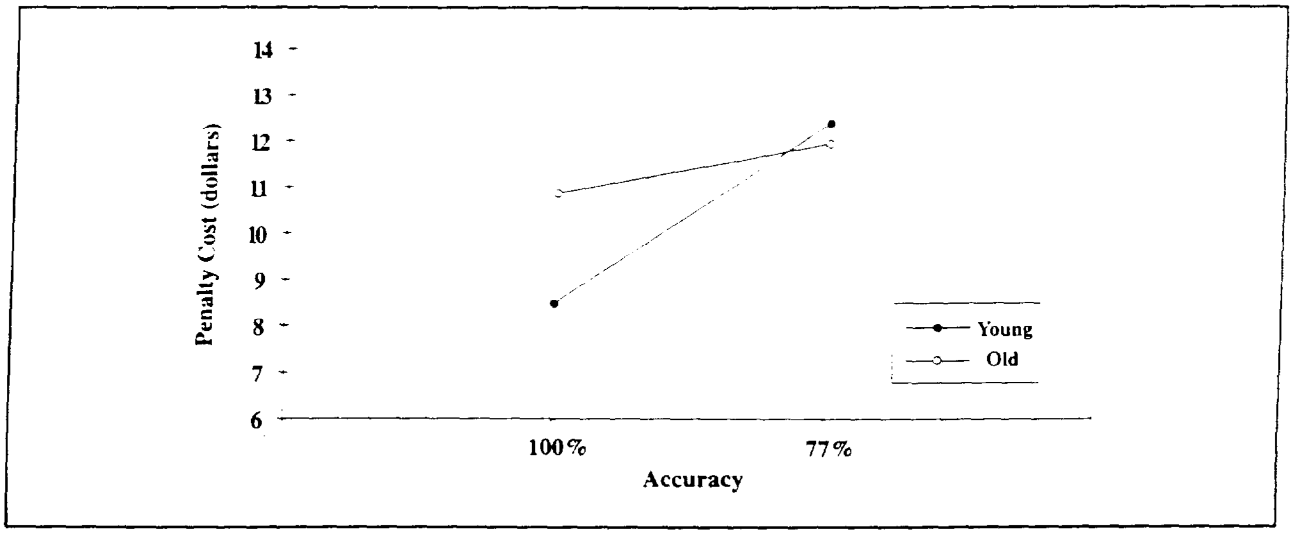


Figure 63. Mean penalty costs as a function of age and accuracy.

Fourth, a significant interaction between *information accuracy* and *repetition* (figure 64) shows that penalty costs increased as drivers went from the 100 percent information accuracy trials to the 77 percent information accuracy trials and that this increase was greater for repetition 2 than for repetition 1, $F(1,46) = 5.03$, $p < 0.05$.

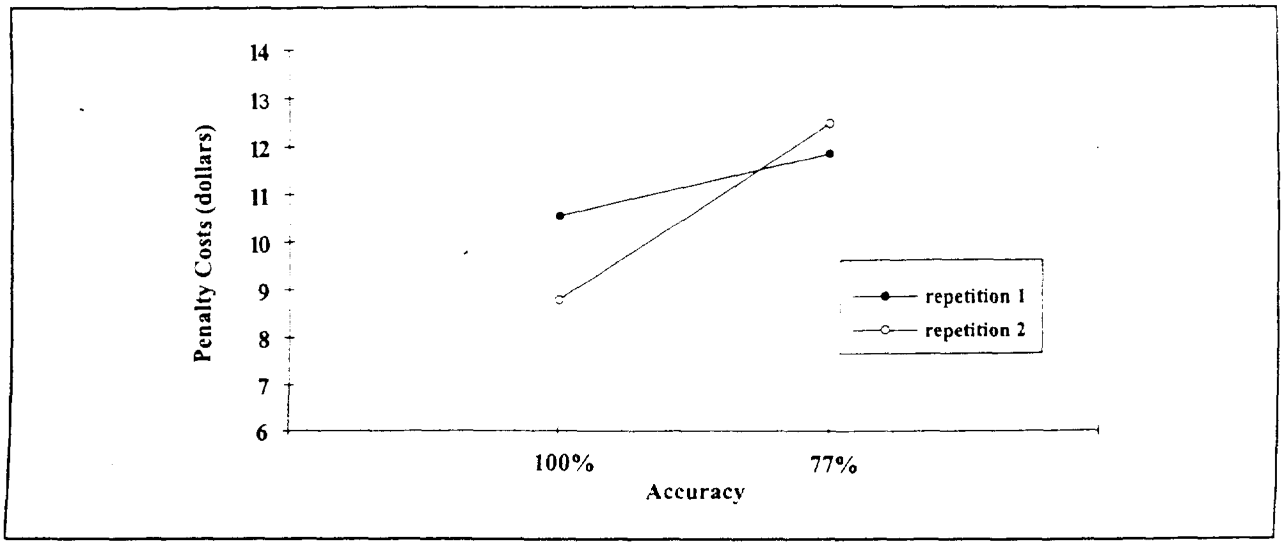


Figure 64. Mean penalty costs as a function of accuracy and repetition.

Convergence

Figure 65 shows mean percent *convergence of links traversed* compared to the baseline route as a function of *information accuracy* and *AGE*. Recall that 100 percent convergence consists of a driver precisely following the indicated pre-trial baseline route. Additionally, zero percent convergence consists of a driver deviating completely from the baseline route. For the 100 percent information accuracy trials, mean convergence was 48.8 percent for younger drivers and 52.7 percent for older drivers. For the 77 percent information accuracy trials, mean convergence was 30.7 percent for younger drivers and 33.6 percent for older drivers. Subjects were less likely to follow their baseline route in trials where the information received was inaccurate, $F(1,46) = 11.93, p < 0.001$.

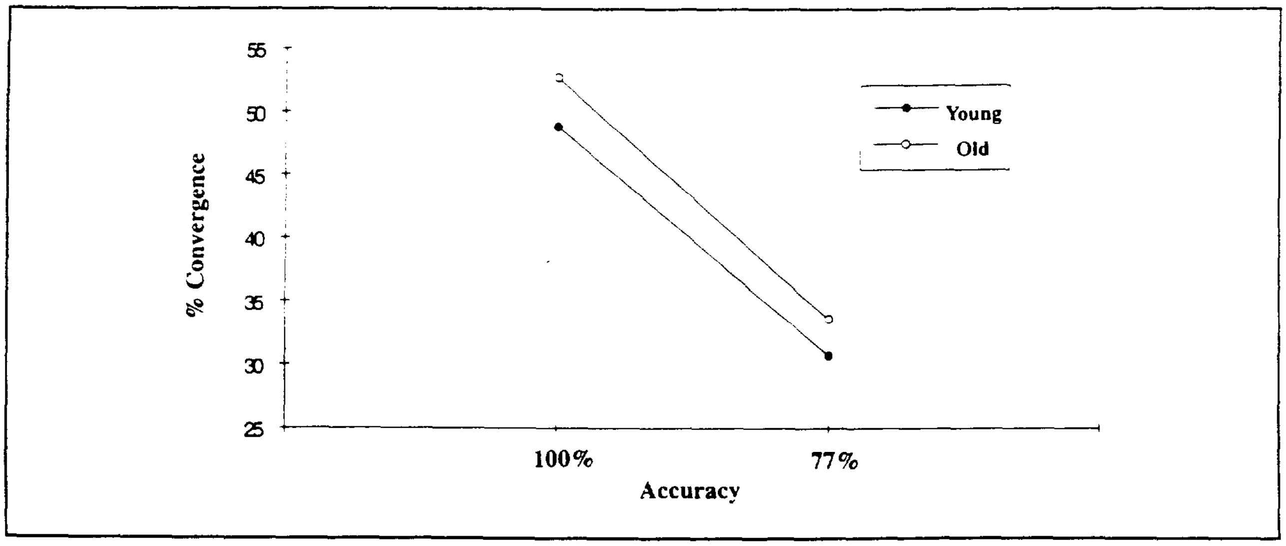


Figure 65. Percentage agreement with baseline route as a function of age and accuracy.

Figure 66 shows a frequency analysis of the number of cases of route convergence, partial convergence, and non-convergence with the pre-trial baseline across all trials for younger and older drivers. Zero and 100 percent convergence levels were chosen as they represent true endpoints. Younger drivers completely deviated from the baseline route (0 percent convergence) on 30 of 96 trials, while older drivers deviated on 23 of 96 trials. Younger drivers precisely followed their baseline routes (100 percent convergence) on 5 of 96 trials, whereas older drivers followed on 10 of 96 trials. Most trials showed partial convergence, with younger drivers following some of their baseline routes on 61 of 96 trials, while older drivers also followed some links on their baseline route on 63 of 96 trials. These differences in *convergence* were statistically reliable, $F(2,92) = 63.2$, $p < 0.001$.

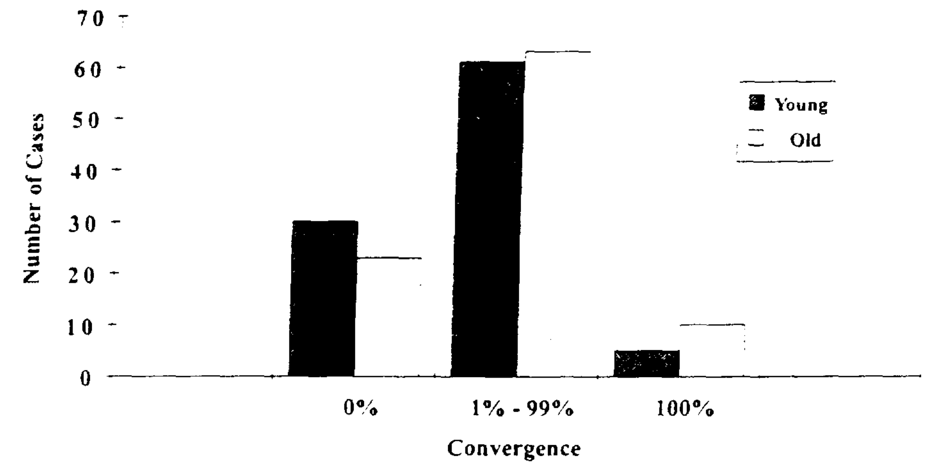


Figure 66. Number of cases of route convergence or non-convergence with pre-trial baseline across all trials.

Trust in the Route Guidance System (Inter-Link)

Figure 67 shows *trust* (rated on a scale from 0, low trust, to 100, high trust) in relation to *repetition* and *information accuracy*. For the 100 percent information accuracy trials, mean rated trust was 78.5 for repetition 1 and 83.9 for repetition 2. For the 77 percent accuracy trials, mean rated trust was 80.3 for repetition 1 and 78.8 for repetition 2. An ANOVA indicated five significant results. First, subjects rated trust in the route guidance system higher in repetition 2 than in repetition 1, $F(1,46) = 6.21$, $p < 0.05$.

Second, figure 67 also indicates a significant interaction between *information accuracy* and *repetition*, $F(1,46) = 22.5$, $p < 0.001$. This interaction shows that when subjects go from repetition 1 to repetition 2, rated trust increased for the 100 percent information accuracy trials and decreased for the 77 percent information accuracy trials. Note that repetition 1 in the 77 percent accuracy trial is the first journey where drivers are given inaccurate information after being given completely accurate information in the previous two trials.

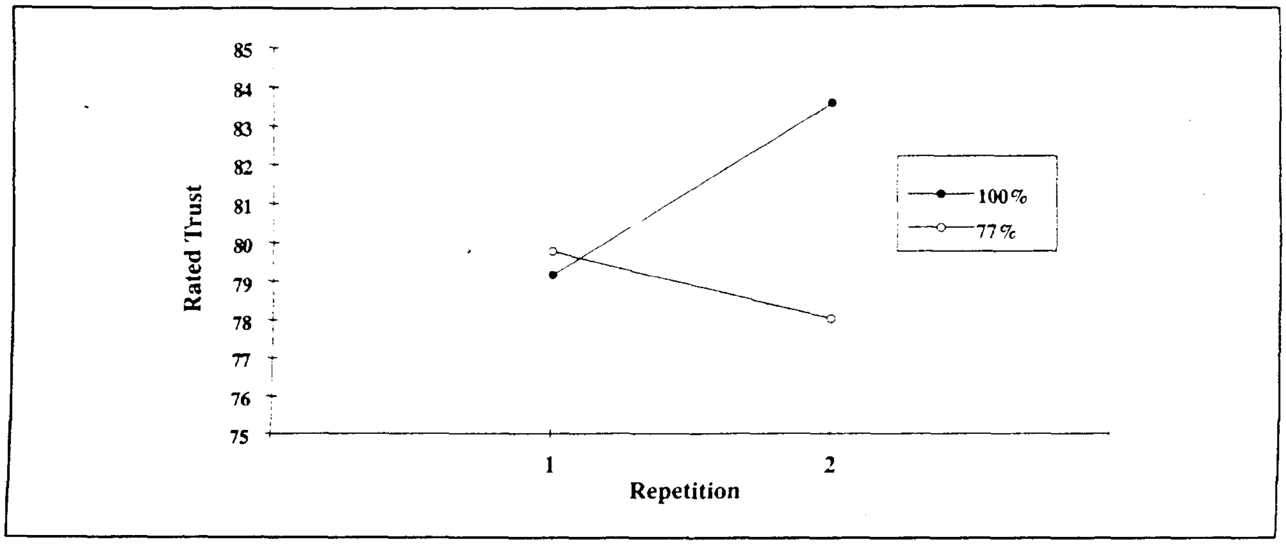


Figure 67. Mean rated trust as a function of information accuracy and repetition.

Third, an interaction between *information accuracy* and *link position* (figure 68) shows that trust continually increases, with each successive link, when drivers traverse the 100 percent information accuracy trials but decreases sharply when subjects are given inaccurate traffic information (in the middle links), $F(1,46) = 16.12$, $p < 0.001$.

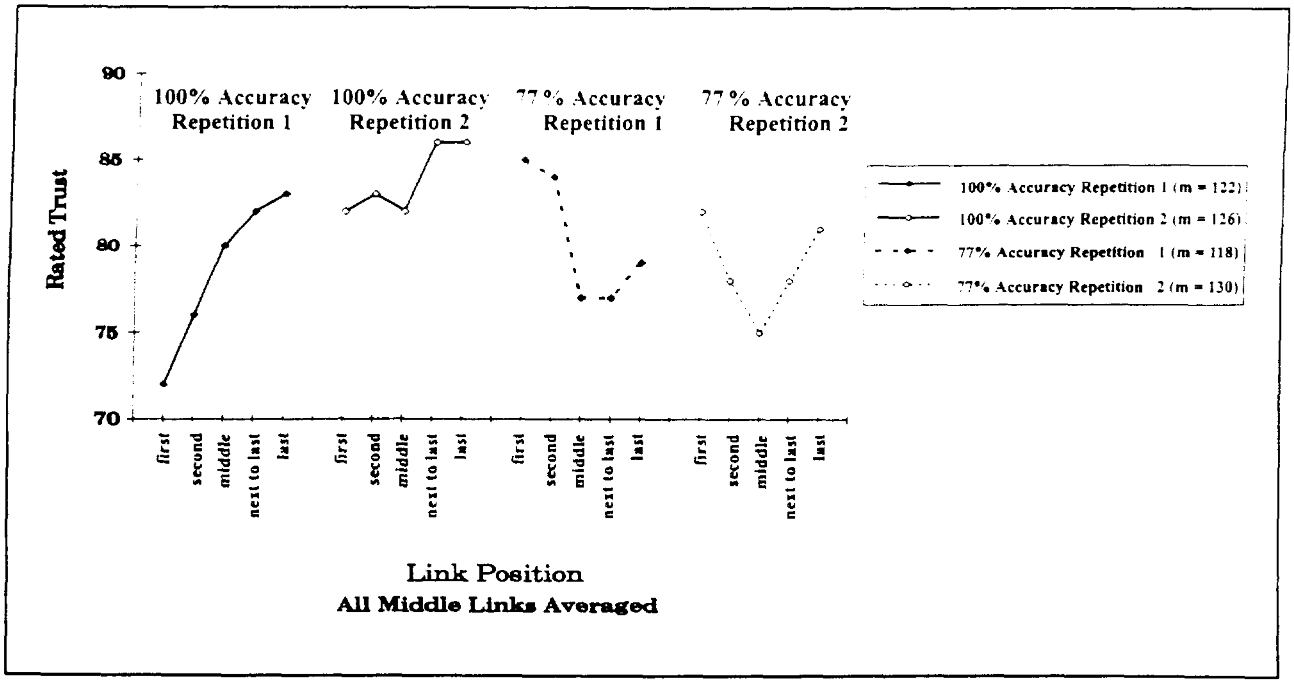


Figure 68. Mean rated trust as a function of information accuracy and link position.

Fourth, figure 69 shows a significant effect of *link position*. On middle links, when subjects were given inaccurate information, rated trust of the route guidance system decreased, $F(4,184) = 4.0$, $p < 0.01$. Multiple t-tests were conducted to compare the middle link, when subjects received inaccurate information, to all other links (table 55).

The middle link, where the inaccuracies occurred, was compared to each of the other four links. Across levels of *information accuracy*, only the second link in the 100 percent information accuracy trials and next-to-last link in the 77 percent information accuracy trials failed to differ from the middle link ($p > 0.05$).

Fifth, figure 68 outlines a three-way interaction among *information accuracy, repetition*, and *link position*, $F(4,184) = 6.11, p < 0.001$. The parameter m indicates the number of links averaged in the middle link. Trust increased for the 100 percent accuracy trials and decreased for the 77 percent accuracy trials when inaccurate information was presented.

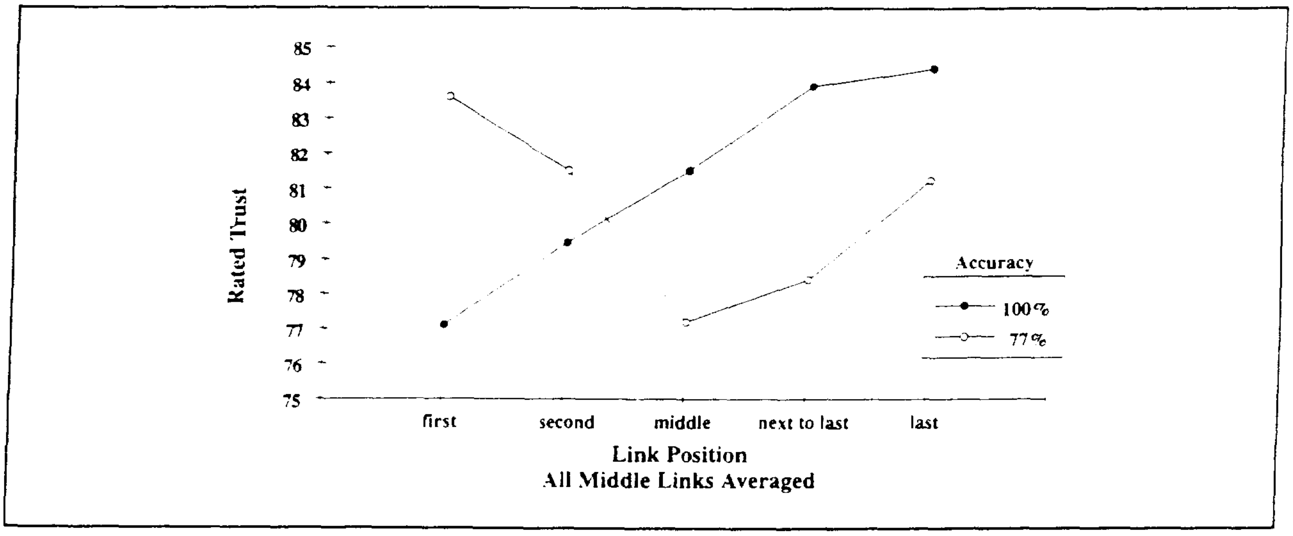


Figure 69. Mean rated trust as a function of link position.

Table 55. Multiple t-tests for information accuracy: Middle links versus other links.

	100% INFORMATION ACCURACY		77% INFORMATION ACCURACY	
	t(184)	**Probability in Two Tails**	**t(184)**	**Probability in Two Tails**
First	2.99	p < 0.01	-5.43	p < 0.001
Second	1.23	p > 0.05	-3.71	p < 0.001
Next to last	-2.14	p < 0.05	-0.97	p > 0.50
Last	-2.49	p < 0.02	-2.92	p < 0.01

Figure 70 is a bar graph outlining mean *trust* ratings for younger and older drivers based on purchased link information. When information was purchased, mean *trust* ratings were identical

(79.9) for younger and older drivers. When no information was purchased, mean *trust* ratings were 83.2 for younger drivers and 77.7 for older drivers. An ANOVA indicated a significant *AGE* effect, $F(1,1260) = 5.13, p < 0.05$, and a significant *AGE x link information* interaction, $F(1,1260) = 9.01, p < 0.01$.

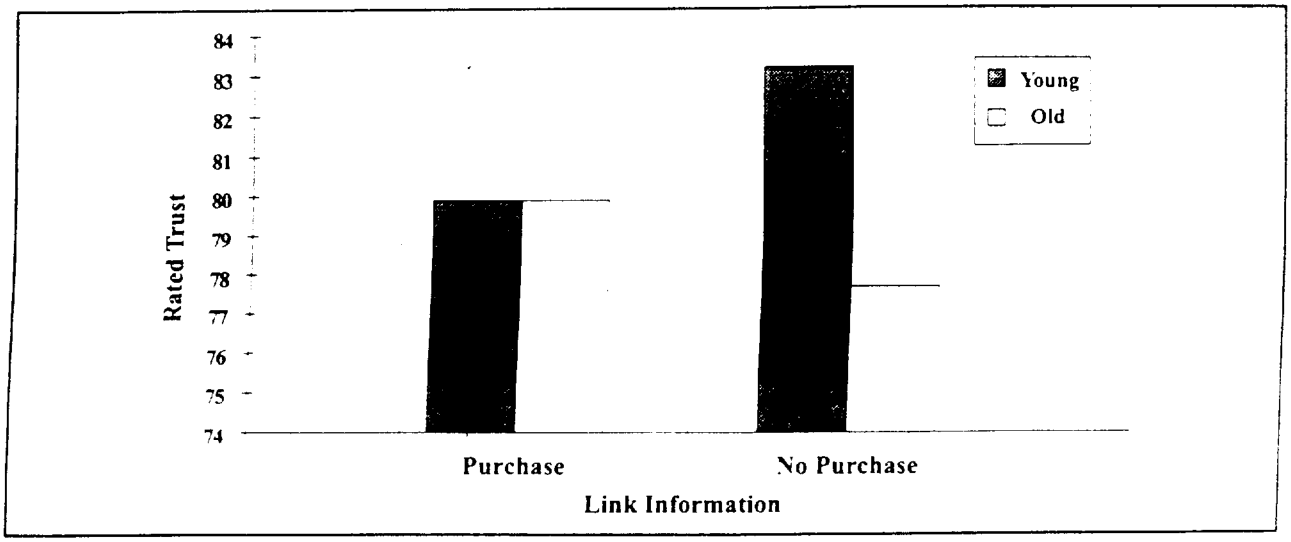


Figure 70. Mean rated trust as a function of age and purchased link information.

Figure 71 outlines mean *trust* ratings for younger and older drivers given the four types of information purchased during the 77 percent accurate trials: (1) no information, (2) accurate information, (3) harmless inaccurate information (told "heavy traffic" when really light traffic), and (4) harmful inaccurate information (told "light traffic" when really heavy traffic). When no information was purchased, trust ratings were 84.3 for younger drivers and 80.8 for older drivers.

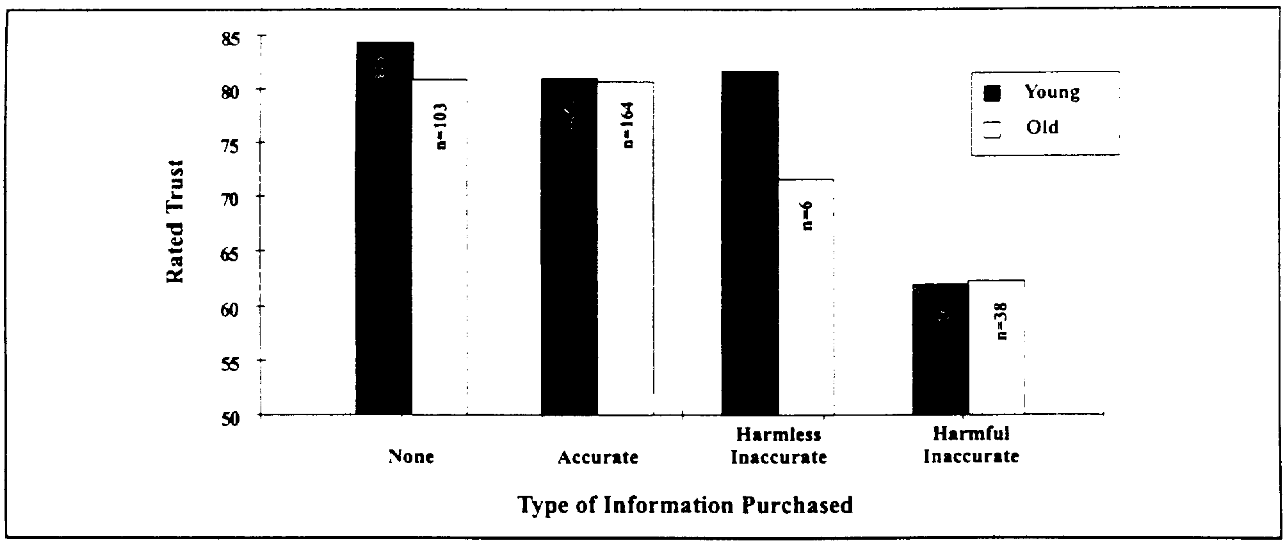


Figure 71. Mean rated trust as a function of age given the type of information purchased for the 77% accurate trials.

When the information purchased was accurate, mean trust ratings were 80.9 for younger drivers and 80.6 for older drivers. When drivers were told that the traffic was heavy when it was actually light, trust ratings were 81.6 for younger drivers and 71.6 for older drivers. And when drivers were told that traffic was light when it was actually heavy, trust ratings were 61.8 for younger drivers and 62.1 for older drivers. An ANOVA indicates a significant *type of information purchased* main effect, $F(3,624) = 36.6, p < 0.001$.

Self-Confidence in Ability to Accurately Anticipate Traffic Conditions (Inter-Link)

Figure 72 is a bar graph outlining mean *self-confidence* ratings for younger and older drivers on purchased link information. When information was purchased, mean self-confidence ratings were 66.2 for younger drivers and 73.8 for older drivers. When no information was purchased, mean self-confidence ratings were 73.2 for younger drivers and 69.6 for older drivers. An ANOVA indicated a significant *AGE* effect, $F(1,1260) = 11.3, p < 0.001$, and a significant *AGE x link information* interaction, $F(1,1260) = 25.8, p < 0.001$.

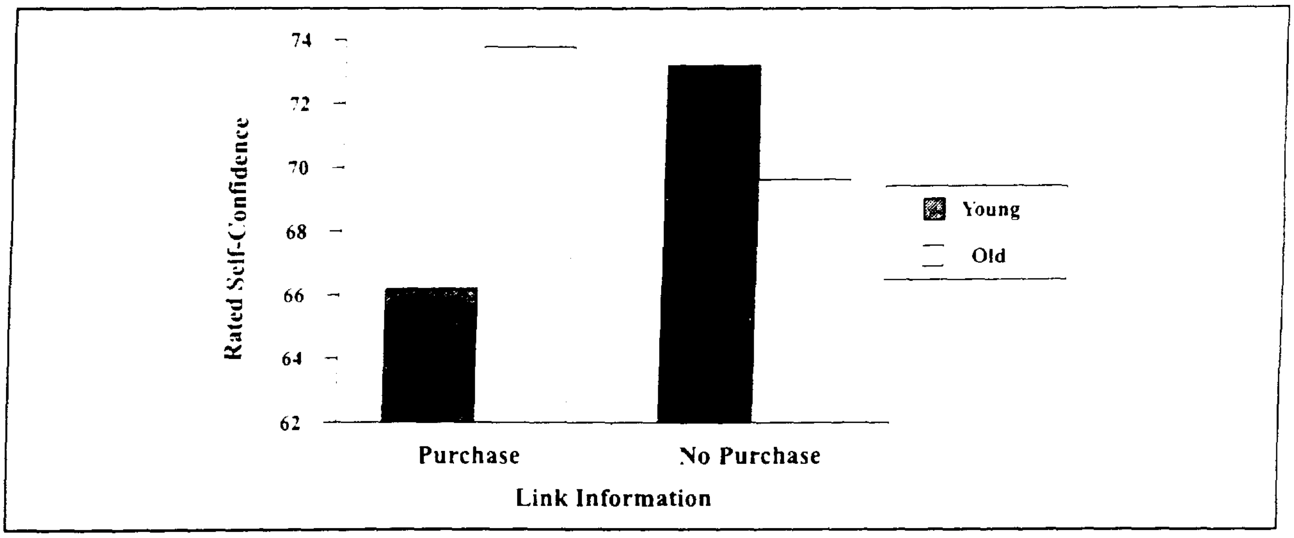


Figure 72. Mean rated self-confidence as a function of age and purchased link information.

Figure 73 illustrates mean *self-confidence* ratings for younger and older drivers given the type of information purchased during the 77 percent accurate information trials: none, accurate, harmless inaccurate, harmful inaccurate. Self-confidence ratings significantly differed for older (68.8) versus younger (70.9) drivers, $F(1,624) = 8.13, p < 0.01$. Additionally, *type of information purchased* was significant, $F(3,624) = 4.28, p < 0.01$.

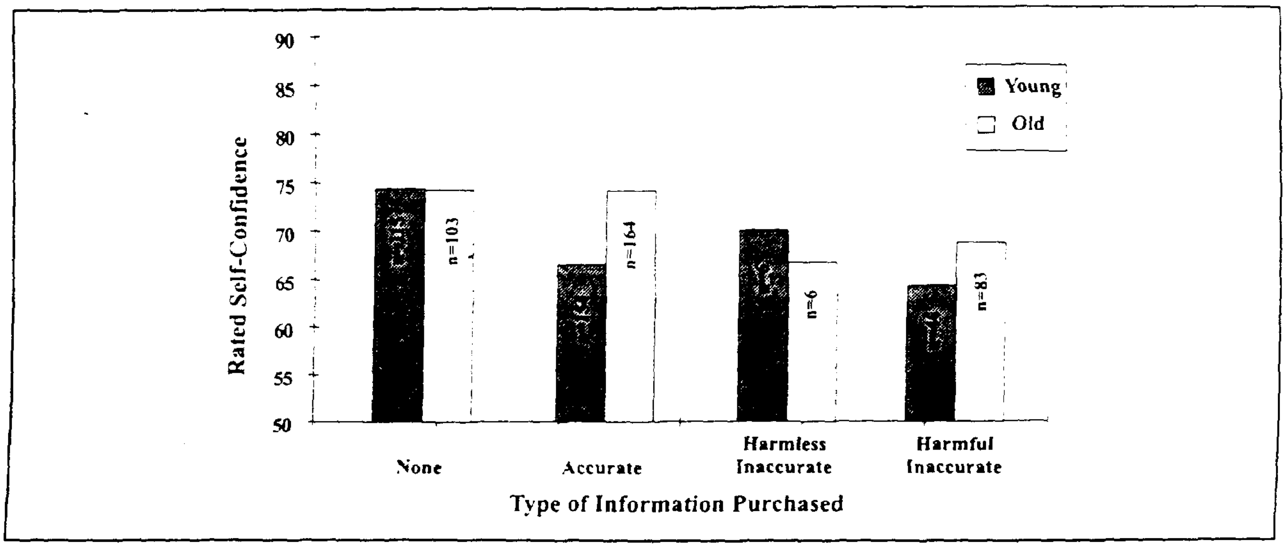


Figure 73. Mean self-confidence ratings as a function of age given the type of information purchased for the 77% accurate trials.

Traffic Expectations (Inter-Link)

Figure 74 outlines mean rated *traffic expectations* for drivers as a function of the availability of accurate information and whether or not drivers purchased this information.

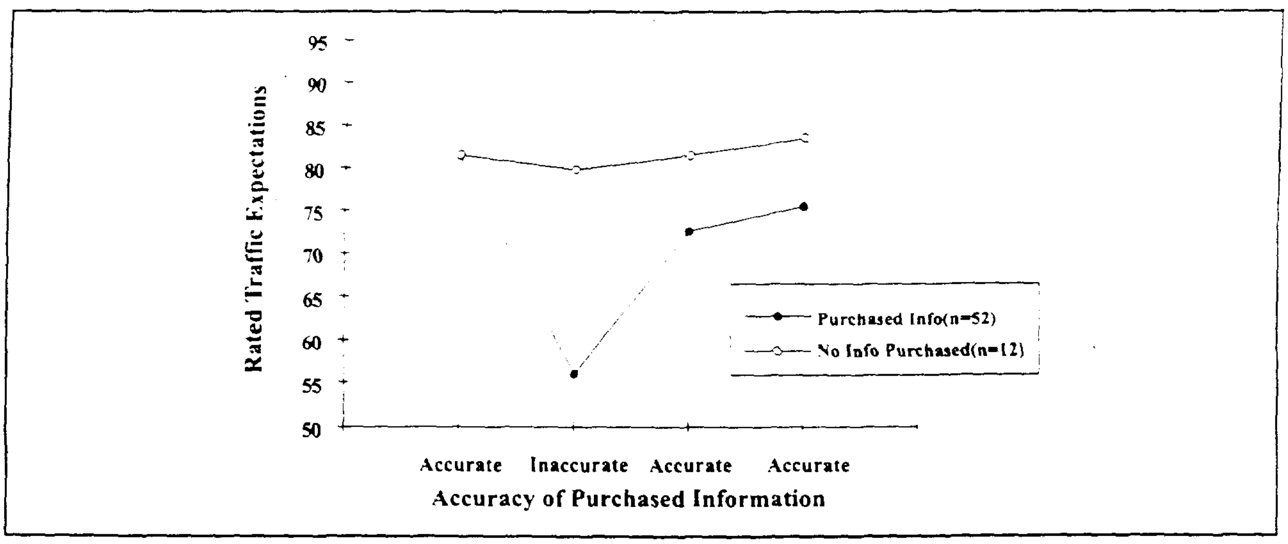


Figure 74. Mean rated traffic expectations as a function of accurate information availability and the purchasing of that information.

"Accurate" and "inaccurate" values along the abscissa indicate the accuracy of information following the sequence, from left to right, that drivers encountered. The "accurate" value on the far left represents accurate information links preceding inaccurate information links. The "accurate" value immediately preceding the "inaccurate" value represents accurate information links that directly followed inaccurate information links. Finally, the far right "accurate" value represents accurate information links that followed one link past the inaccurate information links. The most striking result occurred when drivers purchased inaccurate information. In this instance, drivers' expectations of the traffic conditions were dramatically reduced (56.1). In all other cases when accurate information was available, mean rated traffic expectations were high (ranging from 72.7 to 81.6). As illustrated in figure 74, a significant *accuracy of purchased information* effect was found, $F(3,353) = 6.63$, $p < 0.001$. Also, a Student-Newman-Keuls *a posteriori* test confirmed that the data point corresponding to drivers who purchased inaccurate information was significantly different from all other points ($p < 0.05$). Figure 75 shows the most typical sequence of links experienced by most of the subjects. Other sequences of links that were encountered can be found in appendix E (pp. 285-292).

Figure 75 illustrates mean *traffic expectations* ratings for younger and older drivers based on purchased link information. When information was purchased, mean traffic expectations ratings were 75.7 for younger drivers and 74.9 for older drivers. When no information was purchased, mean traffic expectations ratings were 82.5 for younger drivers and 72.2 for older drivers. An ANOVA indicated a significant *AGE* effect, $F(1,1260) = 14.95$, $p < 0.001$, and a significant *AGE x link information* interaction, $F(1,1260) = 16.5$, $p < 0.001$.

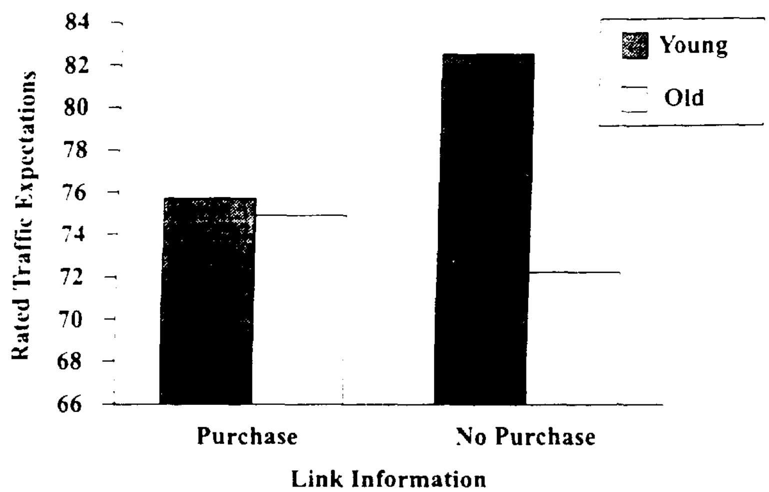


Figure 75. Mean rated traffic expectations as a function of age and purchased link information.

Figure 76 illustrates mean rated *traffic expectations* for younger and older drivers given the type of information purchased during the 77 percent accurate trials: none, accurate, harmless inaccurate, harmful inaccurate. When no information was purchased, rated traffic expectations were 85.7 for younger drivers and 77.4 for older drivers. When the information purchased was accurate, rated traffic expectations were 78.7 for younger drivers and 77.4 for older drivers. When drivers were told that the traffic was heavy when it was actually light, rated traffic expectations were 81.7 for younger drivers and 61.7 for older drivers. And when drivers were told that traffic was light when it was actually heavy, rated traffic expectations were 54.5 for younger drivers and 57.6 for older drivers. An ANOVA found significant effects of *AGE*, $F(1,624) = 5.87$, $p < 0.05$, *type of information purchased*, $F(3,624) = 44.42$, $p < 0.001$, and *AGE* *x type of information purchased*, $F(3,624) = 3.51$, $p < 0.05$. A Student-Newman-Keuls procedure found significant differences between the harmful inaccurate *information purchased* condition and all other levels of *type of information purchased*, and the accurate *type of information purchased* condition versus the none *type of information purchased* condition ($p < 0.05$).

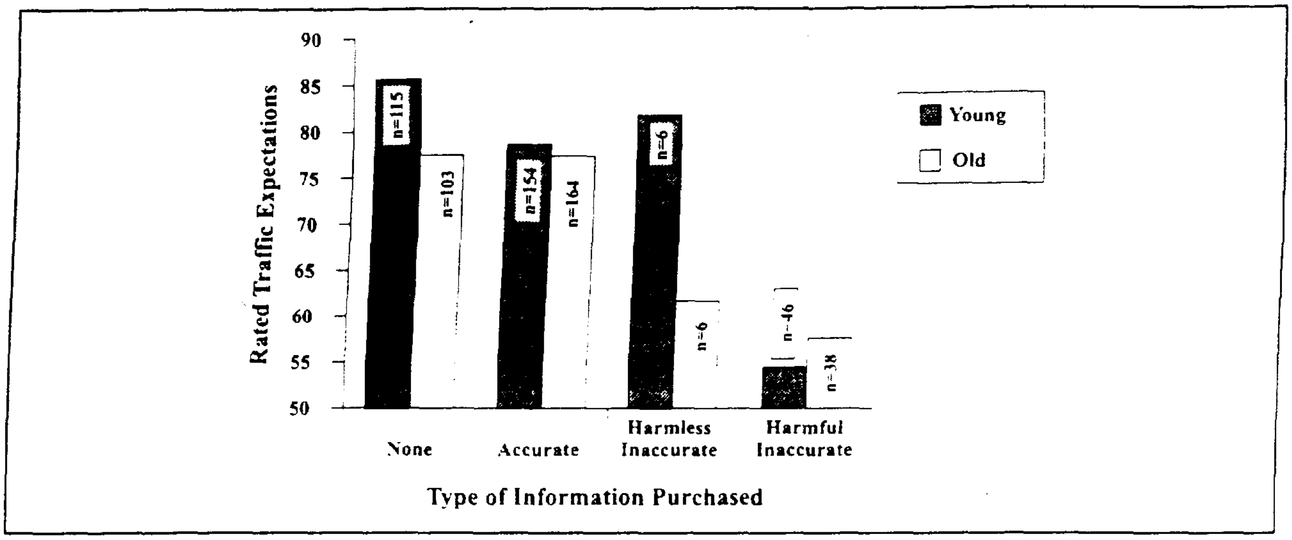


Figure 76. Mean rated traffic expectations as a function of age given the type of information purchased for the 77% accurate trials.

Trust Minus Self-Confidence

Figure 77 depicts the post hoc dependent variable, *trust minus self-confidence*, that was created by subtracting the inter-link ratings of self-confidence from trust. This variable is shown for younger and older drivers as a function of *link information*.

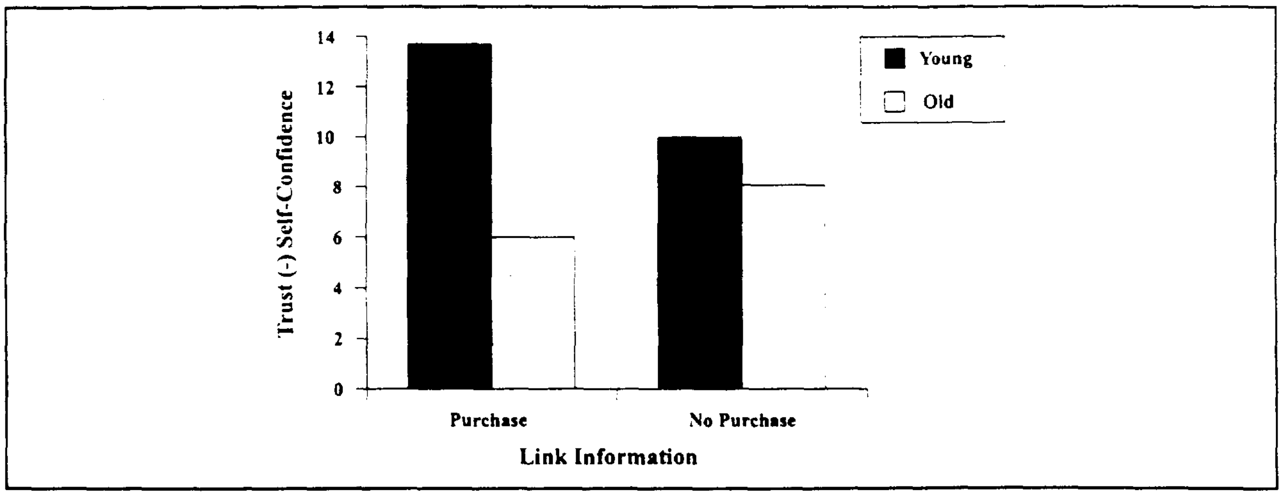


Figure 77. Mean rated trust (-) self-confidence as a function of age and purchased link information.

When information was purchased, mean rated *trust (-) self-confidence* was 13.7 for younger drivers and 6.0 for older drivers. When no information was purchased, mean rated *trust (-) self-confidence* was 10.0 for younger drivers and 8.1 for older drivers. An ANOVA indicated a significant *AGE* effect, $F(1,1260) = 27.3$, $p < 0.001$, and a significant *AGE x link information* interaction, $F(1,1260) = 6.48$, $p < 0.001$. A t-test was conducted on the *AGE x link information* interaction means. Significant differences were found between purchase and no purchase conditions for both older drivers ($t[1260] = 2.80$, $p < 0.01$) and younger drivers ($t[1260] = 4.93$, $p < 0.001$).

Mean rated *trust (-) self-confidence* is also shown for younger and older drivers given the type of information purchased during the 77 percent accurate trials: none, accurate, harmless inaccurate, harmful inaccurate (figure 78). When no information was purchased, rated *trust (-) self-confidence* was 9.9 for younger drivers and 6.6 for older drivers. When the information purchased was accurate, rated *trust (-) self-confidence* was 14.3 for younger drivers and 6.5 for

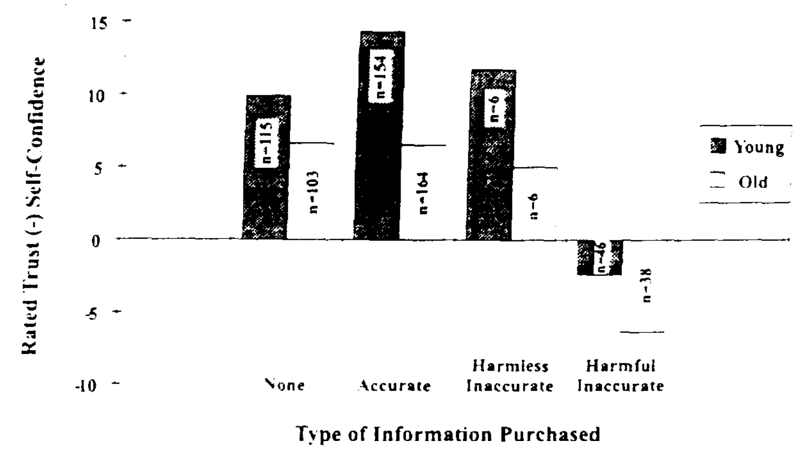


Figure 78. Mean rated trust (-) self-confidence as a function of age given the type of information purchased for the 77% accurate trials.

older drivers. When drivers were told that the traffic was heavy when it was actually light, rated *trust (-) self-confidence* was 11.7 for younger drivers and 5.0 for older drivers. And when drivers were told that traffic was light when it was actually heavy, rated *trust (-) self-confidence* was -2.4 for younger drivers and -6.4 for older drivers. An ANOVA indicated main effects of *AGE*, $F(1,624) = 12.7$, $p < 0.001$, and *type of information purchased*, $F(3,624) = 12.2$, $p < 0.001$. Student-Newman-Keuls multiple comparison tests found that the harmful inaccurate *information purchased* condition differed from all other conditions ($p < 0.05$).

DISCUSSION

Objective Measures of Driver Behavior

The first question to be asked about any ATIS device is "Will people use it?" Results clearly show that subjects diverged from their baseline routes which they would use in the absence of real-time traffic information (figure 65). Thus, at least for the present simulated route-guidance ATIS, one must conclude that driving choice-behavior was influenced by presented information in most of the cases. There was only a small number of cases (7.8 percent) where drivers followed their baseline routes. This is consistent with the expectation that using real-time video to show actual traffic would be an effective way to simulate an ATIS device. Of course, validation of any simulator requires field testing and this is planned for the last year of this research project.

The second question asked about the route guidance ATIS concerns its reliability. When information was 100 percent reliable, the simulated ATIS allowed drivers to reduce their penalty costs versus the condition where it was 77 percent reliable (figure 64). However, drivers continued to purchase information even when it was unreliable (figure 62). Drivers using an unreliable ATIS were more likely to depart from their baseline routes (figure 65) instead of reverting back to known links. One possible explanation for this interesting result is that once having departed from the baseline origin links, drivers were not able to return to the baseline in mid-journey. Indeed, since the present simulation contained only one-way links, drivers wishing to return to the origin to start over again could not do so. Future research with two-way links might prove worthwhile to determine what proportion of "disappointed" drivers might journey backwards to regain their baseline route when frustrated by unexpected heavy traffic. It is clear that drivers will continue to use a simulated ATIS that is degraded from 100 percent to an average reliability of 77 percent. This optimistic finding suggests that real-world ATIS devices do not have to be perfect to be useful. The following section interprets the driver's subjective feelings about using the simulated ATIS device.

Subjective Measures of Driver Behavior

It is reasonable to postulate two opposing hypotheses about driver decision-making in the RGS. A Skinnerian model, based upon learning theory and operant conditioning, would predict that a single instance of faulty information might be sufficient to keep drivers from trusting automation. This is called one-trial extinction in learning theory. An example might be putting additional money into a vending machine that failed to produce an output. In contrast, a Bayesian model would predict graded responses to automation unreliability. Trust would vary, both up and down, in accordance with previous history that extended more than one trial back in time.

The Bayesian model better matches driver behavior in this experiment. Trust in this new machine started out at a moderate level and then increased during the second repetition (figure 67). After the third trial where inaccurate information was presented, trust decreased back to the initial level and continued to decrease slightly on the fourth trial where more inaccurate information occurred. This general picture is confirmed when data are examined at a more micro level, from link to link (figures 68 and 69). Links providing accurate information increase trust and those providing inaccurate information decrease rated trust. This is true even when accurate information follows inaccurate information. The subsequent accurate information tends to restore trust lost during prior links where information was inaccurate.

It seems reasonable to expect that the decision to purchase traffic information be related to trust. Drivers would not be expected to buy information if they did not trust the ATIS device. However, results (figure 71) showed that trust was unchanged when no information was purchased versus purchasing accurate information or harmless inaccurate information (being told that traffic was heavy when it turned out to be light). This outcome could be attributed to the low cost of an information purchase ($0.10) in the experiment; future research needs to increase this cost. However, even with this low cost, trust declined substantially when harmful inaccurate information was purchased (figure 71).

An operator's use of automation is moderated by both trust and self-confidence (Lee & Moray, 1991). The higher the difference of self-confidence subtracted from trust, the more likely it is that automation will be used. Negative values can indicate problems with automated systems. When harmful inaccurate information is provided, trust minus self-confidence became negative (figure 78). Harmless inaccurate information did not alter this difference.

It was clear that not all inaccurate information had the same effect upon the driver's subjective opinion. Harmless inaccurate information was tolerated with no ill effects. It appears that the ATIS device is not castigated for providing inaccurate information so long as that information does not inconvenience the driver. However, harmful inaccurate information has a strong negative effect upon the driver's trust in the system. This result has important implications for the kind of unreliability that drivers will tolerate in route guidance ATIS devices.

Effects of Aging

Before interpreting the interesting aging effects obtained in experiment 2, it is prudent to caution that in a cross-sectional study, aging effects are confounded with cohort effects. It is not possible to determine from this study if the effects reported here are due to (a) the aging process, or (b) the different set of experiences shared by the older cohort relative to the younger cohort, or (c) both of these.

Younger drivers are more adept at learning/using the route guidance system (figure 63). When information is 100 percent reliable, they incur smaller penalties. When information is inaccurate, younger drivers perform at the same level as older drivers. This latter finding may represent a ceiling effect whereby younger drivers do not have access to sufficient good information to perform better than older drivers. One might speculate that older drivers do worse because they choose not to use the system as much as do younger drivers. For example, perhaps older drivers are more frugal and do not wish to purchase information as much as do younger drivers. However, results (figure 62) show statistically equivalent patterns of information purchase for younger and older drivers. Therefore, this speculation is not supported. Similarly, both cohorts exhibited identical patterns of convergence (figure 65) so that rigid adherence to route baselines is not an explanation for the higher penalties incurred by older drivers.

A very interesting difference in trust patterns emerged for the two cohorts. Younger and older drivers exhibited equal trust for links about which information was purchased (figure 70). But trust decreased for older drivers for links where no purchase was made, while younger drivers showed increased trust for those links. It appears that younger drivers did not need to purchase information if rated trust was high. However, when older drivers did not buy information, their rated-trust was lower. A similar pattern of results was obtained for rated traffic expectations (figure 75).

For older drivers, self-confidence was higher for links where information was purchased, whereas the opposite result was obtained for younger drivers (figure 72). Younger drivers had greater trust minus self-confidence differences, which is consistent with a preference for automated technology in younger cohorts (figure 77). Younger drivers had higher difference scores when they purchased link information, while older drivers had higher scores when they did not purchase link information.

The subjective data considered together suggest that the purchase of information is either motivated differently or produces different feelings for the two cohorts. Perhaps younger drivers use the ATIS depending first upon their subjective feelings, while older drivers use the ATIS system to alter their subjective feelings. This speculation implies that younger drivers use internal states to control their use of automated systems, while older drivers use the system to modify their own internal states. If true, this hypothesis has important design implications.

Conclusions

The present results demonstrate that the RGS is a useful tool for investigating driver acceptance of an ATIS device. Drivers do not demand perfect information from an ATIS device. Even unreliable information is purchased. Of course, before broad generalizations from this result can be drawn, additional research is needed to vary the reliability of the information as well as the cost.

Previous research (Bonsall & Parry, 1991) has shown that the quality of advice determines driver acceptance of that advice. The present research did not vary the quality of advice parametrically beyond two levels (100 percent versus 77 percent accuracy). Even so, the present finding that harmful inaccurate advice influences drivers differently than harmless inaccurate advice is important and likely to be maintained as ATIS reliability is varied. However, the tolerance of harmless inaccurate advice may change when the cost of information is increased. Drivers may resent paying large sums of money for inaccurate information and this could color their acceptance of ATIS devices. This hypothesis will be tested in future experiments in task K.

It is important to realize that the present results are based upon a real traffic network and used experienced drivers who were familiar with the Seattle area. Bonsall and Parry (1991) used an artificial network and found that acceptance of advice generally decreased as familiarity with the network increased. This suggests that in a more realistic setting, such as the present experiment, drivers should be more resistant to accepting information. However, our results showed that most drivers diverted from their baseline routes indicating a general acceptance of traffic information. This comparison may indicate a lack of generalizability from studies that use artificial traffic networks.

Finally, it should be noted that the present experiment did not provide route guidance. While drivers did get traffic information, the simulated ATIS device did not offer suggestions for alternate routes as has been done in previous research (Allen, Stein, et al, 1991; Bonsall & Parry, 1991). This is an obvious area for future research. The present research was aimed at driver acceptance of unreliable information. Future research using the RGS will also investigate design issues incorporating route guidance. For example, one might vary the traffic information presented and route guidance simultaneously by having suggested routes go through areas of projected different levels of traffic congestion. It is questionable whether drivers will accept advice that routes them through heavy traffic areas, even when the system advises that this would be shorter than taking less congested minor arterials. The realism of the RGS with its real-time video of traffic should help to answer this and other related questions.

CHAPTER 4. EXPERIMENT 3

ATIS will provide a broad range of support to drivers. Most concepts of ATIS for private vehicles include navigation aids, safety systems, traveler's aid services, and communications. CVO also includes administration, tracking, and management functions. Regardless of the exact functional composition of ATIS, there are overriding concerns about whether such a system will be accepted and purchased by drivers of private vehicles and whether commercial drivers will accept or reject systems installed by fleet owners. As documented in our earlier literature review (Kantowitz, Becker, & Barlow, 1993), user acceptance of new technology is a complex, multi-faceted problem but one which may be tractable to experimental analysis. In the study reported here, our goal has been to examine a variety of methodologies and analytic techniques that may prove useful in assessing user acceptance of ATIS/CVO functions.

The current study addressed CVO function acceptance issues, independent of implementation. Both local and long-haul commercial drivers served as participants in the study. In this study, only paper and pencil questionnaires were used, coupled with verbal explanations and examples of function application. The current study also used a direct magnitude estimation task, a psychophysical forced-choice analysis, and a relatively new link-weighted network analysis (Schvaneveldt, 1990).

Throughout the study, the participants were asked to assess the ATIS functions for their job-related value. The variations between this study and the prior studies increase the range of methodological alternatives considered under this task.

The link-weighted network analysis is an attempt to apply the emerging technology of knowledge engineering to the task of understanding user acceptance issues. The network analysis can yield detailed structures for the concepts under investigation leading to greater specificity in data interpretation, alternative hypotheses, and perhaps even conclusions. The Pathfinder algorithm (Schvaneveldt, 1990) for network analysis has been chosen for use in this study for two reasons. First, it is well founded in mathematical graph theory providing a form of representation that is shared with many system engineering disciplines. Second, Pathfinder was developed for the purpose of more explicitly representing the structures of human memory and the contents of mental models. As such, Pathfinder is also well founded in psychological measurement. Earlier studies using this analysis have identified differences in the networks produced by Air Force instructor pilots, by pilot trainees, and by current fighter pilots (Schvaneveldt et al., 1985), as well as network differences between users of a documentation preparation system and the model used to define the system (Kellog & Breen, 1991). In using Pathfinder, we will attempt to identify how local and long-haul drivers evaluate ATIS functions as job performance aids and whether there are differences between the types of drivers.

METHOD

Participants

Sixty-five commercial truck drivers were recruited from the Sacramento area by the California Trucking Association (CTA). Participants signed up for one of four 4-h group meetings conducted at the CTA building in Sacramento on the weekend of November 20-21, 1993. The four groups ranged in size from 15 to 17. Participants were paid $50.00 for their participation. Fifteen participants were eliminated from the study because of missing data or a failure to follow instructions. Table 56 summarizes the demographic data for the 50 participants whose data were included in the analyses.

Table 56. Demographic data for local and long-haul drivers.

VARIABLE	LEVEL	DRIVER GROUP LOCAL (N=38)	LONG-HAUL (N=12)
Age	21-35 years	34.2%	25.0%
	26-45	42.1%	8.3%
	46-55	18.4%	50.0%
	55+	5.3%	16.7%
Education	Less than 12th grade	2.6%	16.7%
	High School	34.2%	16.7%
	Some College	52.6%	50.0%
	College +	10.5%	16.7%
Local Driving Experience	None	0.0%	16.7%
	≤ 3 years	26.3%	8.3%
	4-8	28.9%	8.3%
	9-15	23.7%	33.3%
	16-25	15.8%	25.0%
	26+	5.3%	8.3%
Annual Income	< $30K	34.2%	16.7%
	$30 - 40K	36.8%	25.0%
	$40 - 50K	28.9%	33.3%
	> $50K	0.0%	25.0%
Computer Experience	None	15.8%	25.0%
	Very little	36.8%	0.0%
	Occasional use	21.1%	16.7%
	Frequent use	13.2%	25.0%
	Daily use	13.2%	33.3%
Long-Haul Driving Experience	None	47.4%	0.0%
	≤ 3 years	28.9%	16.7%
	4-8	10.5%	16.7%
	9-15	10.5%	16.7%
	16-25	0.0%	33.3%
	26+	2.6%	16.7%

Materials and Procedure

A 25-page booklet of concept definitions, ATIS/CVO explanations, task instructions, and answer sheets was prepared specifically for use in this study (see appendix F). The booklet contained five sections. The first section included an introduction to ATIS/CVO as a concept, and definitions of 16 ATIS functions. That section served as the primary training on ATIS systems, functions, and usefulness. The second section of the booklet contained the instructions and answer sheets for a direct magnitude estimation task. The third component contained additional training materials that highlighted the possible interactions among the 16 functions. The fourth section included the instructions and answer sheets for a forced-choice paired comparison task. The final section was a short demographic questionnaire.

At the beginning of each session an introductory explanation of the study was given, and the participants were asked to read and sign a consent form. The booklets were distributed, and the participants were instructed to read the first five pages. The first page included a general characterization of ATIS, attempted to set the context for the drivers' evaluations of the ATIS components, and reiterated some of the points on confidentiality from the consent form. The next four pages contained brief definitions of 16 ATIS functions. When all participants finished reading these materials, a focused discussion addressed any questions that they raised, and attempted to elicit their reactions and comments. During the discussions, the experimenter tried to maintain a focus on the definitions of the 16 individual functions, provided additional information as required to answer questions, and attempted to engage participants in the discussion. In three of the groups, at least half of the participants actively discussed the functions. Participants contributed specific experiences in which an ATIS function might have proved useful, offered comments on the uselessness of some functions, and considered how implementation details might increase or decrease the usefulness of a given function. In the fourth group, about one-third to one-half of the participants were contributors to the discussion with two participants trying to focus the discussion on their concerns. The discussion typically lasted about an hour. Some of the participants' comments are incorporated into the results and discussion sections.

The list of functions published in this experiment was culled from the ATIS capabilities described in a previous report (Lee et al., 1997) to create a smaller set of functions more amenable to this study. Specifically, similar capabilities were merged into single functions (e.g., in-vehicle signage was separated based on four types of information in the previous report, but merged into a single function here). Capabilities that could not stand alone were combined to form a single function (e.g., trip planning and dynamic route selection presuppose a navigation capability; so, these were combined into a single route navigation function). These changes produced 15 of the 16 functions. The final function, *Vehicle Location Update*, was added to the set for two reasons. First, it appeared as an enhanced implementation component for several of the other functions. Second, it is already available and implemented in commercial vehicle operations and, therefore, may serve as an anchor point for some of the estimation tasks.

The following 16 functions were used in this experiment:

- Broadcast services.
- Cargo transfer scheduling.
- Dispatch control.
- Emergency aid request.
- Fleet resource management.
- Immediate hazard warnings.
- In-vehicle roadway control signs.
- Regulatory administration.
- Road condition information.
- Route navigation.
- Route scheduling.
- Route selection and guidance.
- Services directory.
- Vehicle/cargo condition monitoring.
- Vehicle location update.
- Voice and message communication.

Following the discussion, participants performed a direct magnitude estimation task in which they rated each function against *Vehicle Location Update* as the standard. The basis of the rating was "the value to you in performing your job as a commercial vehicle operator." Participants were encouraged to refer back to the function definitions during the task. The complete written instructions for this task are given in appendix F (p. 304). When this first task was completed, the group went on to a second magnitude estimation task which used *Vehicle/Cargo Condition Monitoring* as the standard for comparison. Again, the instructions, given in appendix F (p. 306), emphasized rating the functions on their value for job performance. The participants retained their ratings from the first task while doing the second task, but they were folded into the rest of the materials. Participants were instructed not to refer back to their first ratings when making their second rating. After completing the second rating task, participants were given a 15 to 20 min break.

To begin the second half of the session, participants were instructed to read pages 10 to 13 in the booklet which described how the various functions interact with each other and how they could be combined to provide better total capabilities. These materials described four "option packages" that were designed to provide different services for drivers. The option packages were oriented toward Driver Safety, Driver Services, Management Services, and Navigation support. Because the *Vehicle Location Update* function interacts with functions in each of the option packages, this function was included in all of the packages. The group discussed the new information, commenting on topics like work overload caused by too many system components, the diverting of attention to process potentially unimportant information, the ease with which law enforcement officials could generate speeding tickets, and the fact that your dispatcher would be able to figure out how much time you spent in Winnemucca. At the end of the discussion, participants were instructed to rate the job-related value of the four ATIS option packages against a standard package that included all 16 functions.

The next task in the survey was a forced-choice, paired-comparison task which required a participant to respond to each of the 120 unique function pairings. Each of 10 answer sheets contained 12 pairs. The order of functions within a pair was randomly determined. Ten different orders of the answer sheets were used. The goal of this task was to generate scaled differences between the members of all possible pairs of ATIS functions for use in a link-weighted network analysis. Therefore, participants were asked to do more than simply make a forced choice of the function most valuable on the job. The instructions asked the participant to assign the number

100 to the member of a pair of functions that they deemed to be most valuable in doing their job. Then, they were instructed to assign a number between 1 and 99 to the other member of the pair. The second number was to reflect how much less valuable the other member of the pair was. For example, for the function pair *Vehicle Location Update <-> Services Directory*, one participant assigned 100 to *Vehicle Location Update* and 50 to *Services Directory* indicating that an in-vehicle "yellow pages" was about half as useful on the job as the vehicle locator function. After participants read the instructions, the experimenter reviewed them and answered any questions. Participants were told to complete this task and then fill in the demographic questionnaire. This completed their participation. Participants were paid at the end of the session.

RESULTS

As stated above, 15 participants were eliminated from the study. Three participants omitted one or more responses in one or more of the tasks. Six participants produced ties in the forced-choice task assigning the same number to both members of at least one pair. Six participants assigned absolute ratings in the forced-choice task (e.g., 40 to one member and 50 to the other member of a pair) instead of following the relative rating instructions. Aberrant responses in the main tasks of this study were assumed to reflect a misunderstanding of the instructions for generating and assigning numerical values to functions in the various tasks. This was assumed to reflect other misunderstandings, as well, and hence no attempt was made to repair the data. Nine of the eliminated participants were local drivers, and six were long-haul drivers. One additional participant missed the first magnitude estimation answer sheet entirely. Instead of dropping this participant from the analyses, we will present a formal analysis of only the second direct magnitude estimation task. These errors were detected only at the end of the sessions, at the earliest. We chose not to have participants make corrections.

Magnitude Estimation Data

In the direct magnitude estimation task, each participant rated the ATIS functions twice, against different standards, once against *Vehicle Location Update*, and once against *Vehicle/Cargo Condition Monitoring*. These two functions were chosen as the standards because they are already in use in early forms. Several existing systems provide vehicle tracking services, and a variety of devices currently monitor such things as brake air pressure and trailer refrigeration. A preliminary inspection of the data from this task showed no differences between the first and the second ratings. The findings from the second rating task are reported.

The data from each individual participant was standardized using a z-score transform to minimize the skewing effects of a rating scale that was bounded only on one end. These data are shown in table 57. A Sheffé test was used for each participant group to identify any differences among the functions. For the long-haul drivers, the small number of participants (N = 12) produced a large minimum significant difference; hence, only two groups of functions were detectable with considerable overlap between them. In general, though, safety functions appeared at the top of the list, navigation and communications functions filled out the top half of the list, control and administrative functions were next, and driver services functions were at the bottom of the list. For the sample of local drivers, three function groups were detected. Again, safety-related functions were at the top of the list, followed by communications, control, navigation, administrative, and finally driver services functions. Across the two groups of drivers, there are some differences in the rank-ordering of the functions. We will focus on these differences later in our analyses.

Table 57. Magnitude estimation task mean *z*-scores by driver group and function.

LOCAL DRIVERS		LONG-HAUL DRIVERS	
0.799	EMERGNCY AID	EMERGNCY AID	0.939
0.680	HAZARD WARN	HAZARD WARN	0.888
0.412	ROAD CONDTN	ROUTE GUIDE	0.467
0.248	DISPATCH	ROAD CONDTN	0.399
0.240	COMMUNICATIONS	ROUTE NAV	0.350
0.208	ROUTE NAV	COMMUNICATION	0.314
0.053	VEH/CRGO	VEH/CRGO MON	0.218
-0.047	IN-VEH SIGNS	ROUTE SCHED	0.202
-0.076	ROUTE GUIDE	DISPATCH	-0.044
-0.088	FLEET MGMT	REG ADMIN	-0.124
-0.269	VEH LOCATOR	FLEET MGMT	-0.305
-0.341	REG ADMIN	IN-VEH SIGNS	-0.513
-0.432	ROUTE SCHED	VEH LOCATOR	-0.540
-0.449	BRDCST SERV	SERV DRCTRY	-0.581
-0.451	CARGO XFER	CARGO XFER	-0.761
-0.488	SERV DRCTRY	BRDCST SERV	-0.907

Option Package Magnitude Estimation Data

The main purpose of this section of the materials was to introduce the ways in which the 16 individual functions interact to enhance the overall ATIS capabilities. Four combinations of functions, or option packages, were described and then discussed. Participants then performed a magnitude estimation of the job-related value of each package compared to a complete package containing all functions. The means of the raw ratings are shown in table 58.

Table 58. Mean ratings of option packages.

OPTION PACKAGE	DRIVER GROUP	
	LOCAL	LONG-HAUL
Driver Safety Package	130.11	147.83
Navigation Package	118.92	151.83
Complete Package	100.00	95.83
Driver Services Package	78.61	108.17
Management Package	75.34	83.00

The Complete Package was assigned a standard value of 100 by the experimenter. One participant in the long-haul driver group changed that value, and the change was entered into the data. In these data, both local and long-haul drivers rated the Driver Safety and the Navigation Packages as more valuable than the Complete Package. Both groups rated the Management Package below the Complete Package but disagreed on the relative value of the Driver Services Package. The definitions of the option packages can be found on pages 308-310 of appendix F.

Paired Comparison Preference Data

From the paired-comparison task, we extracted the proportion of times each function was preferred over other functions for each participant. For comparability with the magnitude estimation data, the raw scores were converted to *z*-scores with the means reported in table 59. Again, a Sheffé test was used to identify significant differences among the means. The ordering of the functions here is somewhat different from that obtained for the magnitude estimation task. For long-haul drivers, the most valued functions now include safety and communications, with lower-values assigned to navigation, management and control, and driver services. For the local drivers, the safety functions still comprise the most valued group, with lower ratings for navigation, communications, management and control, and driver services.

Table 59. Paired comparison task mean *z*-scores by driver group and function.

LOCAL DRIVERS		LONG-HAUL DRIVERS	
0.886	EMERGNCY AID	HAZARD WARN	0.896
0.883	HAZARD WARN	EMERGNCY AID	0.806
0.687	ROAD CONDTN	COMMUNICATION	0.769
0.193	VEH/CRGO MON	ROAD CONDTN	0.676
0.159	ROUTE GUIDE	VEH/CRGO MIN	0.357
0.129	ROUTE NAV	ROUTE GUIDE	0.304
0.129	IN-VEH SIGNS	ROUTE NAV	0.281
0.124	COMMUNICATION	ROUTE SCHED	-0.112
0.009	VEH LOCATOR	DISPATCH	-0.198
-0.029	DISPATCH	VEH LOCATOR	-0.286
-0.098	ROUTE SCHED	CARGO XFER	-0.388
-0.417	FLEET MGMT	FLEET MGMT	-0.437
-0.572	BRDCST SERV	IN-VEH SIGNS	-0.446
-0.603	CARGO XFER	SERV DRCTRY	-0.696
-0.727	REG ADMIN	REG ADMIN	-0.729
-0.753	SERV DRCTRY	BRDCST SERV	-0.797

In an overall ANOVA, we examined the effects of *FUNCTION*, *DRIVER GROUPS* (local vs. long-haul), and *TASK* (magnitude estimation vs. paired comparisons). Because of the normalizing, there was no effect of *DRIVER GROUP* ($F < 1$). Unfortunately, there was a very small but apparently consistent effect of *TASK*, $F(1,48) = 4.12$, $p = <0.05$, and a significant interaction of *TASK* with *DRIVER GROUP*, $F(1,48) = 4.40$, $p = <0.05$. The Magnitude Estimation task resulted in very small negative means, -0.0000625 and -0.00125 for local and long-haul drivers, respectively. The Paired-comparison task produced means of zero, as expected. We suspect a small but consistent rounding or truncation error lays behind these significant results, and we are crosschecking the data. There was a significant main effect of *FUNCTION*, $F(15,720) = 15.83$, $p < 0.0001$, supporting the differences discussed above. Finally, there was a marginally significant interaction of *TASK* with *FUNCTION*, $F(15,720) = 1.56$, $p = 0.08$. The source of the interaction probably lies in the shifts for functions rated near the midpoint of the scales. For instance, in the magnitude estimation task, *Vehicle Location Update* received a mean z score of -0.405, and in the paired-comparison task , the mean z score was -0.139. In contrast, *Flëet Resource Management* had a mean z score of -0.197 in the magnitude estimation task and a mean z value of -0.427 in the paired-comparison task. There was no significant three-way interaction ($F[15,720] = 1.08$), $p = > 0.05$.

This configuration of statistical results includes the one bothersome finding of significance where no effect was expected. The main effect of *TASK* does appear to be the result of a truncation error in the manipulation of the magnitude estimation data. Since that truncation occurs in a commercial data analysis package, we do not have the luxury of repairing the problem, nor do we have the luxury of writing our own analysis routine. The marginal interaction of *TASK* with *FUNCTION* may be an artifact of the same problem, or it may reflect a more fundamental difference between the rating tasks. In magnitude estimation, the entire suite of functions was considered at the same time; whereas, the paired-comparison task pitted one function against another. The major finding, that there are clear-cut preferences for certain functions, indicates that some proposed ATIS capabilities may be an "easy" sell to commercial drivers while others may have a long road to driver acceptance. These data begin to separate one type from the other.

Network Analysis

In the paired-comparison task, participants assigned a value of 100 to the member of the pair which had the greatest on-the-job value. They then generated a second number to indicate the relative on-the-job value of the other member of the pair. The absolute value of the difference between the two numbers is a measure of the distance between the members of a pair in the rating space. The task required participants to rate all 120 possible pairs of ATIS functions resulting in a half-matrix of distance estimates between all possible pairs of the 16 ATIS functions. From the distance data, the Pathfinder algorithm (Schvaneveldt, 1990) produces a mathematical graph showing the edges or links that exist among the ATIS functions.

Depending on the parameter values, the resulting graph can contain all pair-wise links (parameter $q = 1$) or exactly n-1 links ($q = n-1$), where n is the number of nodes in the graph (the number of ATIS functions). The q parameter specifies the number of edges or links over which triangle inequalities are resolved. Mathematically, the graphs for each value of the q parameter are equally valid. For our purposes there is a level of graph richness and complexity that is informative somewhere between the two extremes of $q = 1$ and $q = n-1$. The second Pathfinder parameter is the Minkowski r-metric which determines how distance is computed between indirectly linked nodes; that is, there are intervening nodes along the path. For a value of $r = 1$, Pathfinder uses the sum of all edge distances between directly linked nodes along the path between separated nodes. For $r = 2$, multiple-edge path distances are calculated as Euclidian distances, and for $r =$ infinity, the distance of a multiple-edge path is the maximum of the

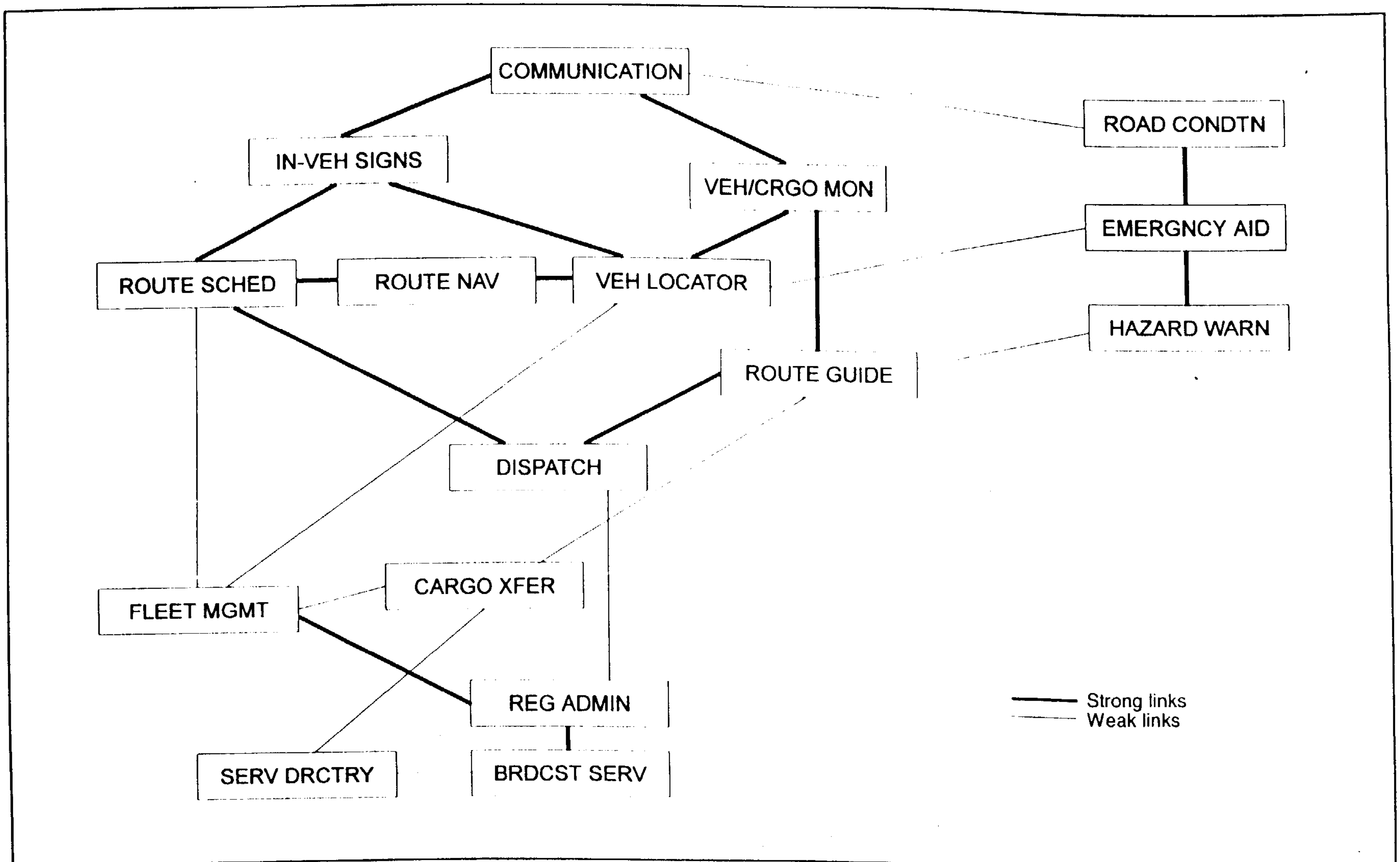


Figure 79. A link-weighted network of ATIS/CVO functions generated for local drivers.

and failures to the driver. In a local driving context, these error conditions may not be much of a safety hazard, but they do require attention. After isolating the problem, correcting it starts with knowing your exact location, communicating your problem to those in a position to make repair decisions, and then getting to a repair point or getting a repair service to you. Bear in mind that these speculations go far beyond the data in attempting to specify the attributes of the connections in the domain of job-related value. There could be other reasons why these functions are near neighbors.

The final, loosely connected group includes those functions that were rated lowest in job-related value. Included here are functions that seem outside of the day-to-day activities of a local driver. Within a single jurisdiction, the value of the *Regulatory Administration* function could be almost Non-existent. *Fleet Management* may be too high a level to have immediate value to the individual driver. *Services Directory* and *Broadcast Services* may offer nothing new to a local driver who operates in the same area every day, and *Cargo Transfer Scheduling* may not enter into a local driver's domain. As one participant put it, "What does any of this matter to me? I just haul rocks."

In addition to assessing the groupings that emerge, it is informative to consider how the groups interconnect. There are three connections between the group of safety functions and the navigation/communications Group. *Road Condition Information* is connected to *Voice and Message Communication*. This link may result from the drivers' current practices in using citizen band (CB) radios to tell each other about the disruptions, congestion, and other delays that often go unreported Elsewhere. *Emergency Aid Request* is connected to *Vehicle Location Update*. This may reflect information from the training in which these two functions were linked in the description of one of the options packages so that an aid request would automatically include the vehicle's current location. Finally, *Immediate Hazard Warning* is connected to *Route Selection and Guidance*. This warning function provides information about hazards within several hundred meters around the vehicle. When a warning is received, the driver may have to unexpectedly deviate from his route and plan his way around the hazard.

The Pathfinder analysis of the data for the 12 long-haul drivers is shown in figure 80. The 15 strongest links are shown as thick lines, and the 4 weakest links are shown as thin lines. The strong links identify how the concept nodes are connected within cohesive groupings. The weaker links indicate connections across the primary groupings. Using the same technique of progressively eliminating the weakest links, three function groups emerge. Again, there is what could be labeled a safety grouping, but for the long-haul drivers, it consists of five functions. *Emergency Aid Request, Immediate Hazard Warning*, and *Road Condition Information* are connected with *Voice and Message Communication* and *Vehicle/Cargo Condition Monitoring*. This set of five functions appears to provide drivers with complete information about their immediate environment coupled with functions that support both normal and emergency communication.

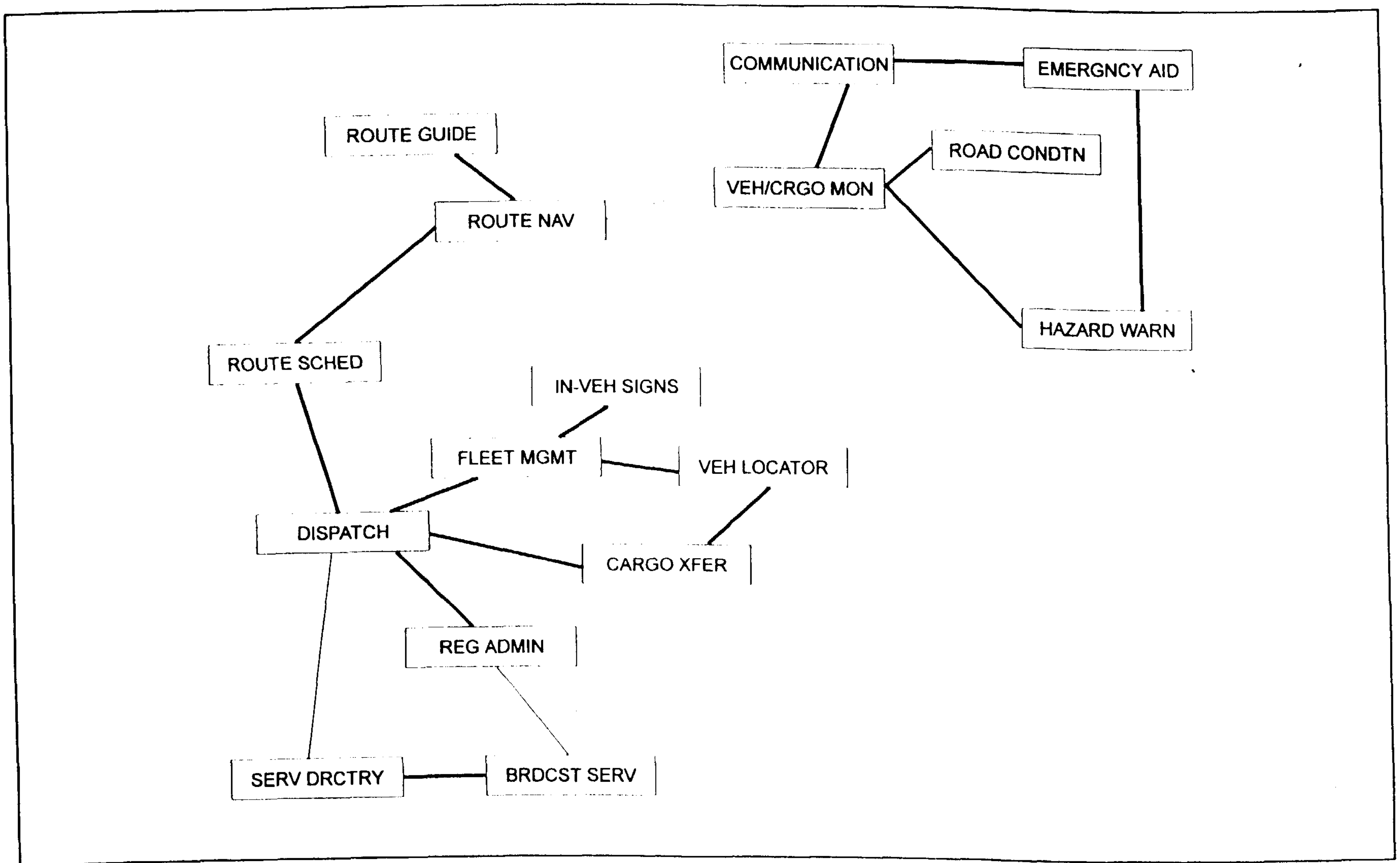


Figure 80. A link-weighted network of ATIS/CVO functions generated for long-haul drivers.

The second group of functions could be labeled navigation and control with the central functions of *Fleet Management* and *Dispatch Control*. The final group includes *Services Directory* and *Broadcast Services* which, from some of the comments, drivers seemed to consider as sources of disruptive workload rather than as effective job aids.

Comparing the networks for local and long-haul drivers is not so simple as counting the pair-wise links that occur in both networks. Of the total 34 unique links, eight occur in both networks yielding a similarity measure of 0.235. By chance, this level of similarity would be expected to occur less than one time in one hundred. Thus, superficially, the two networks share some common ground. A closer inspection of the eight shared links, however, shows that four of them are strong links in both networks, and the other four are strong in one network but weak in the other. One of the strong links, *Voice and Message Communication* with *Vehicle/Cargo Condition Monitoring*, changes groups across networks. Clearly, there are potentially meaningful differences in the larger structures that are not captured in the simple similarity measure. Techniques for comparing networks for "neighborhood" similarities and structural differences are being investigated (Goldsmith & Davenport, 1990), but those preliminary techniques will not be applied here.

The differences between the local and long-haul drivers' networks lie both in different pair-wise links and in different overall structure. An approach to explicating the differences would be to isolate potential ATIS/CVO usage patterns for local and for long-haul drivers and then try to relate different usage to different structures. For example, the weak link between *Emergency Aid Request* and *Vehicle Location Update* in the local driver network does not exist in the long-haul driver network. This may be the result of long-haul drivers' resistance to vehicle tracking systems as they are currently implemented for dispatcher control. Traditionally, long-haul drivers have had the independence to manage the several days drive time between loading and unloading. As one driver put it, "you don't really want your dispatcher to know how long you spent in Winnemucca." The negative reaction to being monitored by vehicle tracking systems may have outweighed any benefit accruing to an *Emergency Aid Request* that includes the exact vehicle location. For local drivers, the total time for loading, delivering, unloading, and the return trip is usually measured in hours rather than days, and the driver is often in continuous radio contact with the dispatcher. Driver monitoring and control is already integrated into the local drivers' job because of the smaller distances and shorter times involved. Here, the perceived threat of *Vehicle Location Update* may be much smaller, and some of its value may surface. The exercise of identifying usage patterns is context dependent, and therefore, we will not apply this approach exhaustively. Later, though, we will consider how the differences in network structure could affect a technology introduction and training plan.

There is one difference between the local and long-haul networks that bears mentioning. The local-driver network is somewhat richer in including several additional links. The added complexity may be the result of the greater number of participants who contributed a greater diversity to the data. Alternatively, the job of the local driver may simply be more diverse than that of the long-haul driver. As time and resources allow, we suggest adding more participants to the sample of long-haul drivers.

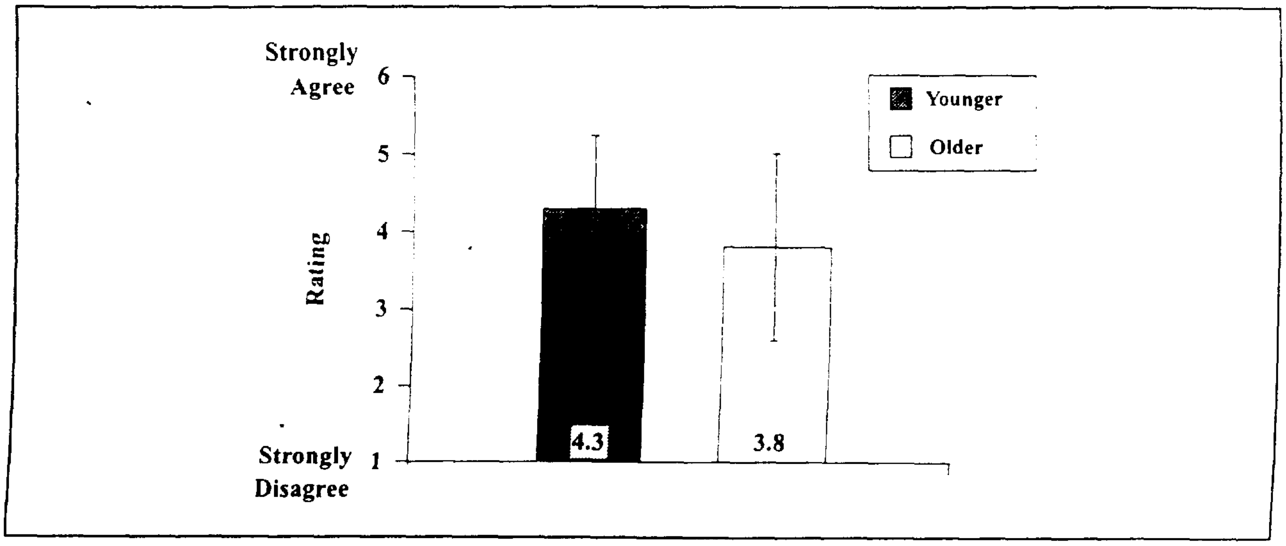


Figure 47. Overall, CityGuide system was easy to learn. (CGTEST4A)

Figure 48 (CGTEST4B) shows mean ratings for the CityGuide system's overall ease of use. A significant main effect occurred for *AGE* $F(1,116) = 11.2$, $p < 0.001$. Younger drivers' ratings for ease of use (mean = 4.4) were higher than older drivers' ratings (mean = 3.9).

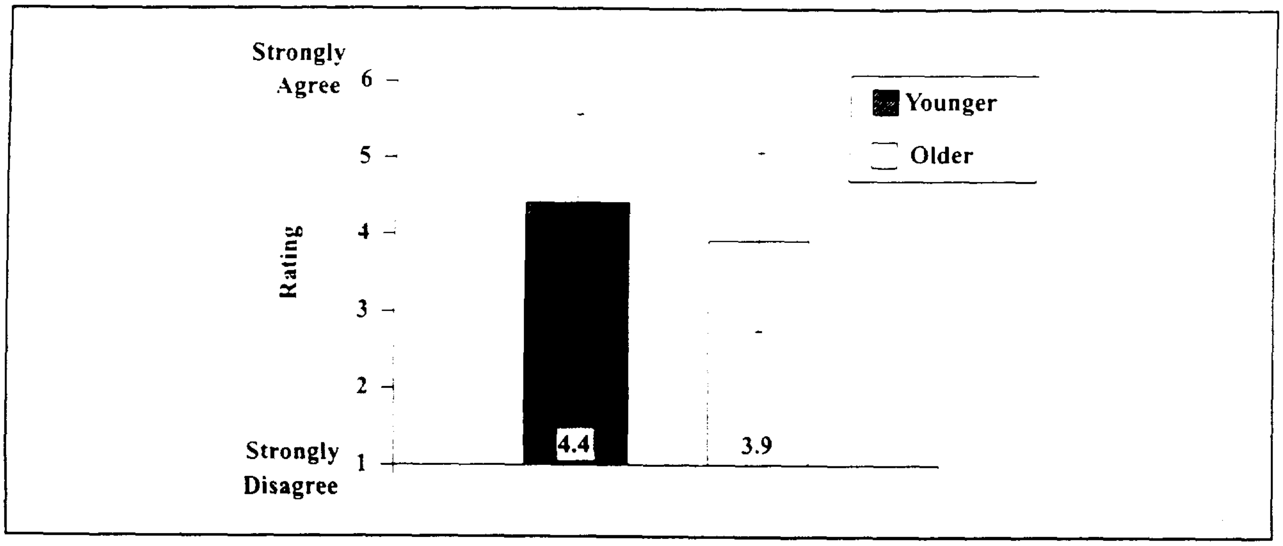


Figure 48. Overall, CityGuide system was easy to use. (CGTEST4B)

Figure 49 (CGTEST4C) shows mean ratings for the CityGuide system's overall usefulness. Younger drivers' mean ratings were 4.3 while older drivers' mean ratings were 4.1.

Control function. The *Broadcast Services* and *Services Directory* functions seem to have little place in commercial driving. On this point, both the local and long-haul drivers' networks agree. Even after discussions about filtering out unwanted information, the drivers' comments addressed concerns about the workload induced by these two functions and about the likelihood of distraction from their primary task of driving.

As stated above, the network extracted for local drivers is more complex than that for long-haul drivers. Each safety function has one relatively weak link to a function in the navigation and control group. A training program designed around this type of network must accommodate the variability, or focus on a single link. We could focus on the link that connects the functions closest to the center of their respective groups. In this instance, that link is the one between *Emergency Aid Request* and *Vehicle Location Update*. After presenting the safety functions, the enhanced value of adding vehicle location to an aid request could bridge the safety functions and the navigation and control functions. Additional functions can then be presented by selecting a path through the strong links in the sub-network. As *Voice/Message Communications* and *Route Selection and Guidance* are encountered, there may be opportunities to emphasize their links to the safety functions and perhaps better tie the navigation and control functions to the more highly valued safety functions. As with the long-haul drivers, there seem to be some functions that have little part in the job of local commercial driving. In addition to the services functions, the local driver network leaves *Fleet Management, Cargo Transfer Scheduling*, and *Regulatory Administration* fairly unconnected. As suggested earlier, perhaps because local drivers operate within a single regulatory jurisdiction and because they operate over short distances and short time periods, the higher-level control functions may not directly affect them. We should consider whether to eliminate these functions from a local driver ATIS/CVO system, or at least to move them into the background.

These preliminary recommendations are based on a first look at driver preferences for ATIS functions as they are currently defined. Even so, we suggest the differences between network structures for local and long-haul drivers are meaningful and they imply differences in the structure of technology introduction and training programs. Before proceeding we will need to affirm the differences and consider other important influences. Probably the most important unexamined influence is the preference and requirements of the trucking companies that would purchase ATIS/CVO systems. Although we have no data from the company perspective, we might speculate that a network of ATIS/CVO functions for trucking company managers would differ from the networks generated by drivers. The company view could well emphasize the management and control functions that would help in minimizing costs. If the company takes a narrow view of costs, the functions might be limited to *Dispatch Control, Fleet Management, Vehicle Location Update, Regulatory Administration*, and, perhaps, *Route Scheduling* incorporated into dispatching operations. These are the functions that the long-haul drivers rated relatively low in the domain of job-related value. For some companies, the safety function could receive relatively high ratings because, in the long run, unsafe operation is costly to the company. Depending on the details of a network of the company perspective, the safety functions could provide a focus for introducing ATIS/CVO technology to decision makers in trucking companies as well as to drivers. The plan here could start by noting the often hidden costs of driver resistance, suggest that the safety functions stand the best chance of technology acceptance, and then link into the other functions that are perhaps more highly valued by the company.

Much of the preceding discussion is tentative, at best. We have assumed the veracity of the Pathfinder networks and we have speculated about networks for which we have no data. Nevertheless, we believe that if there is merit in the methodology used here, the preceding discussion illustrates how the results can be used.

CHAPTER 5. CONCLUSIONS

The goal of this task was to investigate some of the human factors issues specific to the acceptance of ATIS and CVO systems. This was first accomplished analytically by reviewing salient models and data on consumer acceptance of new products. Then three experiments were performed to collect new data, specifically directed at ATIS and CVO devices.

While there are several treatments in the literature of user acceptance of new technology, the models for this are quite complex and very difficult to apply directly to ITS. Nevertheless, these models were useful in suggesting initial directions for the empirical research reported herein. These experimental results were quite encouraging, both in suggesting additional research and for providing some tentative solutions to problems of driver acceptance of new technology.

A framework for driver acceptance of ITS technology is depicted in figure 81. It is based upon a synthesis and extension of the research in this report. The model starts (top of figure 81) with driver demographic characteristics (e.g., age, gender) and driver mental constructs (e.g., trust, tolerance). Any framework for driver acceptance of technology must start with the driver, not with the technology. To be commercially successful, ITS must focus first upon driver needs, and not upon technological capabilities. Technology is used when it fulfills a consumer need or want. The driver's needs and wants are conceived from the driver's mental model of the entire driving system: the vehicle, the roads, the driving environment including other vehicles, and the purpose of the journey. Technology is accepted when its comprehended benefits exceed its perceived costs.

These driver physical and mental characteristics determine feature pattern desirability (experiments 1 and 1B): the psychological structure that defines and differentiates elements of ITS functionality. Specific ATIS features can be divided into preference categories. For example, some desirable TravTek features are congestion information and route guidance to correct a route after a missed turn (table 3). Some undesirable TravTek features are vehicle position provided by voice and advertising information provided by voice (table 4). These components of the framework have been demonstrated in the present experiments. Figure 81 also implies that specific features are more likely to be accepted by drivers if they cluster into a factor (feature pattern). However, due to time and resource limitations this hypothesis was not evaluated in experiments 1 and 1B.

Future research is needed to better relate patterns of features to driver acceptance. Figure 81 hypothesizes that a new variable, termed ATIS complexity, is monotonically related to the sum of all ATIS features. Even neutral or unwanted features increase ATIS complexity. ATIS complexity decreases driver acceptance in two ways. First, it increases ATIS costs. Such costs include not only the dollar amounts needed to purchase and operate ITS technology, but also the added costs of using a more complex system such as increasing driver workload and effort to learn to use the system.

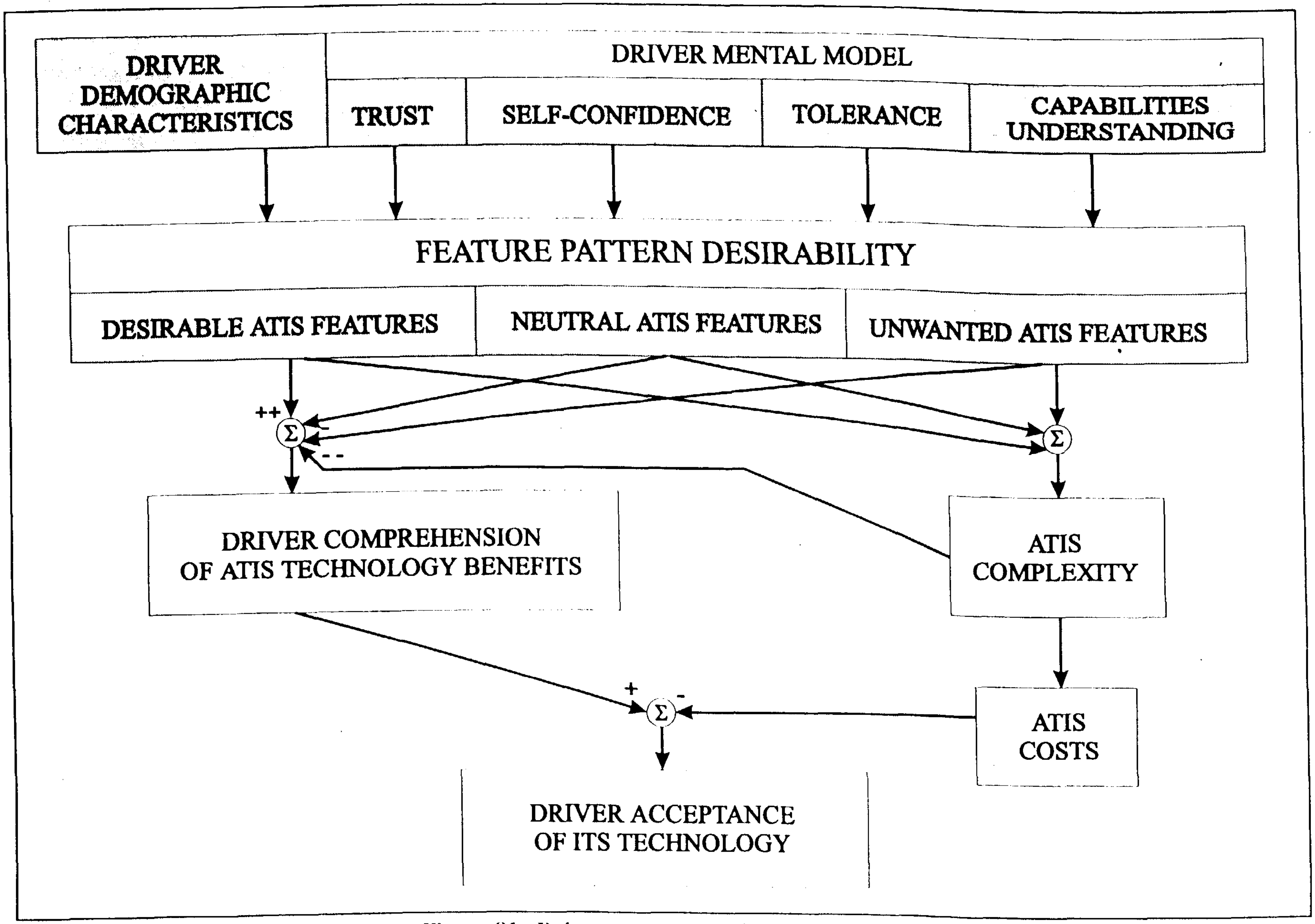


Figure 81. Driver acceptance of ITS technology

Second, ATIS complexity decreases driver comprehension of ATIS technology and its benefits. Desirable features increase driver comprehension and unwanted features decrease comprehension. Effects of neutral features could either increase or decrease comprehension but are anticipated to be weaker than effects of desirable or unwanted features. Driver acceptance is determined by comparing the benefits (driver comprehension) with the deficits (ATIS costs).

This framework predicts that driver acceptance will not be maximized by maximizing the set of ATIS features. Even if unwanted features are avoided, either by omission or by driver allocation of function decisions, too many neutral features will still increase ATIS complexity, thereby decreasing driver acceptance. Of course, if unwanted features are included, driver acceptance will diminish even more. If figure 81 is correct, it implies that good human factors practice would have manufacturers first test ITS features empirically for driver acceptance before including them in a production system. Having a feature that works well is no guarantee that drivers will find that feature to be desirable. More new technology is not necessarily better new technology. As was explained in chapter 1, even people who use new technology (e.g., ATM banking, VCR) seldom use all or even most of the features of new technology.

USE OF MODELS

The typical questionnaire study often reports results from individual questions, as was done in the Phase I analyses of experiments 1 and 1B, without any attempt at building an integrating model of acceptance, as was done in figure 9. This typical approach presents two problems of interpretation. First, it is difficult to integrate a large number of separate analyses of variance, often one statistical analysis per survey question; experiment 1 contained 52 feature-desirability variables. A more theoretical framework is required to better understand the large amount of data collected from questionnaire research. It is hard to grasp the true impact of such a large data set without such a framework. Second, the individual analyses fail to capture joint information about sets of desirable features. Without the Phase 3 analyses, it would not have been possible to understand that only six factors (table 11) are required to capture the desired feature patterns latent in the TravTek data set. Thus, the present research demonstrates the benefits of a model-driven approach to driver acceptance of ITS and strongly suggests that future research continue to use models.

A corollary of this approach is that global evaluations of a particular ATIS device may not be helpful for building design guidelines. While such evaluations may help compare different ATIS devices, knowing that some particular system is well-liked overall does not immediately suggest design improvements. Improvements can be generated from analysis of desired feature patterns, driver demographics, and mental model. A model is vital for detecting systematic departures from optimal human factors design.

of an ATIS function and to learn its strengths and weaknesses. A more emersive full-task simulation environment could afford professional drivers the chance to understand their ATIS systems in a non-lethal setting.

Incentives to Promote ITS Acceptance and Use in CVO

A final goal was to develop recommendations for incentives that could be used to promote ITS acceptance and use in CVO. Most people accept or reject products on the basis of individual experience rather than acting on a desire to achieve broader social goals such as decreased pollution. If social goals were more important to most individuals than personal convenience, many more people would use bicycles and mass transit to get to work. Thus, rather than statements of public approval about ITS, user benefits such as increased safety, shorter commute time, and better fuel economy should be emphasized. Experiment 2 showed that people will use an ATIS if it is provided to them. In fact, less than 8 percent of the subjects did not use the route guidance system when available. Despite this, it must be cautioned that drivers may resent paying money for inaccurate information and therefore may not use it. For commercial drivers, the incentive to accept ATIS systems lies in the increase in the driver's personal safety. If the first CVO system is limited to safety components, it should be accepted by drivers much more easily than a more complete functional system that is overly complex and intimidating and probably includes functions that appear to threaten the drivers' independence. Trucking companies also have a direct incentive to start with a simple safety-oriented ATIS. In recent years, the costs associated with accidents have ballooned either in the form of insurance premiums or in the out-of-pocket expense of self-insurance. Increasing driver safety may also mean a reduction in the accident rate. Another incentive for the trucking companies lies in possible reduction in driver turnover rates. A company that proves its emphasis on driver safety by fielding a safety-related ATIS system may benefit from increased driver loyalty thereby reducing its need to recruit and train new, often less experienced, drivers.

FUTURE RESEARCH

Establishing constructs, such as trust and tolerance, that mediate feature pattern desirability is only a first step towards creating human factors design guidelines. Highway engineers and manufacturers need quite specific guidance about parameters of constructs. While it is reassuring to know that drivers will tolerate imperfect systems and that errors do not completely eradicate trust, such general statements are insufficient for design guidelines. Design engineers need to know more precisely about human limits for trust and tolerance. Is 77 percent reliability a lower limit or will drivers accept 60 percent? These kinds of questions are best answered by more simulations of the type performed in experiment 2. Objective measures of behavior are superior to questionnaire ratings for obtaining design parameter limits.

Of course, it is not practical to obtain objective measures for all, or even most, design parameters. Questionnaire methodology casts a wider net for the same research dollar. Thus, an efficient research strategy would use questionnaires to determine which design parameters are most vital for driver acceptance of ITS technology, followed by objective measures to provide better estimates of key parameters. For example, experiment 2 used an overall level of reliability of 77 percent. But each driver did not experience exactly 77 percent errors, as each subject was allowed to choose an unique route. Future research could use dynamic selection of link traffic levels, which were fixed in experiment 2, to provide specified levels of unreliability for each driver on each simulated trip.

Future research must also take into account effects of attention and fidelity. These variables, although not shown in figure 81, alter the utility of research findings. Fidelity refers to the psychological fidelity of a simulator, not to its physical similarity to real devices. Behavior is controlled more by psychological fidelity, and often high physical fidelity represents an unnecessary research expense (Kantowitz, 1988). Attention controls how effective a simulation might be. For example, in experiment 2 decreasing the driver's bonus when heavy traffic was encountered helped to ensure that attention remained focused throughout the trip.

Commercial drivers may be the best initial group of drivers with which to assess the viability of ATIS functions, both at the concept/survey level and at the hands-on level. Commercial drivers typically operate larger, less easily controlled, vehicles and, therefore, would appear to have a greater need for straightforwardly usable and useful systems.

In summary, the tools and models developed in this task offer great promise for achieving the goals of this project. While evaluating consumer acceptance of future technologies is an arduous challenge, human factors does have methods to tackle the job effectively. These will be applied relentlessly for the remainder of this project.

APPENDIX A: SUMMARY OF RELEVANT LITERATURE

REASONS FOR RESISTING NEW TECHNOLOGY

The content of appendix A represents an attempt to explicitly address the six specific items raised in the Statement of Work. In the first section of appendix A, the literature on technology acceptance, product diffusion, and marketing research was reviewed. Key factors were extracted that were considered relevant to technology resistance. The factors identified in the literature survey are listed in the first column of table 60. An interpretation of how this factor might be expected to affect resistance to ATIS and CVO applications of ITS technology is included in subsequent columns of the table.

The following definitions are given to support the content of table 60. The table is divided into three primary categories of factors: product characteristics, consumer characteristics, and organizational characteristics. Both ATIS and CVO issues are discussed for the first two categories, but for the Organizational Characteristics, only CVO applications are discussed.

Product Characteristic Definitions

Rogers (1971, 1983), Tornatzky and Klein (1982), Feldman and Armstrong (1975), Ram (1989), Holak (1988), and Holak and Lehmann (1990) have proposed 11 product characteristics that influence the acceptance of innovative new products. Rouse and Morris's (1986) assessment of user acceptance of computers in industry suggests that acceptance depends on the perception of the affect on job performance, ease of use, user discretion, and the perception of organizational and peer group attitudes towards automation. Table 60 lists the product characteristics and their expected influence on adoption or resistance of ATIS/CVO technologies.

- Compatibility: The consistency of an adopter's values or norms and consistency with an adopter's daily activities.
- Communicability: The ease of perceiving and expressing the product benefits to others.
- Complexity: The difficulty of understanding and using the new product.
- Cost: The price of the product.
- Discretion: The opportunity to exercise skills, judgment, and creativity while using the product. The functional level at which the product operates determines the amount of discretion allowed by users.
- Divisibility: The ability to try a product without a large initial investment.
- Observability: The visibility to others of the results of using the innovation.
- Perceived risk: The product performance or psychosocial risks attributed to the product.
- Profitability: The level of profit to be gained by adoption of the innovation.
- Relative advantage: The perceived superiority of the product over those preceding it.
- Trialability: The ability to experiment with the innovation on a limited basis.

Consumer Characteristic Definitions

Studies on consumer characteristics have been less definitive than those on product characteristics (e.g., Wilton & Pessemier, 1981; Leonard-Barton, 1985; Hill, Smith, & Mann, 1986). Table 60 also includes a list of the consumer characteristics and their expected influence on adoption and rejection of ATIS/CVO technology.

- Self-efficacy: The perceived ability of oneself to use a product successfully.
- Product knowledge: Knowledge about the product or similar products.
- Product class interest: Inherent interest in the product category.

Table 60 also lists the organizational and work environment characteristics that may influence acceptance of CVO. These factors were taken from studies on the acceptance of automation, computers, and information system in factories and offices (e.g., Nelson, 1990; Buchanan & Boddy, 1983; Wall, Corbett, Clegg, Jackson, & Martin, 1990).

Table 60. Factors affecting resistance to ATIS/CVO technology.

PRODUCT CHARACTERISTICS	ATIS	CVO
COMPATIBILITY: Compatibility negatively affects resistance.	It is expected that an ATIS system will not be compatible with anything drivers currently use in their cars. The system may be compatible with some drivers use of other public access information systems and personal computer products. Those drivers who currently use computer related products will be less resistant to ATIS.	Compatibility for CVO systems may depend on the technological climate within the company. Couriers, such as Federal Express and UPS, and police departments are examples of organizations that utilize the latest in-vehicle technology. These types of companies would be less likely to resist a CVO system.
COMMUNICABILITY: Communicability negatively affects resistance.	Drivers should be able to see a benefit from using the ATIS system. If traffic and route information is a primary function of ATIS, the commuting time for the driver with the system should be less than drivers without the system. To the extent that this type of benefit is apparent to the system owner and can be communicated to others, resistance should decrease.	To the extent that a CVO system improves job performance and the driver can attribute this improvement to the system, resistance will decrease.
COMPLEXITY: Complexity positively affects resistance.	ATIS systems which are difficult to use will increase resistance.	CVO systems which are difficult to use will increase resistance.
COST: Cost positively affects resistance.	Higher cost systems will increase resistance.	Higher cost systems will increase resistance.
DISCRETION: The affect of discretion is dependent on the type of functions performed by the system.	A system that performs those tasks over which the driver prefers control will meet with greater resistance than a system that performs less desirable tasks.	A system that performs those tasks over which the driver prefers control will meet with greater resistance than a system that performs less desirable tasks.

Table 60. Factors affecting resistance to ATIS/CVO technology (continued).

PRODUCT CHARACTERISTICS	ATIS	CVO
DIVISIBILITY: Divisibility negatively affects resistance.	A system that is available to new users at a low cost will reduce resistance. For example, the system could be introduced in stages. The first release could be low cost with limited function. Future releases could increase cost and function. Alternatively, a range of systems could be made available with upgrades as an option.	The same concepts will apply to CVO.
OBSERVABILITY: Observability negatively affects resistance.	The more easily the benefits can be seen by other drivers, the less likely they are to resist.	If resistant companies can see that their competitors are benefiting from CVO use, they will adopt the innovation more quickly.
PERCEIVED RISK: Perceived risk positively affects resistance.	An ATIS system whose use increases the probability of automobile accidents, forces a change in driving habits, or appears to be the latest technological fad (a potential loss of investment) will increase resistance.	Resistance will be greater if drivers believe that CVO systems will adversely affect their jobs or eliminate them altogether. Resistance also will increase if drivers believe the systems will be used to monitor their activities.
PROFITABILITY: Profitability negatively affects resistance.	Drivers will be less likely to resist if ATIS systems decrease the amount of time spent in traffic jams, decrease money spent on gas, decrease time spent navigating in unfamiliar areas.	Companies whose profitability increases because of CVO use will adopt the innovation more quickly. Drivers are less likely to be affected by profitability.
RELATIVE ADVANTAGE: Relative advantage negatively affects resistance.	The biggest hurdle to overcome will be the perception that, for the most part, ITS only offers traffic information and route planning. Drivers realize that in day-to-day driving, traffic information can be obtained pre-departure by watching the local morning news. After departure traffic information is available on the radio. The value of route planning in the local area is very small. Drivers already know local alternative routes. One way to change the opinion of these drivers will be to inform them of other ITS features that will benefit them directly.	Providing the same information that is available through other sources (e.g., maps, billboards, radio traffic reports) will not be enough incentive for drivers to adopt ATIS. The system must offer substantial advantages over current methods of obtaining information to overcome resistance.
SELF EFFICACY: Self efficacy negatively affects resistance.	Drivers who believe they are able to use the system will be more likely to adopt the system. People who have had trouble driving or using other information systems, personal computers, etc., will be more resistant.	The same concepts will apply to CVO.
LOCATION	Drivers in metropolitan areas are expected to be less resistant to ATIS systems. Drivers in rural areas probably do not need ATIS for most of their driving. Approximately 54% of the passengers vehicles in the U.S. are registered in the 50 largest metropolitan areas.	As with ATIS, commercial drivers in urban areas probably will need CVO more than drivers in rural areas. In addition, interstate transporters would need CVO.

Table 60. Factors affecting resistance to ATIS/CVO technology (continued).

CONSUMER CHARACTERISTICS	ATIS	CVO
PRODUCT KNOWLEDGE	Drivers who are more knowledgeable about ATIS systems are more likely to adopt the technology (assuming that the product is worthwhile and more knowledge means more knowledge about product benefits). However, negative information will be more influential than positive information.	In addition to knowledge of system function and benefits, commercial drivers will resist less if they understand why CVO is being used by their company.
SOURCE OF PRODUCT KNOWLEDGE: Source of knowledge interacts with other consumer characteristics.	Drivers who are less knowledgeable about ATIS will be influenced by "experts". These experts may be trade journalists, celebrities, or friends.	Additional sources of information are managers, coworkers, and drivers from other companies.
EDUCATION	Drivers with more education will adopt ATIS more quickly.	The same concepts will apply to CVO. Education level may be interact with organizational level. That is, resistance may be greatest at the lower levels of an organization where educational levels also are lowest.
INCOME	Drivers with higher incomes will adopt ATIS more quickly.	Personal income should not be a factor in resistance to CVO systems. Company profitability or cash flow status may show a relationship with resistance similar to income.
AGE	Older drivers will be more likely to resist ATIS. This resistance will be due to a number of factors: decaying cognitive and perceptual abilities, restricted driving range and frequency, greater knowledge of local driving environment, flexibility to avoid driving during rush hours.	Initial resistance to CVO is expected to be higher among older drivers.
PRODUCT CLASS INTEREST	Interest in computers, information systems, automobiles, and electronics will decrease driver resistance.	The same concepts will apply to CVO.
ORGANIZATIONAL CHARACTERISTICS	**CVO**	
WORK GROUP MORALE	Higher group morale should decrease resistance to CVO.	
SUPPORT OF MANAGEMENT/ CONFIDENCE IN MANAGEMENT	Drivers who support management objectives (e.g., company wide technological change) will be less resistant to CVO. Companies with a history of failed innovation adoption will be more resistant to CVO.	
JOB EXPERIENCE	More experienced drivers will be more resistant towards CVO. However, they will be more productive than newer drivers once they adopt the system.	

Table 61. Possible techniques to resist ATIS/CVO technology (continued).

CVO	
SYSTEM PURCHASE	Refuse to purchase a CVO system for any of the following reasons: the technology is a fad or gimmick, first generation systems are always prone to errors, the system is not cost effective and needs more study, first generation systems are too expensive and the costs will fall over time.
JOB PERFORMANCE: Intentional mistakes.	Drivers may purposely make mistakes when entering information into the system in an attempt to diminish the utility of the system.
JOB PERFORMANCE: Intentional suboptimal performance.	If drivers perceive the system as a means of management measuring job performance, they may intentionally perform below their capability. Possible means of resistance include: ignoring system information, "forgetting" passwords or procedures, working more efficiently without the system than with it, blame the system for poor performance.
JOB PERFORMANCE: Resistance to training.	Drivers may participate in training at a minimum level- attendance but not involvement.
SYSTEM IMPAIRMENT	Drivers may find ways to disable the system permanently or temporarily (i.e., on demand).
MAINTENANCE	Impair, rather than repair, systems brought in for maintenance.
JOB TURNOVER: Intraorganizational.	Drivers may find other jobs within the company in order to avoid use of CVO. They would be expected to communicate their negative feelings about the system to their new coworkers.
JOB TURNOVER: Interorganizational.	Drivers may find jobs with other companies (who have not adopted CVO). They would be expected to communicate their negative feelings about the system to their new coworkers.
ORGANIZED RESISTANCE	Unions may represent drivers with grievances about changes in work conditions as a result of CVO.

ESTIMATE OF THE PERCENTAGE OF DRIVERS LIKELY TO ADOPT ATIS/CVO

Figure 82 shows the cumulative percentage of U.S. households with certain consumer products, plotted as a function of time (years) since the product was introduced. The diffusion of these products follows the traditional S-shape curve associated with successful innovative products. Cellular telephones are possibly the most relevant analogy that can be made with this data to ATIS/CVO. We suggest that the cellular telephone analogy may be more appropriate as a model for ATIS/CVO than the ATM example given previously in the body of this report. As of 1991, cellular subscribers accounted for only 2.5 percent of the U.S. population. Industry experts project market penetration to increase to 15 percent of the population (approximately 45 percent of the households) by the year 2000.

Caveats For Interpreting Figure 82

1) The data represent the adoption and diffusion of successful products. Unsuccessful products would be characterized by shorter duration (fewer years) on the abscissa and very low slope (negligible increase in sales).

2) There may be a maximum adoption level for ATIS equivalent to the percentage of cars in larger metropolitan areas. For 1992, approximately 54 percent of all passenger vehicles (this does not include trucks and buses) were registered in the 50 largest metropolitan statistical areas. That is, the total addressable market for ATIS might be better characterized by the 54 percent figure than by the total number of registered cars in the U.S.

Sources of Data

1) 1992 Statistical Abstract of the United States
2) 1992 Rand McNally Commercial Atlas and Marketing Guide
3) 1991 Consumer Electronics Review
4) Several papers included in the bibliography and reference sections

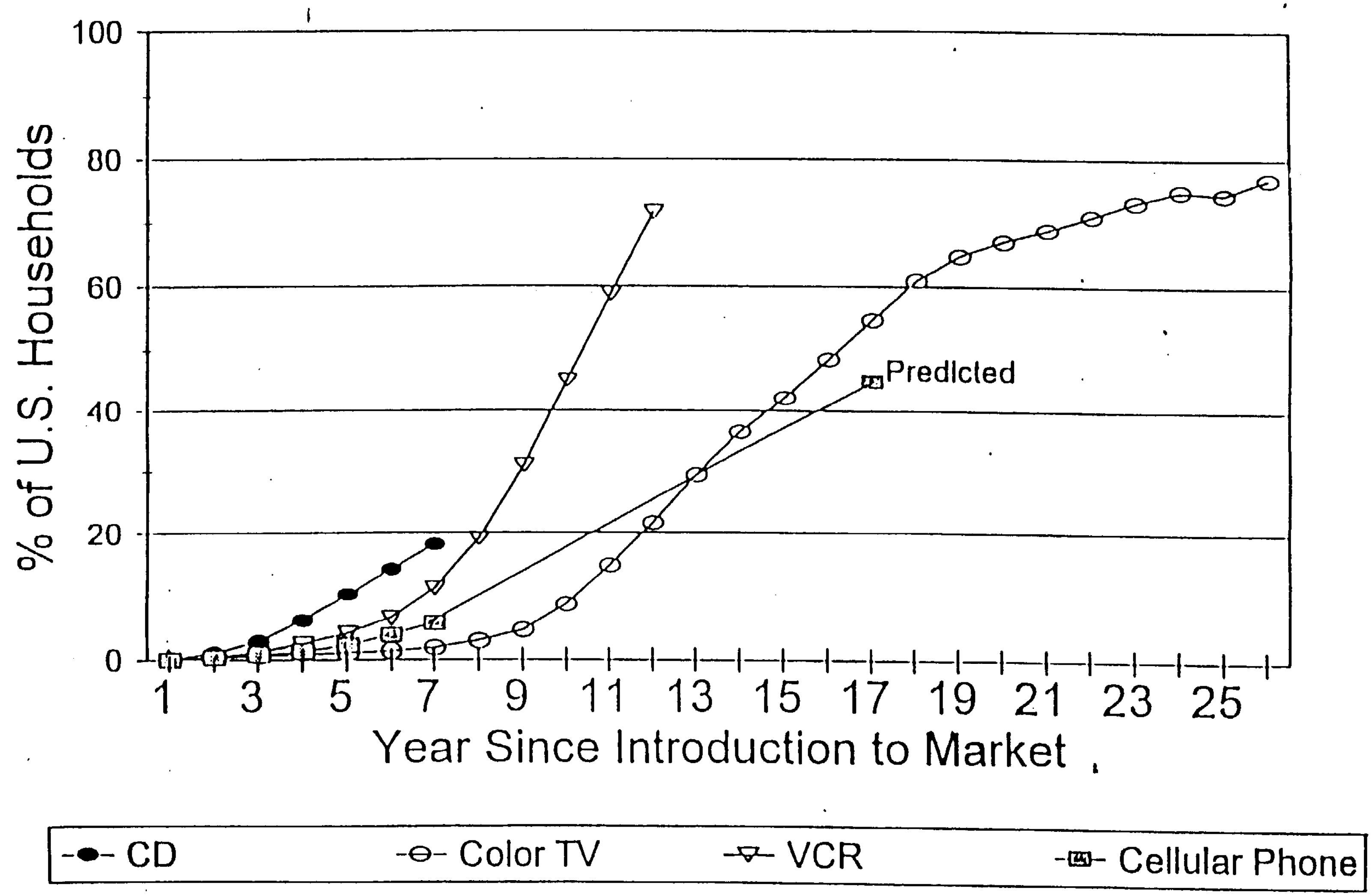


Figure 82. Diffusion curves for four consumer products.

ESTIMATE OF THE PERCENTAGE OF DRIVERS LIKELY TO FOLLOW ATIS/CVO RECOMMENDATIONS

The percentage of drivers accepting or rejecting advice from ATIS or CVO is difficult to estimate. As described in the fifth section, there are a number of variables that will influence the acceptance of ATIS/CVO system recommendations. These variables may act independently or in combination with other variables. In the body of the report a gross estimate was developed of the total proportion of drivers who might follow the recommendations of an in-vehicle system by the year 2020. That estimate, 20 to 35 percent, was based on the compound probability of technology acceptance (40 percent based on analogy with ATM's) and the range of compliance estimates, 50 to 90 percent, based on survey and simulation studies. An estimate based on cellular telephone diffusion data would lead to similar conclusions since, approximately 45 percent of the households in the U.S. are projected to have a cellular phone by the year 2000. These estimates are more appropriate to ATIS than to CVO systems.

The compound probability of following recommendations can be expected be higher in the CVO environment. Driver compliance will be high, possibly over 90 percent, because use of the equipment will be integral to job performance and included in employee training programs. A higher proportion of commercial vehicles can be expected to be outfitted with ITS in-vehicle systems because it may prove to be cost-effective. We have no basis for projecting the proportion of commercial vehicles that will be equipped with CVO systems, therefore a compound probability cannot be calculated. Beyond predicting that the probability of compliance will be greater in CVO than in ATIS, quantitative estimates must await further data collection.

More accurate projections may be possible after results are available from the research in the remainder of this task. An in-depth marketing analysis is advisable to complement user-interface evaluations. The prediction of technology acceptance or compliance which is based on experimentation with individuals or small groups (the Experimental Social Psychology model) is not recommended (see last section of this appendix). Human factors engineering studies are important for the design of good user-interfaces, but similar methodological approaches for predicting technology compliance are not recommended because, as stated in the last section of this appendix, attitudes are not predictive of behavior.

CONDITIONS THAT MAY AFFECT ACCEPTANCE OR REJECTION OF ATIS/CVO ADVICE

The information in the following table is based on information developed from sources listed in the Bibliography and extrapolated in small group discussion.

Table 62. Information developed from bibliography and small-group discussion.

FACTOR	DESCRIPTION
URGENCY	If the driver perceives him or herself to be under pressure to arrive at an unfamiliar destination as quickly as possible, then the acceptance of an alternative route will be increased. (An example would be taking someone to a hospital emergency room.).
FAMILIARITY	A lack of familiarity with the area will increase acceptance of route recommendations. For example, rental cars can be expected to have a relatively high rate of usage and acceptance.
POTENTIAL TIME SAVINGS	Increases in the potential time savings will increase the acceptance of route recommendations.
EXPECTED DURATION OF CONGESTION	The longer the expected duration of the congestion, the greater the chance that a user will comply with a suggested alternative route. For example, if the delay is caused by a hazardous material spill that will close the road for several hours, drivers will be more likely to search for alternatives than if the delay is due to a crash and there is a reasonable expectation of getting past the bottleneck in a short period of time.
EXPECTATION OF CONGESTION ON ALTERNATIVE ROUTES	If the driver expects that conditions on alternative routes are just as bad as on the primary route, the probability of accepting an alternative is low. An alternative route may not be accepted during most normal rush hours if drivers know the surface streets are jammed too.
RAPID ACCESS TO ROUTE PLANNING	Unless it is easy to get the information, pre-route planning features for day to day commuting won't be widely used. For longer trips, or trips out of the normal (e.g., when going to a work site that is not your normal one) use of this feature will increase.
CONGESTION HISTORY	If the road has a history of occasional severe backups, drivers are more likely to want traffic information on a regular basis. However, this type of driver may have alternative routes pre- selected.
PRIMA FACIA REASONABLENESS	The suggested alternative route must look reasonable for a driver to accept it. Apparent backtracking and frequent turns, for example, would make a route appear unreasonable.
USER-INTERFACE FEATURE AND SENSORY MODALITY	The recommended route must be in a format that is readily interpreted in a driving (or a pre-driving) context. For example, arrows (e.g., left, right, continue same direction) could be presented visually. In some circumstances drivers might like a voice system ("Left turn, in 2 blocks"). The system should not divert the driver's attention from driving.
CURRENCY OF INFORMATION	The maps in the ITS system must be current. Ease of updating the maps and the cost of updates will affect acceptance.
PREDEFINED DESTINATIONS	Frequent destinations should be pre-entered (like phone numbers in an autodialer) so that a check on traffic conditions can be made pre-departure.
AUTOMATED AID TO LAW ENFORCEMENT	If ATIS/CVO is perceived to have the potential for law enforcement "abuse", fewer people are likely to buy the system. For instance, if it is believed that speeding tickets could be issued based on the data collected by the system (regardless of whether or not this actually occurs), acceptance will be reduced.
PROBABILITY OF THEFT	If the system is an attractive target for thieves, acceptance will be reduced.
STABILITY OF RECOMMENDATIONS	The system must remain fairly stable. Fluctuations in recommended routes should be minimal. Transient traffic conditions should be ignored. (The size of the delay to ignore should be user defined.)
KNOWLEDGE OF SCHEDULED EVENTS	The system needs to have knowledge of scheduled events that will affect traffic. Examples include sporting events, extraordinarily busy times at airports, parades, and political inaugurations.

Table 62. Information developed from bibliography and small-group discussion (continued).

FACTOR	DESCRIPTION
ERROR RECOVERY AIDING	The system needs to be helpful in error recovery. It should take current position into account and offer a return to the original route or an entirely new route. Also, the system must allow changes in destination to be entered at any time. Rigid and unforgiving systems will reduce acceptance.
RURAL OR OFF-ROAD USE	For vehicles that may become lost in areas where there are not major roads (e.g., rural delivery vehicles) some means (such as GPS) of finding the vehicle's current location in absolute terms will be a desirable feature.
PAST EXPERIENCE WITH THE SYSTEM	Getting directed to go the wrong way down one way streets, failure to account for road closures, or wrong information given a very few times will deter system use. These bad experiences will be more damaging to acceptance than a large number of positive experiences would be toward improving acceptance.
TIMELY DATA	The traffic information used to support system route recommendations must be timely (on the order of 5 minutes).
MAGNITUDE OF RECOMMENDED ROUTE CHANGE	If the route change is a simple detour, as opposed to a new route, the driver will be more likely to accept the recommendation.
PERSONAL SAFETY/CAR-JACKING	There are some neighborhoods that some drivers will not enter no matter how much time might be saved. This is a problem for rental car drivers who are not aware of these neighborhoods. System users will not be pleased with such reroutings.
RENTAL CAR DIRECTIONS	The system should direct the driver to and from the hotel, and to and from the rental car return. The driver may not know the address of either location.
RENTAL CAR FUELING	Since most rental cars need to be refueled during use and before being returned, the driver should be able to get directions to or locations of gas stations. He/she might want to select a particular brand of station, or stations that sell diesel fuel, or stations within 10 min or 16.10 km, or some combination of logical conditions.
HIGHWAY TOLLS	In unfamiliar areas, the driver should be warned about toll booths. The cost also needs to be mentioned. If there are automatic toll collection or exact change only lanes, the driver needs to know which ones they are.
CVO RESTRICTIONS	The system must take roadway restrictions (e.g., maximum height, maximum weight, local delivery only, hazardous material restrictions) into account.
CVO ROUTING RECOMMENDATION	If accepting the recommended route is company policy, and there are sanctions for failure to comply, then acceptance will increase.
CVO WEATHER INFORMATION	Winter storm warnings, tornado warnings and the like affect route selection. However, if the detour is very long relative to the length of time likely to be saved, then the drive may simply be postponed instead.
CVO CONSIDERATION OF ALTERNATIVE ROUTES	Consider the situation of a delivery route driver. Intelligent alternative routings will be more readily accepted than if the system blindly reroutes the drivers to the original stop.
CVO URGENCY	Anything that increases the driver's sense of urgency will increase the acceptance of alternative routes. Perishable cargo and delivery incentives (bonus for timeliness) are two factors that could affect perceived urgency for CVO that are not applicable to private vehicles.

POTENTIAL TECHNIQUES FOR PROMOTING THE ACCEPTANCE AND USE OF ATIS/CVO

The information in this table was generated from small-group discussion after reviewing sources listed in the bibliography.

Table 63. Information generated from small-group discussion.

FACTOR	DESCRIPTION
PROMOTION: Government.	Federal, State, and local governments could promote ATIS/CVO as progress toward economic, efficient, safe automobile travel.
PROMOTION: Consumer groups.	Drivers must be convinced that ATIS/CVO is safe and is not a threat to privacy or mobility. Consumer advocacy organizations should endorse ATIS/CVO because of the safety and economic benefits.
PROMOTION: Auto industry.	Automobile manufacturers have traditionally resisted adding standard features or options to their cars (e.g., airbags and seatbelts). The automobile industry needs to be convinced of the utility of ATIS/CVO and actively promote the systems.
PROMOTION: Unions.	Union leaders should be convinced of CVO's utility or necessity prior to introduction of the system. Union acceptance of CVO technology is important for its viability.
PROMOTION: Opinion leaders.	For certain subgroups, such as car or computer enthusiasts, acceptance of ATIS/CVO may be influenced by editorials or product reviews in trade periodicals. Marketing to the computer enthusiast will probably emphasize the "high tech" aspect of the system. Building on what the computer enthusiast already knows or owns will encourage purchase and use of such a system. Perhaps an add-on to a notebook computer (much like the current TV reception add-ons) would be one way to distribute the system. Marketing the system to car enthusiasts could include racing and rally competition. Many car enthusiasts will want to add the system as an after-market item (like radios and CD players). The after-market systems should be available from the same sources as are radios and other automotive accessories.
PROMOTION: Other industry	Electronics and software/hardware systems manufacturers can promote ITS technologies through the usual advertising and promotion methods.
TRAINING: Learning to use the system.	Government and industry should support training facilities and classes to teach drivers how to use ATIS/CVO. Older drivers could be offered the option of training while training might be required for newly licensed drivers.
TRAINING: Media.	In-vehicle training packages could include embedded multi-media - sound and visual, with interactive examples on the system itself.
TRAINING: Job performance.	For some companies (e.g., taxis, delivery trucks), CVO maps and route information may be used as a training device to teach new drivers.
STAGED INTRODUCTION: Function availability.	The availability of system function might be staged with low function-low cost systems at first and higher function-higher cost systems to follow. Early introduction of feature-rich systems may overload drivers and accentuate problems.
STAGED INTRODUCTION: Geographic availability.	Much as the TravTek system is being introduced in Orlando, ATIS/CVO might be made available in only a few States or cities initially. Consumer products are commonly tested in "bellwether" States before being made available nationally.
STAGED INTRODUCTION: CVO versus ATIS.	Acceptance may be increased by introducing CVO prior to ATIS. Training on the CVO systems and evidence of CVO utility might cause commercial drivers to promote CVO/ATIS among other drivers.
SYSTEM MODIFICATION	One advantage of a staged introduction is the opportunity to modify the system. Early feedback from drivers should be useful in guiding system development.

Table 63. Information generated from small-group discussion (continued).

FACTOR	DESCRIPTION
SOCIETAL/ENVIRON-MENTAL BENEFITS	A possible benefit of ATIS is the substitution of in-vehicle advertising for billboards. Another benefit of buying and using the system is reduced traffic congestion and consequent reductions in air pollution, reduced need to build roadways, etc. This may influence these people to buy a system even though its benefit to them is less than the cost.
SAFETY	Features that have a safety implication may influence some drivers to purchase a system. One example is emergency assistance facilitated by providing the location of the vehicle to the proper authorities. Summoning a tow truck, or the police, might be useful and attractive features.
FORCED ADOPTION	Drivers could be forced to purchase a system by legislative action, such as current seat-belt requirements, making the installation of an ATIS/CVO system mandatory in order to license a vehicle another possibility. Probably the least painful way to mandate the use of ATIS is to require the systems in new vehicles. With normal attrition, the majority of cars would be equipped with systems in the lifetime of production automobiles. Some drivers will resist forced adoption as another intrusion by the government into their private life. This group will feel that the information on, or in, the system can be used against them. For example, the system will have information sufficient to determine driving speeds. It may also allow the government to be able to track the position of their autos. Note that the issue of location tracking will be advertised as positive feature to commercial fleet managers, but perceived as a negative by the drivers.

RELATIONSHIP OF ATTITUDES TO BEHAVIOR: THEORY AND RESEARCH

History of Attitude/Behavior Research

The "attitude" construct received its first serious attention from Darwin in 1872. Darwin defined attitude as a motor concept, or the physical expression of an emotion. For early psychologists, "attitude" was an emotion or thought with a motoric (behavioral) component. In some cases, the motoric component was subvocal speech; in other cases, gross behavior, such as postural change, was of interest. Beginning in the 1930's, psychologists began to argue actively about what components should comprise the attitude concept. Although there was agreement that all attitudes contain an evaluative component, theorists disagreed about whether beliefs (cognitions) and behaviors should be included as part of the attitude concept. The prevailing view among cognitive social psychologists was that "attitude" has both affective and belief components and that attitudes and behavior should be consistent; i.e., people with positive attitudes should behave positively toward the attitude object.

LaPiere (1934) reported that hotel managers' attitudes toward Chinese guests did not predict their responses to a Chinese couple who asked for a room. LaPiere's work was criticized on numerous grounds (e. g., the person who filled out the questionnaire may not have been the same person who later admitted the Chinese to the hotel), but many other researchers reported similar findings: attitudes did not predict behavior even when measured under optimal conditions, (Wicker, 1969).

In 1975, Fishbein and Ajzen published *Belief, Attitude, Intention and Behavior: An Introduction to Theory and Research*, laying out the theory of reasoned action which they claimed would improve our ability to predict behavior. In published reports, the variables specified by the theory generally did account for more of the variance in behavior than had previous attitude/behavior measures. However, it soon became clear that some important limitations on the theory's domain were required, that additional variables would need to be included, and that the theory was perhaps better understood as a taxonomy, as opposed to an explanatory system. Ajzen (1987) has published an updated version of the theory of reasoned action called the theory of planned behavior. Although the theory of planned behavior has undergone relatively few empirical tests, it seems unlikely that it will fare significantly better than Fishbein and Ajzen's earlier work. Although Fishbein's model remains popular with some market researchers, the prevailing theory among psychologists is Fazio's (1986) attitude accessibility model.

In the remainder of this paper, each of these theories will be discussed along with the research undertaken to test them and the major problems each seems to have.

Fishbein and Ajzen's Theory of Reasoned Action

The theory of reasoned action actually applies to the prediction of intentions, as opposed to behavior itself. According to the theory, if behavior is under volitional control, then the intention to perform an action will correlate very highly with the action itself. By and large, this supposition has been found to be correct, with correlations between intention and behavior averaging 0.55. The full model is:

$$B\ I = w_p\, Attitude_{behavior} \quad + \quad w_p\, Subjective\ Norm$$

$$\text{and} \qquad Attitude_{behavior} = b_i e_i$$

$$\text{and} \qquad Subjective\ Norm \ = \ b_i\, m_i$$

and the w's are subjective weightings for a particular person.

Attitudes Toward the Behavior

Attitudes toward the behavior are made up of beliefs about engaging in the behavior and the associated evaluation of that belief. For example, consider the purchase of a car, X. In tests of the model, subjects are asked to list their beliefs associated with buying the car. These beliefs are consequences of the action. One belief might be: "Buying car X will cost me $300 a month." Another belief might be "Buying car X will make me more attractive to the opposite sex." Each belief is then rated for the likelihood that engaging in the behavior will produce that consequence. The likelihood ratings are an index of belief strength. After subjects rate the probability of each belief's being true, they evaluate how good or bad this aspect is. A car payment of $300 might be rated as quite bad, while being attractive to the opposite sex might be quite good. These ratings (both belief strength and evaluations) are quantified on -3 to +3 or 1 to 7 scales. The belief strength and evaluation ratings are multiplied together for each belief and summed across beliefs to give a measure of *attitude toward the behavior.*

Subjective Norm

The *subjective norm* term in the model is also multiplicative. The "b's" in this term are beliefs about what relevant others will think if the respondent engages in the behavior. For example, "People who are important to me would not want me to buy car X." Again, the certainty that this is true is rated by the respondent. Each belief receives a second rating: how strongly does the respondent wish to comply with the referent other's views. So, I might feel very certain that important others would not approve of my buying car X but I might have a very low desire to comply with their views.

Intention

Intention is usually measured by one to four questions asking the likelihood the respondent will engage in the behavior. Bagozzi, Baumgartner, and Yi (1989) have called attention to neglect of the reliability of the intention measure. A recent metanalysis (Sheppard, Harwick & Warshaw, 1988) found the mean correlation between intention and the attitudes + norm component to be 0.66.

Selection of the Beliefs

In some studies, subjects list their own beliefs about the consequences of engaging in a behavior. In other studies, pilot testing of a large sample is used to discover the most common relevant beliefs for a particular group; these common beliefs (usually 7 to 15 different beliefs) are then given to the experimental sample for rating.

This model has been used extensively with health and social issues, particularly intentions to use birth control, stop smoking, smoke marijuana, recycle, use alcohol, etc.

Problems in this Area of Research

Limitations on the Domain of Application

Conscious control. As implied by its name, the theory of reasoned action does not apply to habitual actions that are presumably not under continual conscious processing. In other words, the theory applies to behavior the individual consciously elects to do. Many tests of the model have been conducted with habitual behaviors, however. Kahle & Beatty (1987) applied the model to coffee drinking and found good statistical support for the theory. However, a model that included only habit and situation did an even better job of prediction.

Correspondence Ajzen and Fishbein (1977) subsequently published an article further limiting the theory to those situations in which the attitude and behavior demonstrate *correspondence*. According to Ajzen and Fishbein, attitudes and behavior each have four elements: action, target, context, and time. Correspondence occurs to the extent that attitudes and behaviors are identical on all four elements. To predict intention, attitudes and intention must measure exactly the same four elements. To return to the car purchase example: my intention to buy car X has an action (buy), a target (car X), and to expand the example, a context (at a particular dealer's with a particular loan), and a time (next month). If I want to predict a specific intention, I must measure a specific attitude. The resulting experimental procedure seems extremely trivial; instead of measuring these extremely specific components, one can simply ask "Do you intend to purchase car X from this dealership next month?" Fishbein and Ajzen's primary goal in developing the notion of correspondence was to show why one can't predict specific intentions from general measures of attitude, such as, "What do you think of car X?" To predict specific intentions (behaviors), equally specific attitudes must be measured.

Behavior scaling. Fishbein and Ajzen (1976) also addressed a measurement problem that makes the prediction of intentions problematic. They noted that researchers spend great effort to develop attitude scales that are reliable, valid, and satisfy certain measurement criteria, such as Guttman or Thurstone scales. Behaviors are often chosen haphazardly. Other than the researcher's intuition, there is no way to scale how positive or negative a particular behavior might be. Consider someone who has a "very positive attitude" toward abortion rights. I may find that the person does not sport a bumper sticker advocating abortion rights. Fishbein would not find this puzzling because we don't know anything about how the behavior, displaying the bumper sticker, scales. Is it an extremely positive behavior? Is it slightly positive? Fishbein and Ajzen found that scaling behaviors and attitudes on the same scale (e. g., Likert, Guttman, etc.) resulted in dramatic improvements in the attitude/intention (behavior) correlation. In addition, the predictive power of general attitude measures, in particular Likert scales, improved when a number of behaviors were presented and subjects were asked how many behaviors they had performed or intended to perform. Prediction of individual behaviors from a general attitude measure was extremely poor. Prediction of the score on this so-called behavioral composite scale was much better. People with more positive attitudes performed a greater number of positive behaviors but which specific behavior was performed was not predictable from the general attitude measure.

Additional Variables

Moderators. Although Fishbein and Ajzen believed that any other variable affecting the attitude-intention (behavior) link exerted its effect on one of the terms in the model, Ajzen's own research proved this was erroneous. Self-monitoring refers to a stable individual difference (Snyder, 1974) in the tendency to vary one's behavior in different situations. High self-monitors are sensitive to situation cues and tailor their behavior, dress, and speech to the situation. Low self-monitors are indifferent to situational cues and act on the basis of their principles. Ajzen, Timko and White (1982) found that the attitude/intention model was more predictive of the behavior of low self-monitors than high self-monitors. High self-monitors' intentions did not correlate with their behavior. Low self-monitors apparently tend to act on their attitudes no matter what the situation. High self-monitors may not express an attitude in behavior if they feel the behavior is inappropriate for the situation. To summarize, the Fishbein-Ajzen model works better for low self-monitors because these people are more likely to translate their attitudes into behavior across a variety of situations.

Private self-consciousness. This is a second individual difference moderator currently receiving attention. Private self-consciousness is the dispositional tendency to be aware of one's own internal thoughts and feelings. Miller & Grush (1986) found higher attitude/behavior consistency for people high in private self-consciousness, presumably because they were more aware of their own attitudes.

Other variables. In many tests of Fishbein's model, additional variables have been included and found to increase the attitude/behavior correlation. Some of these include: economic variables (Lynne & Rola, 1988) in predicting farmers' behavior regarding soil conservation; moral values (Boyd & Wandersman, 1991) in predicting condom use; and academic achievement and friends' intentions (Carpenter & Fleishman, 1987) to predict college entry.

Measurement Problems

Methodology. Most tests of Fishbein's model ask subjects to indicate how strongly they believe that a series of belief statements are true. These ratings are followed by a request to indicate how good or bad each belief consequence is. Research by Budd and Spencer (1986) suggests that this format creates a serious confound. First, when the Fishbein items are scattered within a larger questionnaire, the correlations between intention and the $[b_i e_i + b_i m_i]$ term are much lower than when all the ratings are presented in a cluster. Second, Budd and Spencer asked students to rate how honestly they felt a questionnaire measuring attitudes, beliefs, norms, and intentions had been answered. When the theory of reasoned action was violated (attitudes were inconsistent with intentions), the hypothetical respondent was seen as more dishonest. The authors argue that Fishbein's theory is part of an intuitive psychology of intention and that this intuitive psychology acts as a source of response bias, promoting consistency between responses.

Self-reports. A second methodology issue is that tests of the Fishbein-Ajzen model rely almost exclusively on self-reports. Behavior itself is rarely directly observed. Self-reports of behavior are notoriously unreliable and have been found to vary with attitude (Ross, McFarland, Conway & Zanna, 1986); people with more positive attitudes report more positive actions than they actually performed; people with negative attitudes report more negative actions than actually performed. Manfredo and Shelby (1988) studied wildlife tax-fund donations. Fishbein and Ajzen's model was applied to both actual behavior gathered from the fund's records and self-reports from donors. The correlations for predicting actual and self-reported behaviors were both significant but were significantly different from each other.

Statistical issues. Evans (1991) has criticized the Fishbein and Ajzen model on statistical grounds. Evans notes that when one is using a multiplicative component to predict a simple variable (e.g., attitudes toward the behavior to predict intention), one must include the main effects (the belief strengths and the evaluations of each belief) in the model prior to the entry of the multiplicative component. Evans notes that multiplicative components have a peculiar property: a change in the zero point or a change in the interval size of either component scale can have marked effects on the size of the correlation coefficient. Evans singles out the Fishbein-Ajzen model for scrutiny. He notes that of 40 studies covered in a recent meta analysis (Sheppard et al., 1988), none have tested a full additive model that included main effects. Evans could find only a single study (Hewstone & Young, 1988) in which attitude researchers studied main effects. These authors examined the relationship between beliefs and evaluations of outcomes to overall attitudes toward the European Economic Community. Hewstone and Young actually compared an additive model that included main effects and a multiplicative model without the main effects. They also compared two different ways of scaling beliefs and evaluations, a -3 to +3 scale and a +1 to +7 scale. For the full additive model, scaling had no effect on the multiple R which was 0.46. For the multiplicative model, the -3 to +3 scale version correlated 0.30 with attitudes. Given the variety of scales used to study the attitude/behavior link and the failure of investigators to enter the main effects first, Evans concludes that a whole body of literature is rendered suspect.

Ajzen's Theory of Planned Behavior

The theory of planned behavior (Schifter & Ajzen, 1985) is an extension of the theory of reasoned action. The theory of planned behavior includes one additional variable: perceived behavioral control. Perceived behavioral control is assessed by asking people how much control they have over performing a particular behavior. In Ajzen's tests of the theory (Ajzen & Madden, 1986; Madden, Ellen & Ajzen, 1992) the measurement of the attitudinal component has also been simplified. Attitudes toward the behavior are measured on a five item semantic differential scale. Including the perceived behavior control variable does lead to significant improvements in R^2 for behaviors perceived to be low in control. "Getting a good night's sleep" is an example of a low control behavior; "taking vitamins" is a high control behavior. The behavioral control variable did not improve prediction for the latter behavior, presumably because the behavior itself is already perceived as high control.

Problems. All the problems associated with the theory of reasoned action are also problems for the theory of planned behavior.

Fazio's Attitude Accessibility Theory

Fazio's (1986) model of the process by which attitudes guide behavior is currently receiving a fair amount of attention in the social psychological literature. Fazio defines attitude as a learned association between a concept and an evaluation. Like any construct based on associative learning, attitude strength varies. Fazio indexes strength using a reaction time paradigm. The more rapidly an attitude can be expressed, the greater its strength. The stronger the attitude the more accessible it is.

To guide behavior, attitudes must be accessible. Attitudes that are highly accessible from memory are much more likely to guide behavior than less accessible attitudes. Fazio, Sanbonmatsu, Powell and Kardes (1986) have demonstrated that accessible attitudes are activated spontaneously upon presentation of the attitude issue. Their emphasis on the automatic activation of attitudes differs markedly from Fishbein's view that attitudes result from a controlled effortful process of attribute consideration and evaluation.

Fazio and his colleagues have shown that correlations between attitudes and behavior are much higher among people with highly accessible attitudes. In one study (Fazio and Williams, 1986), accessibility was assessed by how quickly respondents rated the 1984 candidates for U.S. President. Four months later on thé day after the elections, the respondents were asked if they had voted and for whom. Among voters with highly accessible attitudes, 80 percent of the variance in voting behavior was explained by attitudes; among voters with less accessible attitudes, only 44 percent of the voting behavior was accounted for by attitudes. Fazio and Williams believe the greater consistency of the highly accessible group is a function of greater attitudinal stability. Highly accessible attitudes are linked to selective processing of information and even selective attention (Fazio, 1989; Roskos-Ewoldson & Fazio, 1992). To the extent that accessible attitudes are accessed each time an individual encounters the relevant concept, the attitude protects its holder against counter-attitudinal information and potential attitude/behavior inconsistency.

Accessibility is weakly related (0.30) to attitudinal polarity. Extreme attitudes do have a tendency to be more accessible. Accessibility, measured by reaction time to an attitudinal query, is a function of: number of previous expressions of the attitude; opportunities for review or rehearsal of the beliefs and behaviors associated with the attitude; direct experience with the attitude object; and anticipation of future interaction with the attitude object. Highly accessible attitudes are more difficult to change (Wu and Shaffer, 1987).

Problems

There have been few published criticisms of the attitude accessibility model. Bargh and Chaiken (1992) have recently claimed that variations in associative strength are more a function of word frequency and cultural norms than individual differences in experience with the attitude object. Bargh and Chaiken were able to replicate Fazio and colleagues' reaction time findings.

The lack of criticism may result from a number of factors: the relative recency of the theory is one obvious consideration. Because the computers needed to measure reaction times are more expensive than a paper questionnaire, attempts to replicate and extend the theory may be more difficult. Finally, social psychologists essentially abandoned interest in learning theories of attitudes in the 1950's; Fazio's work on the power of learned associations to guide behavior may raise issues with which cognitive theorists are less comfortable. One interesting development is that Ajzen discusses Fazio's model without criticism (but possibly without enthusiasm) in a recent chapter.

Summary

As Evans (1991) noted, interest in the Fishbein/Ajzen models has waned in recent years. Attitude accessibility would appear to be the promising newcomer. There are, however, two strands of thought that suggest accurate prediction of specific volitional actions may be a difficult, if not impossible, task.

First, consistency between nonhabitual behaviors themselves tends to be quite low. Epstein (1979) tracked the behaviors of college students over a 2-week period. Behaviors were actions such as number of telephone calls made, number of letters written, number of social contacts initiated, etc. Consistency between actions on any two days was extremely low. With 7-day means, correlations improved dramatically. Thus, even the old adage that the best predictor of behavior is past behavior held true only for aggregated behaviors. To the extent that behaviors themselves exhibit temporal instability, a stable construct, such as an attitude, cannot predict a particular behavior successfully.

Second, Mischel (1983) has noted the power of situations, relative to attitudes or traits, in the control of behavior. He has argued that consistency between an internal state and a behavior is an epiphenomenon constructed by the observer to simplify the task of making sense of the world. Mischel believes behavior is situationally specific and cannot be understood by aggregation to remove temporal instability.

One should also note that the attitude/behavior relationship is currently receiving relatively little research attention. Whether this declining interest is a consequence of the difficulty of demonstrating the relationship or simply a manifestation of the "fads and fashions" of social psychology is a question yet unanswered.

APPENDIX B: EXPERIMENT 1 AND 1B MATERIALS

DRIVER DEMOGRAPHIC CHARACTERISTICS

In this section, the questions we ask will give us an idea of your background and use of certain kinds of devices. For some questions you will need to fill in a number or word. For other questions, you can answer by placing an "X" in the box that applies to you. Please answer each question as accurately as possible. Remember that all responses will be confidential.

1. Age: _____

2. Number of years as a licensed driver: _____

3. Number of years driving in Seattle: _____

4. Town of residence: ________________________

5. Gender: ☐ Male ☐ Female

6. Marital status: ______ (single, married, other)

7. Education level:

   ☐ Below 12th grade (less than high school completion)
   ☐ High School diploma (or equivalent)
   ☐ Some College
   ☐ Associates Degree
   ☐ Bachelors Degree
   ☐ Advanced Degree

8. Ethnic group:

   ☐ American Indian/Alaskan Native
   ☐ Asian or Pacific Islander
   ☐ African American
   ☐ Caucasian
   ☐ Hispanic
   ☐ Other (please describe) __________

9. Number of family members in household: _____

10. Annual household income:

- ☐ under $20,000
- ☐ $20,000 - 39,999
- ☐ $40,000 - 59,999
- ☐ $60,000 - 79,999
- ☐ $80,000 - 99,999
- ☐ greater than $100,000

11. Do you own your own automobile? ☐ Yes ☐ No

Answer the following for the vehicle you most frequently drive.

Make _________

Model _________

Year _____

12. Check the average number of miles you drive annually.

- ☐ less than 5,000
- ☐ 5,000 - 9,999
- ☐ 10,000 - 19,999
- ☐ 20,000 - 39,999
- ☐ 40,000 - 69,999
- ☐ 70,000 - 99,999
- ☐ more than 100,000

13. For each of the following trip types, please estimate the number of trips per week you make.

_____ commute to work (one way only)
_____ shopping trips
_____ errands
_____ social visits
_____ recreation

14. How many vacation trips per year do you take? _____

15. Which of the following does the vehicle you most frequently use have?

- ☐ air bags
- ☐ anti-lock brakes (ABS)
- ☐ cassette player
- ☐ cellular phone/radio phone
- ☐ cruise control
- ☐ electronic dashboard displays
- ☐ garage door opener
- ☐ power brakes
- ☐ power steering
- ☐ power windows and door locks
- ☐ radar detector

16. For each of the following devices, please indicate if you own the device by marking an "X" in the "OWN" column. Then indicate if you use the device by marking an "X" in the "USE" column. For the devices you use, please indicate how frequently you use each device by entering a number in the "FREQUENCY OF USE" column (e.g., once a month, three times a week).

DEVICE	OWN	USE	FREQUENCY OF USE
Automatic teller machine (ATM) card	N/A		
Videocassette recorder (VCR)			
Hand-held calculator			
Cordless phone			
Microwave oven			
Personal computer			
• DOS			
• Windows			
• Macintosh			
Computer bulletin boards	N/A		
Telephone answering machine/voice messaging			

It is important to us to understand how comfortable you feel with computers. For items 17-22, please mark with an "X" to indicate how much each statement below applies to you. Marking toward the 100 would indicate that a statement strongly applies. Marking toward the 0 would indicate that it does not apply.

17. I am sure I could do work with computers.

0 Does not Apply — 50 — 100 Strongly Applies

18. I would like working with computers.

0 Does not Apply — 50 — 100 Strongly Applies

19. I would feel comfortable working with computers.

0 Does not Apply — 50 — 100 Strongly Applies

20. Working with a computer would make me very nervous.

0 Does not Apply — 50 — 100 Strongly Applies

21. I do as little work with computers as possible.

0 Does not Apply — 50 — 100 Strongly Applies

22. I think using a computer would be very hard for me.

0 Does not Apply — 50 — 100 Strongly Applies

23. Have you ever visited Orlando, Florida? ☐ Yes ☐ No
If yes, how many times have you visited? ____

24. Have you ever lived in Orlando, Florida? ☐ Yes ☐ No
If yes, how long did you live there? ____

25. Have you ever visited New York City? ☐ Yes ☐ No
If yes, how many times have you visited? ____

26. Have you ever lived in New York City? ☐ Yes ☐ No
If yes, how long did you live there? ____

TRAVTEK SYSTEM CAPABILITIES

- For this section, please indicate which functions/features you think the TravTek system has by marking the "HAS" column with an "X." Base your responses on what you learned from the video(s).

#	HAS	Trip Planning, Navigation, and Routing
		Position/location of your vehicle provided by:
1		• electronic map display
2		• text or icon display
3		• voice
		Congestion information provided by:
4		• electronic map display
5		• text or icon display
6		• voice
		Coordination of Travel:
7		• with bus time tables
8		• with real-time bus information
9		• with airline arrivals/departures

#	HAS	Trip Planning, Navigation, and Routing
		Toll Information:
10		• toll prices
11		• toll credit remaining (toll automatically deducted from account bar code on vehicle)
		Pre-drive Route Selection:
12		• that accepts driver preferences
13		• that calculates route to avoid congestion
		Route Guidance:
14		• that corrects your route after a missed turn
15		• that responds to changes in congestion by generating a new route
16		• shown on an electronic map with a view of the whole route
17		• that shows only current position and next turn with directional arrows
18		• given by voice
		Multi-destination Trip Planning Function: (planning a route with more than one stop)
19		• allows selection of scenic routes
20		• coordinates hotel accommodations
21		• calculates mileage, time, and cost estimates
		Other features not mentioned:
22		•
23		•
24		•

#	HAS	Services and Attraction Information
		Parking information present: (e.g., location of parking, cost)
25		• on electronic map display
26		• on a text or icon display
27		• by voice
		Restaurant reservations:
28		• made by the system
		Advertising information provided by: (similar to billboard advertising, radio commercials, tourist information signs)
29		• electronic map
30		• text or icon display
31		• voice
		Computer-based yellow pages:
32		• that provides a services and attractions directory
		Other features not mentioned:
33		•
34		•
35		•

#	HAS	In-Vehicle Road Sign Information
		Notification of road closures or detours provided by:
36		• electronic map display
37		• text or icon display
38		• voice
		Advisory speeds for potential hazards such as sharp turns provided by:
39		• electronic map display
40		• text or icon display
41		• voice
		Street names, highway numbers, and distances to towns/exits provided by:
42		• electronic map display
43		• text or icon display
44		• voice
		Regulation information such as speed limits and one-way streets provided by:
45		• electronic map display
46		• text or icon display
47		• voice
		Only signs relevant to driver's pre-planned route provided in vehicle:
48		• electronic map display
49		• text or icon display
50		• voice
		Other features not mentioned:
51		•
52		•
53		•

#	HAS	Safety and Warning Information
		Hazard warning of road construction or accident occurrence provided by:
54		• electronic map display
55		• text or icon display
56		• voice
		Vehicle monitoring, such as oil level, fuel level, or engine status, provided by:
57		• text or icon display
58		• voice
		Notification of poor road conditions due to weather, congestion, ice, and snow provided by:
59		• electronic map display
60		• text or icon display
61		• voice
		Aid request: (e.g., 911 emergency dispatch, tow truck request)
62		• automatic aid request when airbag is activated
63		• use the system to call for help
		Other features not mentioned:
64		•
65		•
66		•

TRAVTEK SYSTEM FEATURE DESIRABILITY

- For this section, please indicate which functions/features you think are Essential, Desirable, or Not Needed by marking the "VALUE" columns with values from the scale below. In the first column, indicate the value of each item in an unfamiliar city. In the second column, indicate the value of each item in a familiar city.

- Scale:

  0 = Not Needed.

  1 = Desirable: The feature would be nice to have but is not essential for me to consider buying the program.

  2 = Essential: I would not consider buying the program without this feature.

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	**Unfamiliar City**	**Familiar City**	**Trip Planning, Navigation, and Routing**
			Position/location of your vehicle provided by:
1			• electronic map display
2			• text or icon display
3			• voice
			Congestion information provided by:
4			• electronic map display
5			• text or icon display
6			• voice
			Coordination of Travel:
7			• with bus time tables
8			• with real-time bus information
9			• with airline arrivals/departures

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	**Unfamiliar City**	**Familiar City**	**Trip Planning, Navigation, and Routing:**
			Toll Information:
10			• toll prices
11			• toll credit remaining (toll automatically deducted from account bar code on vehicle)
			Pre-drive Route Selection:
12			• that accepts driver preferences
13			• that calculates route to avoid congestion
			Route Guidance:
14			• that corrects your route after a missed turn
15			• that responds to changes in congestion by generating a new route
16			• shown on an electronic map with a view of the whole route
17			• that shows only current position and next turn with directional arrows
18			• given by voice
			Multi-destination Trip Planning Function: (planning a route with more than one stop)
19			• allows selection of scenic routes
20			• coordinates hotel accommodations
21			• calculates mileage, time and cost estimates
			Other features not mentioned:
22			•
23			•
24			•

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	Unfamiliar City	Familiar City	Services and Attraction Information
			Parking information present: (e.g., location of parking, cost)
25			• on electronic map display
26			• on a text or icon display
27			• by voice
			Restaurant reservations:
28			• made by the system
			Advertising information provided by: (similar to billboard advertising, radio commercials, tourist information signs)
29			• electronic map
30			• text or icon display
31			• voice
			Computer-based yellow pages:
32			• that provides a services and attractions directory
			Other features not mentioned:
33			•
34			•
35			•

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	**Unfamiliar City**	**Familiar City**	**In-Vehicle Road Sign Information**
			Notification of road closures or detours provided by:
36			• electronic map display
37			• text or icon display
38			• voice
			Advisory speeds for potential hazards such as sharp turns provided by:
39			• electronic map display
40			• text or icon display
41			• voice
			Street names, highway numbers, and distances to towns/exits provided by:
42			• electronic map display
43			• text or icon display
44			• voice
			Regulation information such as speed limits and one-way streets provided by:
45			• electronic map display
46			• text or icon display
47			• voice
			Only signs relevant to driver's pre-planned route provided in vehicle:
48			• on an electronic map display
49			• on a text or icon display
50			• by voice
			Other features not mentioned:
51			•
52			•

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	**Unfamiliar City**	**Familiar City**	**Safety and warning information:**
			Hazard warning of road construction or accident occurrence provided by:
53			• electronic map display
54			• text or icon display
55			• voice
			Vehicle monitoring, such as oil level, fuel level, or engine status, provided by:
56			• text or icon display
57			• voice
			Notification of poor road conditions due to weather, congestion, ice, and snow provided by:
58			• electronic map display
59			• text or icon display
60			• voice
			Aid request (911 emergency dispatch, tow truck request):
61			• automatic when airbag is activated
62			• use the system to call for help manually
			Other features not mentioned:
63			•
64			•
65			•

TRAVTEK DEMONSTRATION FIDELITY

It is important to understand how much the TravTek demonstration put you in the place of a user. To help us, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 indicates that it does not apply.

1. I felt the demonstration captured my attention.

0 Does not Apply	50	100 Strongly Applies

2. In my opinion, other drivers will feel the demonstration captures what using the system will be like.

0 Does not Apply	50	100 Strongly Applies

3. In my opinion, other drivers will feel their attention captured by the demonstration.

0 Does not Apply	50	100 Strongly Applies

4. The demonstration gave me the feel of what using the system would be like.

0 Does not Apply	50	100 Strongly Applies

5. I would like to see other new system demonstrations.

0 Does not Apply	50	100 Strongly Applies

6. My attention wandered during the demonstration.

0 Does not Apply	50	100 Strongly Applies

7. In my opinion, other drivers' attention will wander during the demonstration.

0 Does not Apply	50	100 Strongly Applies

8. The demonstration gave me a realistic impression of how the system might work.

0 Does not Apply	50	100 Strongly Applies

9. The demonstration will give other drivers a realistic impression of how the system might work.

0 Does not Apply	50	100 Strongly Applies

TRAVTEK: MODIFYING YOUR TRIP TO AVOID TRAFFIC

This section is used to help us understand how accurate navigation advice needs to be for drivers to use it. Pick the response that's best for you.

1. Would you pay attention to navigation advice which might <u>occasionally</u> make your trip longer (in minutes) intentionally, but would reduce overall traffic congestion?

   ☐ Yes ☐ No

2. If so, how many extra minutes of travel, for a trip that normally takes 35 minutes, would you be willing to accept?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

3. How often would you tolerate such delays and still use the advice?

   ☐ 0-1 times in 20 trips ☐ 5-10 times in 20 trips
   ☐ 1-5 times in 20 trips ☐ more than 10 times in 20 trips

4. For a journey that normally takes 35 minutes, how many minutes would you need to save to make it worthwhile to use an unfamiliar route?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

5. Imagine you can get a time estimate for a trip that accounts for traffic conditions. This trip normally takes 35 minutes. If the system was occasionally wrong, how many minutes would you accept arriving early and still use the system?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

6. For the same system, how many minutes would you accept arriving late and still use the system?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

TRAVTEK: TRUST & SELF-CONFIDENCE

We are interested in your judgments of how trustworthy you believe the technology to be. In addition, we are interested in how much self-confidence you have in your ability to do things yourself.

First, think about your trust in people. We all trust some people more than others. If you think about people you know, you can probably think of some you trust very much and others you trust much less. We do not trust all people equally, and we can express how much we trust a particular person.

We also think about trusting things, such as products. For example, I trust my car to start in the morning because it has never failed to do so. I trust my spouse's car much less because of a history of trouble.

Similar to trust, we can also consider the self-confidence in our own abilities. For example, you might have a great deal of self-confidence in your ability to walk to work because you have been doing it every day for several years.

If you think about it for a moment, we could rate our degree of trust and self-confidence in many of the things we use on a scale like those shown below. So let's rate a few functions that may be available in your vehicle in the future. Marking toward the 100 would indicate that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1a. I would trust a navigation system to guide me through an unfamiliar city.

0 Does not Apply — 50 — 100 Strongly Applies

1b. I have confidence in my ability to navigate myself through an unfamiliar city.

0 Does not Apply — 50 — 100 Strongly Applies

4b. I have confidence in my ability to navigate myself through an unfamiliar city to the airport on time.

0 Does not Apply	50	100 Strongly Applies

5a. I would trust a new automatic route guidance system to avoid highway congestion.

0 Does not Apply	50	100 Strongly Applies

5b. I have confidence in my ability to avoid highway congestion based upon my own observation of traffic.

0 Does not Apply	50	100 Strongly Applies

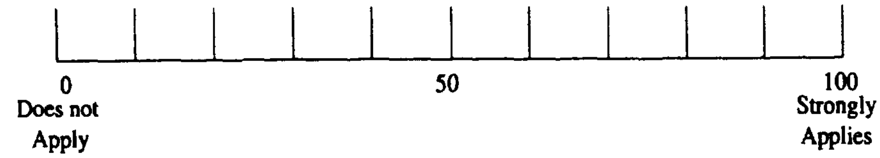
6a. I would trust an in-vehicle service directory to locate a restaurant in an unfamiliar town.

0 Does not Apply	50	100 Strongly Applies

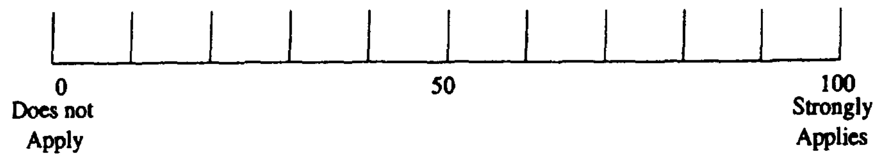
6b. I have confidence in my ability to locate a restaurant in an unfamiliar town.

0 Does not Apply	50	100 Strongly Applies

7a. I would trust an in-vehicle system to notify me of changes in the speed limit.



7b. I have confidence in my ability to recognize changes in the speed limit by observing roadway signs.



TRAVTEK USER ACCEPTANCE ISSUES

The following items will give us a better idea of your opinion of TravTek. For each item, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1. TravTek would match my driving style.

0 Does not Apply — 50 — 100 Strongly Applies

2. I can see benefits of using TravTek.

0 Does not Apply — 50 — 100 Strongly Applies

3. I can explain the benefits of using TravTek to other drivers.

0 Does not Apply — 50 — 100 Strongly Applies

4. TravTek is easy to understand.

0 Does not Apply — 50 — 100 Strongly Applies

5. TravTek is easy to use.

0 Does not Apply	50	100 Strongly Applies

6. The demonstration let me experience what using TravTek would be like.

0 Does not Apply	50	100 Strongly Applies

7. The driver in the video benefited from using TravTek.

0 Does not Apply	50	100 Strongly Applies

8. TravTek has advantages over paper maps.

0 Does not Apply	50	100 Strongly Applies

9. TravTek has advantages over listening to traffic reports on the radio.

0 Does not Apply	50	100 Strongly Applies

10. I am comfortable evaluating TravTek after watching the video.

0 Does not Apply	50	100 Strongly Applies

11. I would be able to use TravTek successfully.

0 Does not Apply	50	100 Strongly Applies

12. Using TravTek would be consistent with my daily activities.

0 Does not Apply	50	100 Strongly Applies

13. Using TravTek would be consistent with the way I drive.

0 Does not Apply	50	100 Strongly Applies

14. I think other drivers will see the benefits of using TravTek.

0 Does not Apply	50	100 Strongly Applies

20. I could use TravTek effectively.

0 Does not Apply — 50 — 100 Strongly Applies

21. Other drivers could use TravTek effectively.

0 Does not Apply — 50 — 100 Strongly Applies

22. I would use TravTek if it was available in a rental (or borrowed) vehicle.

0 Does not Apply — 50 — 100 Strongly Applies

23. I would consider buying TravTek for use in my own vehicle.

0 Does not Apply — 50 — 100 Strongly Applies

24. I think other drivers would use TravTek if it were available in a rental (or borrowed) vehicle.

0 Does not Apply — 50 — 100 Strongly Applies

25. I think other drivers would consider buying TravTek for use in their vehicles.

0 Does not Apply — 50 — 100 Strongly Applies

26. TravTek will reduce the probability of automobile accidents in unfamiliar cities.

0 Does not Apply — 50 — 100 Strongly Applies

27. TravTek will reduce the probability of automobile accidents in familiar cities.

0 Does not Apply — 50 — 100 Strongly Applies

28. TravTek will force a change in my driving habits.

0 Does not Apply — 50 — 100 Strongly Applies

29. TravTek is a technological fad.

0 Does not Apply — 50 — 100 Strongly Applies

TRAVTEK PERCEIVED USEFULNESS

The following items will help us to understand the usefulness of TravTek. For each item, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1. Using TravTek would enable me to reach my destination faster.

0 Does not Apply — 50 — 100 Strongly Applies

2. Using TravTek would improve my driving performance.

0 Does not Apply — 50 — 100 Strongly Applies

3. Using TravTek would increase my productivity.

0 Does not Apply — 50 — 100 Strongly Applies

4. Using TravTek would make traveling safer.

0 Does not Apply — 50 — 100 Strongly Applies

5. Using TravTek would help me arrive on time.

0 Does not Apply — 50 — 100 Strongly Applies

6. Using TravTek would enhance my driving effectiveness.

0 Does not Apply — 50 — 100 Strongly Applies

7. Using TravTek would make traveling easier.

0 Does not Apply — 50 — 100 Strongly Applies

8. I would find TravTek useful.

0 Does not Apply — 50 — 100 Strongly Applies

TRAVTEK PERCEIVED EASE OF USE

The following items will help us to understand how easy to use drivers find TravTek to be. For each item, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1. Learning to operate TravTek would be easy for me to do on my own.

0 Does not Apply	50	100 Strongly Applies

2. I would find it easy to get TravTek to do what I want it to do.

0 Does not Apply	50	100 Strongly Applies

3. TravTek would be clear to interact with.

0 Does not Apply	50	100 Strongly Applies

4. TravTek would be understandable.

0 Does not Apply	50	100 Strongly Applies

5. I would find TravTek to be flexible to interact with.

0 Does not Apply — 50 — 100 Strongly Applies

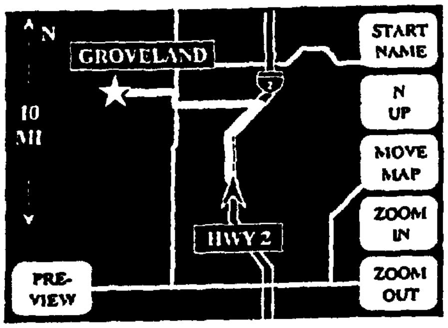
6. It would be easy for me to become skilled at using TravTek.

0 Does not Apply — 50 — 100 Strongly Applies

7. I would find TravTek easy to use.

0 Does not Apply — 50 — 100 Strongly Applies

2. The TravTek System's *Route Map*:



was easy to learn

1	2	3	4	5	6
Strongly Disagree					Strongly Agree

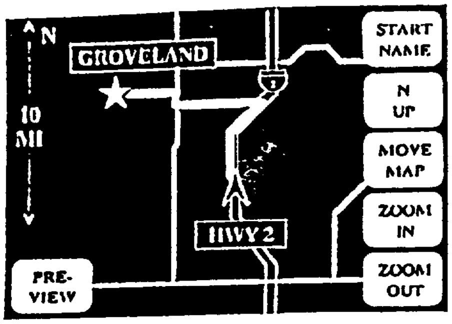
was easy to use

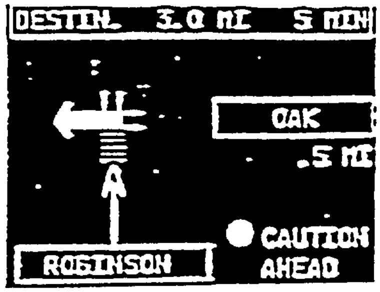
1	2	3	4	5	6
Strongly Disagree					Strongly Agree

was useful

1	2	3	4	5	6
Strongly Disagree					Strongly Agree

4. Of the two routing displays, *Route Map* and *Guidance Display*, which did you prefer?





1	2	3	4	5	6
Strongly Prefer Route Map					Strongly Prefer Guidance Display

5. Overall, the TravTek system:

was easy to learn

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

was easy to use

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

was useful

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

CITYGUIDE SYSTEM CAPABILITIES

- For this section, please indicate which functions/features you think the CityGuide system has by marking the "HAS" column with an "X." Base your answers on what you learned from the demonstration.

#	HAS	
		Position/location shown on an electronic map
1		• hotels
2		• restaurants
3		• landmark/tourist attractions
4		• theaters/shows/movies
5		• sports arenas
6		• shops
7		• museums
8		• parks
9		• specific address

#	HAS	
General Travel Information:		
26		• computer-based yellow pages that provides a services and attractions directory
27		• identification of places represented on the map (e.g., hotel, restaurants, landmarks, streets)
28		• information about prices (restaurants, hotels, special features)
29		• coordination of travel with airlines
30		• restaurant reservations made by the system
Parking information:		
31		• locations shown on map display
32		• text descriptions
Other routing information:		
33		• calculates route to avoid congestion
34		• calculates mileage, time, and cost estimates
35		• route selection preference for main highways or local access roads
36		• multi-destination (several stops) trip planning function
37		• one-way streets shown on the electronic map
38		• notification of road closures or detours
Other features not mentioned:		
39		•
40		•
41		•

CITYGUIDE SYSTEM FEATURE DESIRABILITY

- For this section, please indicate which functions/features you think are Essential, Desirable, or Not Needed by marking the "VALUE" columns with values from the scale below. In the first column, indicate the value of each item in an unfamiliar city. In the second column, indicate the value of each item in a familiar city.

- Scale:

  0 = Not Needed.

  1 = Desirable: The feature would be nice to have but is not essential for me to consider buying the program.

  2 = Essential: I would not consider buying the program without this feature.

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	Unfamiliar City	Familiar City	
			Position/location shown on an electronic map:
1			• hotels
2			• restaurants
3			• landmark/tourist attractions
4			• theaters/shows/movies
5			• sports arenas
6			• shops
7			• museums
8			• parks
9			• specific address

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	**Unfamiliar City**	**Familiar City**	**Trip Planning, Navigation, and Routing:**
			Toll Information:
10			• hotels
11			• restaurants
12			• landmark/tourist attractions
14			• theaters/shows/movies
15			• sports arenas
16			• shops
17			• museums
18			• parks
19			• specific address
			Route distance based on:
20			• using fewest roads possible
21			• shortest route distance
			Route Guidance:
22			• outlined on an electronic map on the computer screen
23			• map printed on a piece of paper (for use in car)
24			• written directions displayed on the computer screen
25			• written directions printed on a piece of paper (for use in car)

VALUE: 0 = Not Needed 1 = Desirable 2 = Essential			
#	Unfamiliar City	Familiar City	
			Parking information present:
26			• computer-based yellow pages that provides a services and attractions directory
27			• identification of places represented on the map (e.g., hotels, restaurants, landmarks, streets)
28			• information about prices (restaurants, hotels, special features)
29			• coordination of travel with airlines
30			• restaurant reservations made by the system
			Parking information:
31			• locations shown on map display
32			• text description
33			• calculates route to avoid congestion
34			• calculates mileage, time, and cost estimates
35			• route selection preference for main highways or local access roads
36			• multi-destination (several stops) trip planning function
37			• one-way streets shown on the electronic map
38			• notification of road closures or detours
			Other features not mentioned:
39			•
40			•
41			•

CITYGUIDE DEMONSTRATION FIDELITY

It is important to understand how much the CityGuide demonstration put you in the place of a user. To help us, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 indicates that it does not apply.

1. I felt the demonstration captured my attention.

0 Does not Apply					50					100 Strongly Applies

2. In my opinion, other drivers will feel the demonstration captures what using the system will be like.

0 Does not Apply					50					100 Strongly Applies

3. In my opinion, other drivers will feel their attention captured by the demonstration.

0 Does not Apply					50					100 Strongly Applies

4. The demonstration gave me the feel of what using the system would be like.

0 Does not Apply					50					100 Strongly Applies

5. I would like to see other new system demonstrations.

0 Does not Apply	50	100 Strongly Applies

6. My attention wandered during the demonstration.

0 Does not Apply	50	100 Strongly Applies

7. In my opinion, other drivers' attention will wander during the demonstration.

0 Does not Apply	50	100 Strongly Applies

8. The demonstration gave me a realistic impression of how the system might work.

0 Does not Apply	50	100 Strongly Applies

9. The demonstration will give other drivers a realistic impression of how the system might work.

0 Does not Apply	50	100 Strongly Applies

CITYGUIDE: TRUST & SELF-CONFIDENCE

We are interested in your judgments of how trustworthy you believe the technology to be. In addition, we are interested in how much self-confidence you have in your ability to do things yourself.

First, think about your trust in people. We all trust some people more than others. If you think about people you know, you can probably think of some you trust very much and others you trust much less. We do not trust all people equally, and we can express how much we trust a particular person.

We also think about trusting things, such as products. For example, I trust my car to start in the morning because it has never failed to do so. I trust my spouse's car much less because of a history of trouble.

Similar to trust, we can also consider the self-confidence in our own abilities. For example, you might have a great deal of self-confidence in your ability to walk to work because you have been doing it every day for several years.

If you think about it for a moment, we could rate our degree of trust and self-confidence in many of the things we use on a scale like those shown below. So let's rate a few functions that may be available in your vehicle in the future. Marking toward the 100 would indicate that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1a. I would trust a navigation system to guide me through an unfamiliar city.

0 Does not Apply — 50 — 100 Strongly Applies

1b. I have confidence in my ability to navigate myself through an unfamiliar city.

0 Does not Apply — 50 — 100 Strongly Applies

2a. I would trust a navigation system to guide me through a familiar city (e.g., home town).

0 Does not Apply	50	100 Strongly Applies

2b. I have confidence in my ability to navigate myself through a familiar city (e.g, home town).

0 Does not Apply	50	100 Strongly Applies

3a. I would trust a warning system to notify me of icy roads.

0 Does not Apply	50	100 Strongly Applies

3b. I have confidence in my ability to identify icy roads based on my own experience.

0 Does not Apply	50	100 Strongly Applies

4a. I would trust a navigation system to guide me through an unfamiliar city to the airport on time.

0 Does not Apply	50	100 Strongly Applies

4b. I have confidence in my ability to navigate myself through an unfamiliar city to the airport on time.

0 Does not Apply | 50 | 100 Strongly Applies

5a. I would trust a navigation program to avoid highway congestion.

0 Does not Apply | 50 | 100 Strongly Applies

5b. I have confidence in my ability to avoid highway congestion based upon my own observation of traffic.

0 Does not Apply | 50 | 100 Strongly Applies

6a. I would trust navigation program to locate a restaurant in an unfamiliar town.

0 Does not Apply | 50 | 100 Strongly Applies

6b. I have confidence in my ability to locate a restaurant in an unfamiliar town.

0 Does not Apply | 50 | 100 Strongly Applies

7a. I would trust a navigation program to locate an acceptable hotel in an unfamiliar town.

0 Does not Apply — 50 — 100 Strongly Applies

7b. I have confidence in my own ability to locate an acceptable hotel in an unfamiliar town.

0 Does not Apply — 50 — 100 Strongly Applies

8a. I would trust a navigation program to select a route that avoids highways.

0 Does not Apply — 50 — 100 Strongly Applies

8b. I have confidence in my own ability to select a route that avoids highways.

0 Does not Apply — 50 — 100 Strongly Applies

CITYGUIDE USER ACCEPTANCE ISSUES

The following items will give us a better idea of driver's opinions of CityGuide. For each item, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 indicates that it does not apply.

1. CityGuide would match my driving style.

0 Does not Apply — 50 — 100 Strongly Applies

2. I can see benefits of using CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

3. I can explain the benefits of using CityGuide to other drivers.

0 Does not Apply — 50 — 100 Strongly Applies

4. CityGuide is easy to understand.

0 Does not Apply — 50 — 100 Strongly Applies

5. CityGuide is easy to use.

0 Does not Apply — 50 — 100 Strongly Applies

6. The demonstration let me experience what using CityGuide would be like.

0 Does not Apply — 50 — 100 Strongly Applies

7. I would benefit from using CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

8. CityGuide has advantages over paper maps.

0 Does not Apply — 50 — 100 Strongly Applies

9. CityGuide has advantages over listening to traffic reports on the radio.

0 Does not Apply — 50 — 100 Strongly Applies

10. I am comfortable evaluating CityGuide after watching the demonstration.

0 Does not Apply — 50 — 100 Strongly Applies

11. I would be able to use CityGuide successfully.

0 Does not Apply — 50 — 100 Strongly Applies

12. Using CityGuide would be consistent with my daily activities.

0 Does not Apply — 50 — 100 Strongly Applies

13. Using CityGuide would be consistent with the way I drive.

0 Does not Apply — 50 — 100 Strongly Applies

14. I think other drivers will see the benefits of using CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

15. I think that other drivers would find CityGuide is easy to use.

0 Does not Apply — 50 — 100 Strongly Applies

16. I think that other drivers would find CityGuide is easy to understand.

0 Does not Apply — 50 — 100 Strongly Applies

17. CityGuide is an improvement over currently existing driving information sources.

0 Does not Apply — 50 — 100 Strongly Applies

18. CityGuide has advantages over guide books.

0 Does not Apply — 50 — 100 Strongly Applies

19. I think it will be easy for me to tell when other drivers are using CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

20. I think the driver in the demonstration benefited from CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

21. I could use CityGuide effectively.

0 Does not Apply — 50 — 100 Strongly Applies

22. Other drivers could use CityGuide effectively.

0 Does not Apply — 50 — 100 Strongly Applies

23. I would use CityGuide if it was available for a city I was going to visit.

0 Does not Apply — 50 — 100 Strongly Applies

24. I would consider buying CityGuide software for use in my home town (city of residence).

0 Does not Apply — 50 — 100 Strongly Applies

15. I think that other drivers would find CityGuide is easy to use.

0 Does not Apply — 50 — 100 Strongly Applies

16. I think that other drivers would find CityGuide is easy to understand.

0 Does not Apply — 50 — 100 Strongly Applies

17. CityGuide is an improvement over currently existing driving information sources.

0 Does not Apply — 50 — 100 Strongly Applies

18. CityGuide has advantages over guide books.

0 Does not Apply — 50 — 100 Strongly Applies

19. I think it will be easy for me to tell when other drivers are using CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

20. I think the driver in the demonstration benefited from CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

21. I could use CityGuide effectively.

0 Does not Apply — 50 — 100 Strongly Applies

22. Other drivers could use CityGuide effectively.

0 Does not Apply — 50 — 100 Strongly Applies

23. I would use CityGuide if it was available for a city I was going to visit.

0 Does not Apply — 50 — 100 Strongly Applies

24. I would consider buying CityGuide software for use in my home town (city of residence).

0 Does not Apply — 50 — 100 Strongly Applies

25. I would consider buying CityGuide software for unfamiliar places.

0 Does not Apply — 50 — 100 Strongly Applies

26. I think other drivers would use CityGuide software for use in unfamiliar places.

0 Does not Apply — 50 — 100 Strongly Applies

27. CityGuide will reduce the probability of automobile accidents in unfamiliar cities.

0 Does not Apply — 50 — 100 Strongly Applies

28. CityGuide will reduce the probability of automobile accidents in familiar cities.

0 Does not Apply — 50 — 100 Strongly Applies

29. CityGuide will force a change in my driving habits.

0 Does not Apply — 50 — 100 Strongly Applies

30. CityGuide is a technological fad.

0 Does not Apply — 50 — 100 Strongly Applies

31. CityGuide will reduce the amount of time I spend in traffic jams.

0 Does not Apply — 50 — 100 Strongly Applies

32. CityGuide will decrease the amount of money I spend on gas.

0 Does not Apply — 50 — 100 Strongly Applies

33. CityGuide will decrease the amount of time I spend navigating in unfamiliar areas.

0 Does not Apply — 50 — 100 Strongly Applies

CITYGUIDE PERCEIVED USEFULNESS

The following items will help us to understand how useful drivers find CityGuide to be. For each item, please mark with an "X" how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1. Using CityGuide would enable me to reach my destination faster.

0 Does not Apply — 50 — 100 Strongly Applies

2. Using CityGuide would improve my driving performance.

0 Does not Apply — 50 — 100 Strongly Applies

3. Using CityGuide would increase my productivity.

0 Does not Apply — 50 — 100 Strongly Applies

4. Using CityGuide would make traveling safer.

0 Does not Apply — 50 — 100 Strongly Applies

5. Using CityGuide would help me arrive on time.

0 Does not Apply — 50 — 100 Strongly Applies

6. Using CityGuide would enhance my driving effectiveness.

0 Does not Apply — 50 — 100 Strongly Applies

7. Using CityGuide would make traveling easier.

0 Does not Apply — 50 — 100 Strongly Applies

8. I would find CityGuide useful.

0 Does not Apply — 50 — 100 Strongly Applies

CITYGUIDE PERCEIVED EASE OF USE

The following items will help us to understand how easy to use drivers find CityGuide to be. For each item, please mark with an "X" how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 would indicate it did not apply.

1. Learning to operate CityGuide would be easy for me to do on my own.

0 Does not Apply					50					100 Strongly Applies

2. I would find it easy to get CityGuide to do what I want it to do.

0 Does not Apply					50					100 Strongly Applies

3. CityGuide would be clear to interact with.

0 Does not Apply					50					100 Strongly Applies

4. CityGuide would be understandable.

0 Does not Apply					50					100 Strongly Applies

5. I would find CityGuide to be flexible to interact with.

0 Does not Apply — 50 — 100 Strongly Applies

6. It would be easy for me to become skilled at using CityGuide.

0 Does not Apply — 50 — 100 Strongly Applies

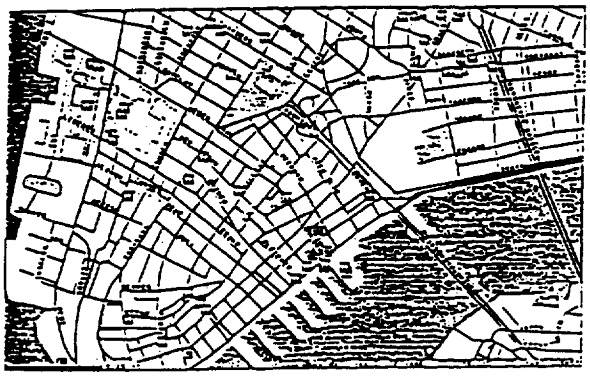
7. I would find CityGuide easy to use.

0 Does not Apply — 50 — 100 Strongly Applies

CITYGUIDE USER TEST QUESTIONS

Please mark with an "X" how much the statements below apply to you. Marking toward the "6" indicates that you strongly agree with the statement. Marking toward the "1" indicates that you strongly disagree with the statement.

1. The CityGuide system's *Map Display*:



was easy to learn

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

was easy to use

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

was useful

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

2. The CityGuide system's *Text Instructions*:

Start on 81st St.
Go south on 81st St for 2 blocks to Ditmars Blvd.

Turn right onto Ditmars Blvd.
Continue north-west on Ditmars Blvd for 1.2 miles to 31st St.

Turn left onto 31st St.
Continue south-west on 31st St for 5 tenths of a mile to Astoria Blvd.

Turn right onto Astoria Blvd.
Go west on Astoria Blvd for 4 tenths of a mile to 21st St.

Turn left onto 21st St.
Continue south-west on 21st St for 2.2 miles to Jackson Av.

Bear right onto Jackson Av.
Continue south-west on Jackson Ave for 3 tenths of a mile to I 495.

Turn right onto I 495.
Go north-west on I 495 for 7 tenths of a mile to Franklin D Roosevelt Dr.

Bear right onto Franklin D. Roosevelt Dr.
Continue north-east on Franklin D. Roosevelt Dr for 9 tenths of a mile to Hwy 2.

Turn left onto Hwy 25.
Go north-west on Hwy 25 for 1 block to 1st Av.

Turn right onto 1st Av.
Go north-east on 1st Av for 1.8 miles to E 96th St.

Turn left onto E 96th St.
Go north-west on E 96th St for 3 tenths of a mile to Park Av.

Turn left onto Park Av.
Continue south-west on Park Av for 4 blocks to Park Av.

You have reached Park Av.

Total distance traveled is 8.77 miles.

were easy to learn

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

were easy to use

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

were useful

1 2 3 4 5 6

Strongly Disagree — Strongly Agree

3. Of the two routing options, *Map Display* and *Text Instructions*, which did you prefer?

1 2 3 4 5 6

Strongly Prefer Map Display	Strongly Prefer Text Instructions

4. Overall, the CityGuide system:

was easy to learn

1	2	3	4	5	6
Strongly Disagree					Strongly Agree

was easy to use

1	2	3	4	5	6
Strongly Disagree					Strongly Agree

was useful

1	2	3	4	5	6
Strongly Disagree					Strongly Agree

EXPERIMENT 1B: CVO SURVEY

E. Questions About <u>Using an In-Vehicle Traffic Information System</u>

26. Lets say you were given an in-vehicle traffic information system (e.g., a computer screen in your vehicle), that had the capability to show you current traffic conditions. The system can also provide roadside motorist services, such as nearest rest stop and next gas station, as well as provide you information about oncoming road conditions.

☐ Yes ☐ No

27. How much would you pay for this in-vehicle traffic information system? $__________

28. How important is the following information for an in-vehicle traffic information system?

	Very important			Moderate importance			Not important
Navigation and route selection	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Road and traffic information	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Roadside services (e.g., restaurants, hotels, etc.)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Personal communication (i.e., the ability to make and receive calls, including those for emergencies)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

29. If an in-vehicle traffic information system was provided to you, how many miles ahead would you like to know about...

Alternate routes __________ miles

Inspection site location __________ miles

Road accident and hazardous conditions __________ miles

Changing weather conditions __________ miles

Weigh station location __________ miles

30. If an in-vehicle traffic information system provided you with road-sign information, how many miles ahead would you like to be informed of the following on-coming signs?

Regulatory signs (e.g., STOP, YIELD, ONE WAY)	____________ miles
Warning signs (e.g., Hill ahead, Winding road ahead)	____________ miles
Route markers (e.g., Interstate 5, Junction 47, Highway 99)	____________ miles
Alternative route markers (e.g., detour, business route, truck route)	____________ miles
General information guide signs (e.g., Airports, restaurants, hotels, hospitals)	____________ miles

31. How important would the following factors be in your decision to purchase an in-vehicle traffic information system?

	Very important			Moderate importance			Not important
Cost of system	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Accuracy of data displayed on system	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Type of visual display (color, b/w, LED)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
System dimensions (i.e., is it the size of a tape deck or as large as the dashboard?)	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7
Audio capabilities (i.e., can it talk to you?	☐ 1	☐ 2	☐ 3	☐ 4	☐ 5	☐ 6	☐ 7

F. Questions About Driving Characteristics

32. Do you typically operate: **(Check only one)**

☐ Cross country (greater than 500 miles)
☐ Regional line haul (100 to 499 miles)
☐ Local line haul (less than 100 miles)

33. If you checked <u>cross country</u>:

In how many states do you operate? ________(# of states)

34. Do you typically operate: **(Check only one)**

☐ alone ☐ in a team or couple

35. Do you take your commercial vehicle home: **(Check only one)** ☐ Yes ☐ No

36. Your trip typically begins at: **(Check only one)**

☐ Home ☐ Terminal ☐ Customer site ☐ Other (please specify) _________

37. Your trip (from start to finish) typically involves: **(Check only one)**

☐ Multiple stops, and how many? __________
☐ Single pick-up/delivery

38 Your route is usually determined: **(Check only one)**

☐ Dispatcher
☐ Customer
☐ Self
☐ Other (please specify) _________

39. What is your typical operating weight (GVW)? ____________

40. What is your maximum operating weight (GVW)? ____________

41. How many hours per day do you personally drive? ____________

42. How many hours per day is your vehicle in operation? ____________

43. How many miles per year does your vehicle average? ___________

44. How would you describe your typical cargo? ___________
(Check only one)

☐ Automobiles
☐ Cargo tanks
☐ Equipment and machinery
☐ General freight
☐ Hazardous material
☐ Heavy haul (Flat beds)
☐ Household goods
☐ Iron and steel
☐ Livestock
☐ Passengers
☐ Perishable items
☐ Other (please specify)___________

45. Are you currently an independent truck driver or employed by a trucking firm?
(Check only one)

☐ Independent driver
☐ Employed by a firm

46. Are you: **(Check only one)**

☐ an ICC common carrier
☐ an ICC contract carrier
☐ Other (please specify)___________
☐ ICC exempt
☐ Private

Licensing

47. How many years have you been driving a truck? ___________

48. How many years have you had a commercial driving license (CDL)? ___________

49. What type of CDL endorsement do you have? **(Check ALL that apply)**

☐ Air brakes
☐ Double triple trailer
☐ Hazardous material
☐ Passenger
☐ Tank
☐ Other (please specify) ____________

Equipment

50. What type of vehicle do you usually driver? **(Check only one)**

☐ Bus
☐ Single unit
☐ Truck/trailer
☐ Truck-tractor (bobtail)
☐ Tractor-semi trailer
☐ Tractor-double trailer
☐ Tractor-triple trailer
☐ Other (please specify) ____________

51. Do you have a:
(Check "Yes" or "No" for each category)

Beeper	☐ Yes ☐ No	Police scanner	☐ Yes ☐ No
Cellular phone	☐ Yes ☐ No	Radar detector	☐ Yes ☐ No
Company tracking	☐ Yes ☐ No	Retarder	☐ Yes ☐ No
Computer (laptop)	☐ Yes ☐ No	Satellite communication	☐ Yes ☐ No
Cruise control	☐ Yes ☐ No	Sleeper	☐ Yes ☐ No
Jake brakes	☐ Yes ☐ No	Two-way radio	☐ Yes ☐ No

52. What is your usual cargo body type? **(Check only one)**

- ☐ Automobile transporter
- ☐ Bus
- ☐ Cargo tank
- ☐ Concrete mixer
- ☐ Dry van
- ☐ Dump
- ☐ Flatbed
- ☐ Garbage or refuse
- ☐ Low boy
- ☐ Refer van
- ☐ Other (please specify) ____________

G. Background Information

53. What is your home city, state? ______________________________

54. Are you: ☐ Male ☐ Female

55. For housing, do you: ☐ Rent ☐ Own

56. What is your age? ______________________________

57. Are you currently: ☐ Married ☐ Single

58. What is your annual household income? (Check only one)

- ☐ No income
- ☐ Under $10,000
- ☐ 10,000 - 19,999
- ☐ 20,000 - 29,999
- ☐ 30,000 - 39,999
- ☐ 40,000 - 49,999
- ☐ 50,000 - 59,999
- ☐ 60,000 - 74,999
- ☐ 75,000 - 100,000
- ☐ Over 100,000

G. CVO Background Information, cont'd.

59. Number of years as a licensed driver: _____
(private & commercial)

60. Number of years driving in Seattle: _____
(private & commercial)

61. Education level:

- ☐ Below 12th grade (less than high school completion)
- ☐ High School diploma (or equivalent)
- ☐ Some College
- ☐ Associates Degree
- ☐ Bachelors Degree
- ☐ Advanced Degree

62. Ethnic group:

- ☐ American Indian/Alaskan Native
- ☐ Asian or Pacific Islander
- ☐ African American
- ☐ Caucasian
- ☐ Hispanic
- ☐ Other (please describe) __________

63. Number of family members in household: _____

64. Do you own your own (private) automobile? ☐ Yes ☐ No

Answer the following for the automobile you most frequently drive.

Make _________

Model _________

Year _____

65. Check the average number of miles you drive annually as a <u>private</u> driver.

- ☐ less than 5,000
- ☐ 5,000 - 9,999
- ☐ 10,000 - 19,999
- ☐ 20,000 - 39,999
- ☐ 40,000 - 69,999
- ☐ 70,000 - 99,999
- ☐ more than 100,000

66. Check the average number of miles you drive annually as a <u>commercial</u> driver.

- ☐ less than 5,000
- ☐ 5,000 - 9,999
- ☐ 10,000 - 19,999
- ☐ 20,000 - 39,999
- ☐ 40,000 - 69,999
- ☐ 70,000 - 99,999
- ☐ more than 100,000

67. For each of the following trip types, please estimate the number of trips per week you make as a private driver.

_____ commute to work (one way only)
_____ shopping trips
_____ errands
_____ social visits
_____ recreation

68. How many vacation trips per year do you take? _____

69. Which of the following does the (private) vehicle you most frequently use have?

- ☐ air bags
- ☐ anti-lock brakes (ABS)
- ☐ cassette player
- ☐ cellular phone/radio phone
- ☐ cruise control
- ☐ electronic dashboard displays
- ☐ garage door opener
- ☐ power brakes
- ☐ power steering
- ☐ power windows and door locks
- ☐ radar detector

70. For each of the following devices, please indicate if you own the device by marking an "X" in the "OWN" column. Then indicate if you use the device by marking an "X" in the "USE" column. For the devices you use, please indicate how frequently you use each device by entering a number in the "FREQUENCY OF USE" column (e.g., once a month, three times a week).

DEVICE	OWN	USE	FREQUENCY OF USE
Automatic teller machine (ATM) card	N/A		
Videocassette recorder (VCR)			
Hand-held calculator			
Cordless phone			
Microwave oven			
Personal computer			
• DOS			
• Windows			
• Macintosh			
Computer bulletin boards	N/A		
Telephone answering machine/voice messaging			

It is important to us to understand how comfortable you feel with computers. For items 71-76, please mark with an "X" to indicate how much each statement below applies to you. Marking toward the 100 would indicate that a statement strongly applies. Marking toward the 0 would indicate that it does not apply.

72. I am sure I could do work with computers.

0 Does not Apply — 50 — 100 Strongly Applies

73. I would like working with computers.

0 Does not Apply — 50 — 100 Strongly Applies

74. I would feel comfortable working with computers.

0 Does not Apply — 50 — 100 Strongly Applies

75. Working with a computer would make me very nervous.

0 Does not Apply — 50 — 100 Strongly Applies

76. I do as little work with computers as possible.

0 Does not Apply — 50 — 100 Strongly Applies

77. I think using a computer would be very hard for me.

0 Does not Apply — 50 — 100 Strongly Applies

APPENDIX C: EXPERIMENT 1 AND 1B RESULTS

EXPERIMENT 1 ANOVA TABLES

Table 64. Analysis of variance for TRAV1A: Guidance easy to learn.

SOURCE OF VARIATION	df	MS	F	p
Age	1	34.78	18.97	0.000
Gender	1	0.02	0.01	0.912
Age X Gender	1	1.05	0.57	0.450
Subjects	102	1.83		
Video	1	1.89	5.78	0.18
Age X Video	1	0.29	0.89	0.347
Gender X Video	1	0.00	0.00	0.956
Age X Gender X Video	1	0.05	0.14	0.705
Subjects	102	0.33		

Table 65. Analysis of variance for TRAV1B: Guidance easy to use.

SOURCE OF VARIATION	df	MS	F	p
Age	1	22.14	16.86	0.000
Gender	1	0.05	0.04	0.851
Age X Gender	1	0.41	0.31	0.578
Subjects	99	1.31		
Video	1	9.54	20.68	0.000
Age X Video	1	0.37	0.80	0.374
Gender X Video	1	2.43	5.26	0.024
Age X Gender X Video	1	0.31	0.67	0.416
Subjects	99	0.46		

Table 66. Analysis of variance for TRAV1C: Guidance useful.

SOURCE OF VARIATION	df	MS	F	p
Age	1	10.75	7.71	0.007
Gender	1	0.04	0.03	0.867
Age X Gender	1	0.52	0.38	0.542
Subjects	99	1.39		
Video	1	3.21	7.05	0.009
Age X Video	1	0.00	0.00	0.946
Gender X Video	1	0.39	0.87	0.354
Age X Gender X Video	1	1.47	3.21	0.076
Subjects	99	0.46		

Table 67. Analysis of variance for TRAV2A: Route map easy to learn.

SOURCE OF VARIATION	df	MS	F	p
Age	1	14.76	11.19	0.001
Gender	1	0.11	0.09	0.770
Age X Gender	1	0.38	0.29	0.592
Subjects	102	1.32		
Video	1	0.95	2.32	0.131
Age X Video	1	2.10	5.12	0.026
Gender X Video	1	0.31	0.76	0.385
Age X Gender X Video	1	2.15	5.26	0.024
Subjects	102	0.41		

Table 68. Analysis of variance for TRAV2B: Map route easy to use.

SOURCE OF VARIATION	df	MS	F	p
Age	1	13.10	8.51	0.004
Gender	1	1.02	0.66	0.417
Age X Gender	1	0.08	0.05	0.816
Subjects	99	1.54		
Video	1	2.20	3.19	0.077
Age X Video	1	2.81	4.07	0.046
Gender X Video	1	0.28	0.41	0.523
Age X Gender X Video	1	0.53	0.76	0.384
Subjects	99	0.69		

Table 69. Analysis of variance for TRAV2C: Route map useful.

SOURCE OF VARIATION	df	MS	F	p
Age	1	6.56	4.85	0.030
Gender	1	0.41	0.31	0.582
Age X Gender	1	0.05	0.03	0.853
Subjects	100	1.35		
Video	1	2.27	3.69	0.058
Age X Video	1	4.12	6.68	0.011
Gender X Video	1	0.17	0.27	0.603
Age X Gender X Video	1	4.12	6.68	0.011
Subjects	100	0.62		

Table 70. Analysis of variance for TRAV3A: Voice easy to learn.

SOURCE OF VARIATION	df	MS	F	p
Age	1	9.18	5.80	0.018
Gender	1	0.83	0.52	0.471
Age X Gender	1	0.29	0.18	0.670
Subjects	102	1.58		
Video	1	5.19	10.06	0.002
Age X Video	1	0.49	0.95	0.332
Gender X Video	1	0.02	0.04	0.848
Age X Gender X Video	1	0.00	0.00	0.985
Subjects	102	0.52		

Table 71. Analysis of variance for TRAV3B: Voice easy to use.

SOURCE OF VARIATION	df	MS	F	p
Age	1	9.15	6.08	0.015
Gender	1	0.66	0.44	0.510
Age X Gender	1	1.59	1.06	0.307
Subjects	100	1.50		
Video	1	6.39	12.00	0.001
Age X Video	1	0.97	1.83	0.179
Gender X Video	1	0.04	0.07	0.785
Age X Gender X Video	1	0.33	0.61	0.435
Subjects	100	0.53		

Table 72. Analysis of variance for TRAV3C: Voice useful.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.12	0.06	0.812
Gender	1	0.32	0.15	0.704
Age X Gender	1	0.02	0.01	0.925
Subjects	100	2.21		
Video	1	10.67	9.30	0.003
Age X Video	1	0.36	0.32	0.575
Gender X Video	1	0.25	0.21	0.644
Age X Gender X Video	1	0.67	0.58	0.448
Subjects	100	1.15		

Table 73. Analysis of variance for TRAV4: Routing preference.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.81	0.19	0.660
Gender	1	2.23	0.54	0.465
Age X Gender	1	0.85	0.21	0.652
Subjects	99	4.16		
Video	1	32.27	39.01	0.000
Age X Video	1	0.34	0.41	0.525
Gender X Video	1	2.45	2.97	0.088
Age X Gender X Video	1	0.12	0.14	0.704
Subjects	99	0.83		

Table 74. Analysis of variance for TRAV5A: TravTek easy to learn.

SOURCE OF VARIATION	df	MS	F	p
Age	1	35.18	23.36	0.000
Gender	1	0.02	0.02	0.903
Age X Gender	1	0.19	0.12	0.726
Subjects	102	1.51		
Video	1	0.32	1.38	0.242
Age X Video	1	0.01	0.03	0.869
Gender X Video	1	0.15	0.65	0.421
Age X Gender X Video	1	0.07	0.29	0.594
Subjects	102	0.23		

Table 75. Analysis of variance for TRAV5B: TravTek easy to use.

SOURCE OF VARIATION	df	MS	F	p
Age	1	17.71	13.95	0.000
Gender	1	0.65	0.51	0.475
Age X Gender	1	0.12	0.10	0.756
Subjects	100	1.27		
Video	1	2.40	5.35	0.023
Age X Video	1	0.10	0.22	0.643
Gender X Video	1	0.03	0.08	0.783
Age X Gender X Video	1	0.26	0.57	0.451
Subjects	100	0.45		

Table 76. Analysis of variance for TRAV5C: TravTek useful.

SOURCE OF VARIATION	df	MS	F	p
Age	1	7.38	4.74	0.032
Gender	1	0.71	0.45	0.502
Age X Gender	1	0.56	0.36	0.550
Subjects	100	1.56		
Video	1	0.00	0.01	0.923
Age X Video	1	0.08	0.21	0.650
Gender X Video	1	0.00	0.00	0.991
Age X Gender X Video	1	0.00	0.00	0.977
Subjects	100	0.39		

Table 77. Analysis of variance for TRAV6A: At home daily driving.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.04	0.10	0.756
Gender	1	0.48	1.20	0.276
Age X Gender	1	0.00	0.00	0.990
Subjects	91	0.40		
Video	1	0.13	1.38	0.242
Age X Video	1	0.00	0.00	0.967
Gender X Video	1	0.13	1.38	0.242
Age X Gender X Video	1	0.00	0.00	0.967
Subjects	91	0.09		

Table 78. Analysis of variance for TRAV6B: Out-of-town vacation driving.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.01	0.22	0.638
Gender	1	0.00	0.02	0.900
Age X Gender	1	0.02	0.48	0.492
Subjects	97	0.05		
Video	1	0.00	0.15	0.700
Age X Video	1	0.02	2.06	0.154
Gender X Video	1	0.02	2.06	0.154
Age X Gender X Video	1	0.00	0.15	0.700
Subjects	97	0.01		

Table 79. Analysis of variance for TRAV6C: Out-of-town business trips.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.20	3.02	0.085
Gender	1	0.02	0.31	0.581
Age X Gender	1	0.01	0.10	0.755
Subjects	95	0.07		
Video	1	0.04	3.57	0.062
Age X Video	1	0.04	3.57	0.062
Gender X Video	1	0.00	0.01	0.917
Age X Gender X Video	1	0.00	0.01	0.917
Subjects	95	0.01		

Table 80. Analysis of variance for TRAV7: Willing to pay for TravTek.

SOURCE OF VARIATION	df	MS	F	p
Age	1	828675.47	0.94	0.336
Gender	1	316320.66	0.36	0.551
Age X Gender	1	88385.67	0.10	0.753
Subjects	94	884687.99		
Video	1	25815.68	0.80	0.373
Age X Video	1	69187.12	2.15	0.146
Gender X Video	1	36573.92	1.13	0.290
Age X Gender X Video	1	12083.63	0.37	0.542
Subjects	94	32245.92		

Table 81. Analysis of variance for TRAV8A: Energy conservation.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.89	0.53	0.467
Gender	1	1.74	1.05	0.309
Age X Gender	1	1.06	0.64	0.427
Subjects	96	1.66		
Video	1	0.98	3.18	0.078
Age X Video	1	0.40	1.31	0.255
Gender X Video	1	1.82	5.93	0.017
Age X Gender X Video	1	0.99	3.22	0.076
Subjects	96	0.31		

Table 82. Analysis of variance for TRAV8B: Environmental quality.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.08	0.04	0.842
Gender	1	2.38	1.17	0.282
Age X Gender	1	2.91	1.43	0.234
Subjects	96	2.04		
Video	1	0.64	2.81	0.097
Age X Video	1	0.01	0.03	0.873
Gender X Video	1	0.21	0.93	0.338
Age X Gender X Video	1	0.39	1.72	0.193
Subjects	96	0.23		

Table 83. Analysis of variance for TRAV8C: Highway/traffic safety.

SOURCE OF VARIATION	df	MS	F	p
Age	1	2.78	1.45	0.231
Gender	1	0.05	0.02	0.875
Age X Gender	1	4.53	2.37	0.127
Subjects	96	1.91		
Video	1	0.07	0.23	0.633
Age X Video	1	0.21	0.63	0.428
Gender X Video	1	0.07	0.23	0.633
Age X Gender X Video	1	0.21	0.63	0.428
Subjects	96	0.33		

Table 84. Analysis of variance for TRAV8D: Relief of highway congestion.

SOURCE OF VARIATION	df	MS	F	p
Age	1	0.01	0.01	0.937
Gender	1	0.00	0.00	0.985
Age X Gender	1	2.16	1.20	0.277
Subjects	96	1.81		
Video	1	0.55	1.89	0.173
Age X Video	1	0.00	0.00	0.975
Gender X Video	1	0.10	0.36	0.551
Age X Gender X Video	1	0.00	0.01	0.942
Subjects	96	0.29		

Table 85. Analysis of variance for overall TravTek system capabilities.

SOURCE OF VARIATION	df	MS	F	p
Age	1	10581.91	23.51	0.000
Gender	1	1348.51	3.00	0.086
Age X Gender	1	817.74	1.82	0.181
Subjects	105	450.05		
Video	1	21819.59	166.65	0.000
Age X Video	1	1112.44	8.50	0.004
Gender X Video	1	173.32	1.32	0.253
Age X Gender X Video	1	0.22	0.00	0.967
Subjects	105	130.93		

EXPERIMENT 1B ANOVA TABLES

Table 86. Analysis of covariance for CGTEST 1A.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	0.458	0.447	0.505
Type	1	0.458	0.447	0.505
Main Effects	2	4.925	4.801	0.010
Age	1	9.322	9.089	0.003
Gender	1	0.626	0.610	0.436
2-way Interactions	1	0.025	0.024	0.877
Age X Gender	1	0.025	0.024	0.877
Explained	4	2.583	2.519	0.045
Residual	122	1.026		
Total	126	1.075		

Table 87. Analysis of covariance for CGTEST 1B.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	0.806	0.828	0.365
Type	1	0.806	0.828	0.365
Main Effects	2	5.560	5.714	0.004
Age	1	10.647	10.942	0.001
Gender	1	0.706	0.726	0.396
2-way Interactions	1	0.078	0.080	0.778
Age X Gender	1	0.078	0.080	0.778
Explained	4	3.001	3.084	0.019
Residual	120	0.973		
Total	124	1.038		

Table 88. Analysis of covariance for CGTEST 1C.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	1.141	1.334	0.250
Type	1	1.141	1.334	0.250
Main Effects	2	5.488	6.419	0.002
Age	1	9.769	11.425	0.001
Gender	1	1.450	1.696	0.195
2-way Interactions	1	0.137	0.160	0.690
Age X Gender	1	0.137	0.160	0.690
Explained	4	3.064	3.583	0.008
Residual	121	0.855		
Total	125	0.926		

Table 89. Analysis of covariance for CGTEST 2A.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	0.013	0.011	0.915
Type	1	0.013	0.011	0.915
Main Effects	2	15.595	13.663	0.000
Age	1	31.114	27.260	0.000
Gender	1	0.191	0.167	0.683
2-way Interactions	1	0.756	0.663	0.417
Age X Gender	1	0.756	0.663	0.417
Explained	4	7.990	7.000	0.000
Residual	120	1.141		
Total	124	1.362		

Table 90. Analysis of covariance for CGTEST 2B.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	0.378	0.331	0.566
Type	1	0.378	0.331	0.566
Main Effects	2	12.761	11.165	0.000
Age	1	24.431	21.376	0.000
Gender	1	0.598	0.523	0.471
2-way Interactions	1	0.163	0.143	0.706
Age X Gender	1	0.163	0.143	0.706
Explained	4	6.516	5.701	0.000
Residual	118	1.143		
Total	122	1.319		

Table 91. Analysis of covariance for CGTEST 2C.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	1.610	1.536	0.218
Type	1	1.610	1.536	0.218
Main Effects	2	12.499	11.928	0.000
Age	1	24.981	23.839	0.000
Gender	1	0.006	0.006	0.940
2-way Interactions	1	0.444	0.423	0.517
Age X Gender	1	0.444	0.423	0.517
Explained	4	6.763	6.454	0.000
Residual	120	1.048		
Total	124	1.232		

Table 92. Analysis of covariance for CGTEST3.

SOURCE OF VARIATION	df	MS	F	P
Covariates	1	1.380	0.578	0.449
Type	1	1.380	0.578	0.449
Main Effects	2	1.811	0.758	0.471
Age	1	2.572	1.077	0.301
Gender	1	1.054	0.441	0.508
2-way Interactions	1	0.093	0.039	0.844
Age X Gender	1	0.093	0.039	0.844
Explained	4	1.274	0.533	0.712
Residual	117	2.388		
Total	121	2.351		

Table 93. Analysis of covariance for CGTEST 4A.

SOURCE OF VARIATION	df	MS	F	P
Covariates	1	4.632	4.533	0.035
Type	1	4.632	4.533	0.035
Main Effects	2	6.578	6.439	0.002
Age	1	11.691	11.442	0.001
Gender	1	1.220	1.194	0.277
2-way Interactions	1	0.298	0.291	0.590
Age X Gender	1	0.298	0.291	0.590
Explained	4	4.522	4.425	0.002
Residual	118	1.022		
Total	122	1.136		

Table 94. Analysis of covariance for CGTEST 4B.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	3.272	3.326	0.071
Type	1	3.272	3.326	0.071
Main Effects	2	6.538	6.645	0.002
Age	1	11.044	11.225	0.001
Gender	1	1.517	1.542	0.217
2-way Interactions	1	0.499	0.507	0.478
Age X Gender	1	0.499	0.507	0.478
Explained	4	4.212	4.281	0.003
Residual	116	0.984		
Total	120	1.091		

Table 95. Analysis of covariance for CGTEST 4C.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	2.232	2.021	0.158
Type	1	2.232	2.021	0.158
Main Effects	2	2.445	2.214	0.114
Age	1	3.180	2.879	0.092
Gender	1	1.508	1.366	0.245
2-way Interactions	1	1.275	1.155	0.285
Age X Gender	1	1.275	1.155	0.285
Explained	4	2.099	1.901	0.115
Residual	117	1.104		
Total	121	1.137		

Table 96. Analysis of covariance for overall CityGuide system capabilities.

SOURCE OF VARIATION	df	MS	F	p
Covariates	1	43.251	0.582	0.447
Type	1	43.251	0.582	0.447
Main Effects	2	1215.865	16.374	0.000
Age	1	2235.330	30.103	0.000
Gender	1	169.047	2.277	0.134
2-way Interactions	1	87.178	1.174	0.281
Age X Gender	1	87.178	1.174	0.281
Explained	4	640.540	8.626	0.000
Residual	123	74.255		
Total	127	92.091		

APPENDIX D: EXPERIMENT 2 MATERIALS

SUBJECT'S FAMILIARITY WITH DRIVING IN SEATTLE: PRE-SELECTION PHONE QUESTIONNAIRE

Purpose: Before a subject can be selected to participate in Experiment 2, he or she must have a sufficient degree of familiarity with driving in Seattle.

Questions:

1) Do you have an active Driver's License? Yes No

2) How familiar are you with driving in Seattle?

very unfamiliar unfamiliar familiar very familiar

3) How familiar are you with driving in Bellevue?

very unfamiliar unfamiliar familiar very familiar

4) How many times per week do you drive in Seattle?

< 1/wk 1-2 times/wk 3-4 times/wk 5 + times/wk

Scoring:

1) All subjects MUST have an active Driver's License.
2) Subjects must answer "familiar" or "very familiar" with driving in Seattle.
3) Subjects must drive at least 1-2 times/wk.

DRIVER DEMOGRAPHIC CHARACTERISTICS QUESTIONNAIRE (PHONE)

1. Age: _____

2. Number of years as a licensed driver: _____

3. Number of years driving in Seattle: _____

4. Number of years lived in Seattle _____

5. Town of residence: ________________________

6. Gender: ☐ Male ☐ Female

7. Marital status: ______ (single, married, other)

8. Number of family members in household: _____

9. Do you own your own automobile? ☐ Yes ☐ No

Answer the following for the vehicle you most frequently drive.

Make _________

Model _________

Year _____

10. Check the average number of miles you drive annually.

    ☐ less than 5,000
    ☐ 5,000 - 9,999
    ☐ 10,000 - 19,999
    ☐ 20,000 - 39,999
    ☐ 40,000 - 69,999
    ☐ 70,000 - 99,999
    ☐ more than 100,000

11. For each of the following trip types, please estimate the number of trips per week you make in Seattle.

_____ commute to work (one way only)
_____ shopping trips
_____ errands
_____ social visits
_____ recreation

12. How many vacation trips per year do you take? _____

13. Which of the following does the vehicle you most frequently use have?

- ☐ air bags
- ☐ anti-lock brakes (ABS)
- ☐ cassette player
- ☐ cellular phone/radio phone
- ☐ cruise control
- ☐ electronic dashboard displays
- ☐ garage door opener
- ☐ power brakes
- ☐ power steering
- ☐ power windows and door locks
- ☐ radar detector

DRIVER DEMOGRAPHIC CHARACTERISTICS

In this section, the questions we ask will give us an idea of your background and use of certain kinds of devices. For some questions you will need to circle your response. For other questions, you can answer by placing an "X" in the box that applies to you. Please answer each question as accurately as possible. Remember that all responses will be confidential.

1. Education level:

- ☐ Below 12th grade (less than high school completion)
- ☐ High School diploma (or equivalent)
- ☐ Some College
- ☐ Associates Degree
- ☐ Bachelors Degree
- ☐ Advanced Degree

2. Ethnic group:

- ☐ American Indian/Alaskan Native
- ☐ Asian or Pacific Islander
- ☐ African American
- ☐ Caucasian
- ☐ Hispanic
- ☐ Other (please describe) __________

3. Annual household income:

- ☐ under $20,000
- ☐ $20,000 - 39,999
- ☐ $40,000 - 59,999
- ☐ $60,000 - 79,999
- ☐ $80,000 - 99,999
- ☐ greater than $100,000

4. For each of the following devices, please indicate if you own the device by marking an "X" in the "OWN" column. Then indicate if you use the device by marking an "X" in the "USE" column. For the devices you use, please indicate how frequently you use each device by entering a number in the "FREQUENCY OF USE" column (e.g., once a month, three times a week).

DEVICE	OWN	USE	FREQUENCY OF USE
Automatic teller machine (ATM) card	N/A		
Videocassette recorder (VCR)			
Hand-held calculator			
Cordless phone			
Microwave oven			
Personal computer			
• DOS			
• Windows			
• Macintosh			
Computer bulletin boards	N/A		
Telephone answering machine/voice messaging			

It is important to us to understand how comfortable you feel with computers. For items 17-22, please mark with an "X" to indicate how much each statement below applies to you. Marking toward the 100 would indicate that a statement strongly applies. Marking toward the 0 would indicate that it does not apply.

5. I am sure I could do work with computers.

0 Does not Apply — 50 — 100 Strongly Applies

6. I would like working with computers.

0 Does not Apply — 50 — 100 Strongly Applies

7. I would feel comfortable working with computers.

0 Does not Apply — 50 — 100 Strongly Applies

8. Working with a computer would make me very nervous.

0 Does not Apply — 50 — 100 Strongly Applies

9. I do as little work with computers as possible.

0 Does not Apply | 50 | 100 Strongly Applies

10. I think using a computer would be very hard for me.

0 Does not Apply | 50 | 100 Strongly Applies

EXPERIMENT 2: TRUST AND SELF-CONFIDENCE IN ATIS TECHNOLOGY

We are interested in your judgments of how trustworthy you believe the technology to be. In addition, we are interested in how much self-confidence you have in your ability to do things yourself.

First, think about your trust in people. We all trust some people more than others. If you think about people you know, you can probably think of some you trust very much and others you trust much less. We do not trust all people equally, and we can express how much we trust a particular person.

We also think about trusting things, such as products. For example, I trust my car to start in the morning because it has never failed to do so. I trust my spouse's car much less because of a history of trouble.

Similar to trust, we can also consider the self-confidence in our own abilities. For example, you might have a great deal of self-confidence in your ability to walk to work because you have been doing it every day for several years.

If you think about it for a moment, we could rate our degree of trust and self-confidence in many of the things we use on a scale like those shown below. So let's rate a few functions that may be available in your vehicle in the future. Marking toward the 100 would indicate that a statement strongly applies. Marking toward the 0 would indicate it does not apply.

1. I would trust a navigation system to guide me through a familiar city (e.g., home town).

0 Does not Apply — 50 — 100 Strongly Applies

2. I have confidence in my ability to navigate myself through a familiar city (e.g, home town).

0 Does not Apply — 50 — 100 Strongly Applies

3. I would trust a new automatic route guidance system to avoid highway congestion.

0 Does not Apply — 50 — 100 Strongly Applies

4. I have confidence in my ability to avoid highway congestion based upon my own observation of traffic.

0 Does not Apply — 50 — 100 Strongly Applies

EXPERIMENT 2: INTER-LINK QUESTIONS

TRIAL ________ LINK ________

INTER-LINK QUESTIONS

We are interested to know what your feelings are about using the Route Guidance System . To help us, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 indicates that it does not apply.

1. I have trust in the Route Guidance System to provide accurate traffic information about traffic conditions.

0 Does not Apply	50	100 Strongly Applies

2. I have self-confidence in my ability to accurately anticipate traffic conditions.

0 Does not Apply	50	100 Strongly Applies

3. I felt that the actual traffic situation met my expectations of what I anticipated the traffic to be like.

0 Does not Apply	50	100 Strongly Applies

EXPERIMENT 2: MODIFYING YOUR TRIP TO AVOID TRAFFIC

This section is used to help us understand how accurate navigation advice needs to be for drivers to use it. Pick the response that's best for you.

1. Would you pay attention to navigation advice which might occasionally make your trip longer (in minutes) intentionally, but would reduce overall traffic congestion?

   ☐ Yes ☐ No

2. If so, how many extra minutes of travel, for a trip that normally takes 35 minutes, would you be willing to accept?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

3. How often would you tolerate such delays and still use the advice?

   ☐ 0-1 times in 20 trips ☐ 5-10 times in 20 trips
   ☐ 1-5 times in 20 trips ☐ more than 10 times in 20 trips

4. For a journey that normally takes 35 minutes, how many minutes would you need to save to make it worthwhile to use an unfamiliar route?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

5. Imagine you can get a time estimate for a trip that accounts for traffic conditions. This trip normally takes 35 minutes. If the system was occasionally wrong, how many minutes would you accept arriving early and still use the system?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

6. For the same system, how many minutes would you accept arriving late and still use the system?

   ☐ 0-1 min. ☐ 5-10 min.
   ☐ 1-5 min. ☐ more than 10 min.

7. Imagine you have a system that predicts traffic congestion but does not always warn you of traffic delays. How frequently could the system fail to predict delays and still be useful to you?

- ☐ 0-1 times in 20 trips
- ☐ 1-5 times in 20 trips
- ☐ 5-10 times in 20 trips
- ☐ more than 10 times in 20 trips

8. Imagine you have a system that predicts traffic congestion but you find that it occasionally predicts congestion when traffic is moving smoothly. How frequently could the system falsely report congestion and still be useful to you?

- ☐ 0-1 times in 20 trips
- ☐ 1-5 times in 20 trips
- ☐ 5-10 times in 20 trips
- ☐ more than 10 times in 20 trips

EXPERIMENT 2: TRUST IN THE ROUTE GUIDANCE SYSTEM

We are interested in your judgments of how trustworthy you believe the technology to be.
To help us, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 indicates that it does not apply.

1. I trust the system because it produces reliable information.

0 Does not Apply	50	100 Strongly Applies

2. I trust the system because of my knowledge of how it operates.

0 Does not Apply	50	100 Strongly Applies

3. I trust that the system will act in my interest.

0 Does not Apply	50	100 Strongly Applies

4. I trust how the system processes and displays traffic information.

0 Does not Apply | 50 | 100 Strongly Applies

5. I trust the system based on how often it is correct.

0 Does not Apply | 50 | 100 Strongly Applies

6. I trust the system because it was designed to minimize my trip time.

0 Does not Apply | 50 | 100 Strongly Applies

7. I trust the system based on my understanding of how it generates information.

0 Does not Apply — 50 — 100 Strongly Applies

8. I trust the system because its purpose is to provide accurate information.

0 Does not Apply — 50 — 100 Strongly Applies

9. I trust the system to accurately predict traffic conditions.

0 Does not Apply — 50 — 100 Strongly Applies

EXPERIMENT 2: DEMONSTRATION FIDELITY

It is important to understand how much the Advanced Traveler Information System demonstration put you in the place of a user. To help us, please mark with an "X" to indicate how much the statements below apply to you. Marking toward the 100 indicates that a statement strongly applies. Marking toward the 0 indicates that it does not apply.

1. I felt the demonstration captured my attention.

0 Does not Apply — 50 — 100 Strongly Applies

2. In my opinion, other drivers will feel the demonstration captures what using the system will be like.

0 Does not Apply — 50 — 100 Strongly Applies

3. In my opinion, other drivers will feel their attention captured by the demonstration.

0 Does not Apply — 50 — 100 Strongly Applies

4. The demonstration gave me the feel of what using the system would be like.

0 Does not Apply — 50 — 100 Strongly Applies

5. I would like to see other new system demonstrations.

0 Does not Apply — 50 — 100 Strongly Applies

6. My attention wandered during the demonstration.

0 Does not Apply — 50 — 100 Strongly Applies

7. In my opinion, other drivers' attention will wander during the demonstration.

0 Does not Apply — 50 — 100 Strongly Applies

8. The demonstration gave me a realistic impression of how the system might work.

0 Does not Apply — 50 — 100 Strongly Applies

9. The demonstration will give other drivers a realistic impression of how the system might work.

0 Does not Apply — 50 — 100 Strongly Applies

APPENDIX E: EXPERIMENT 2 RESULTS

SUBJECTIVE RATINGS FIGURES

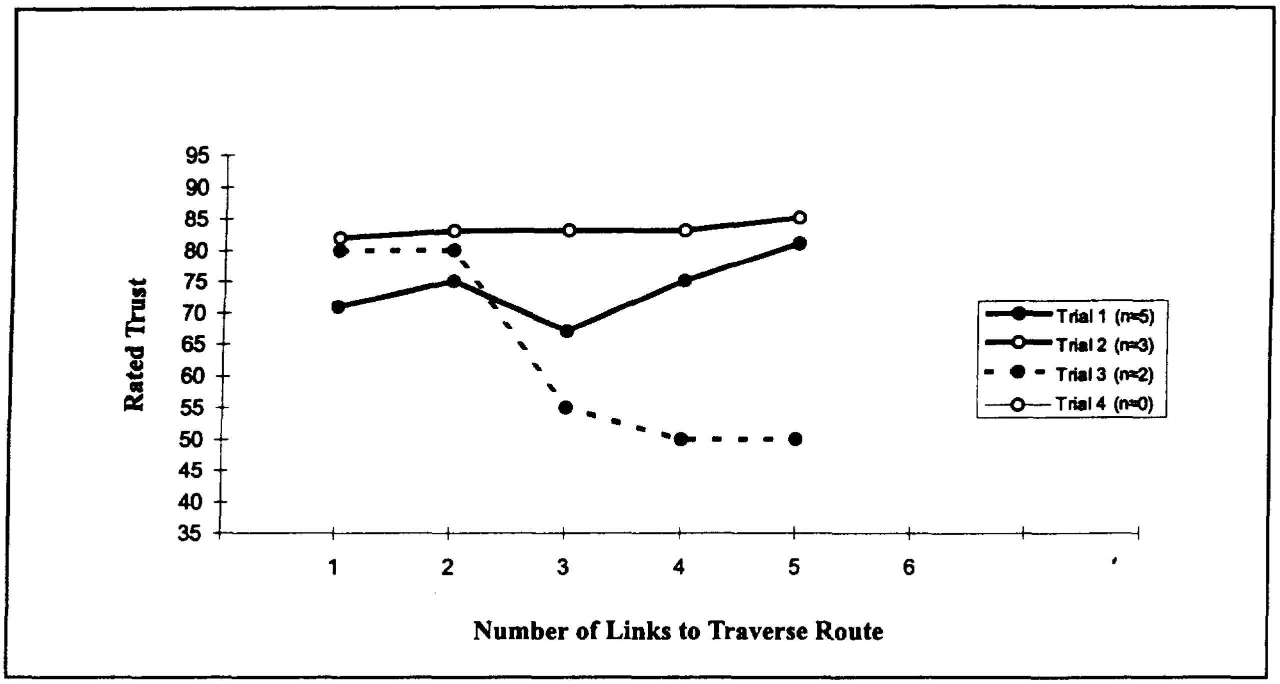


Figure 83. Mean rated trust for five links traversed.

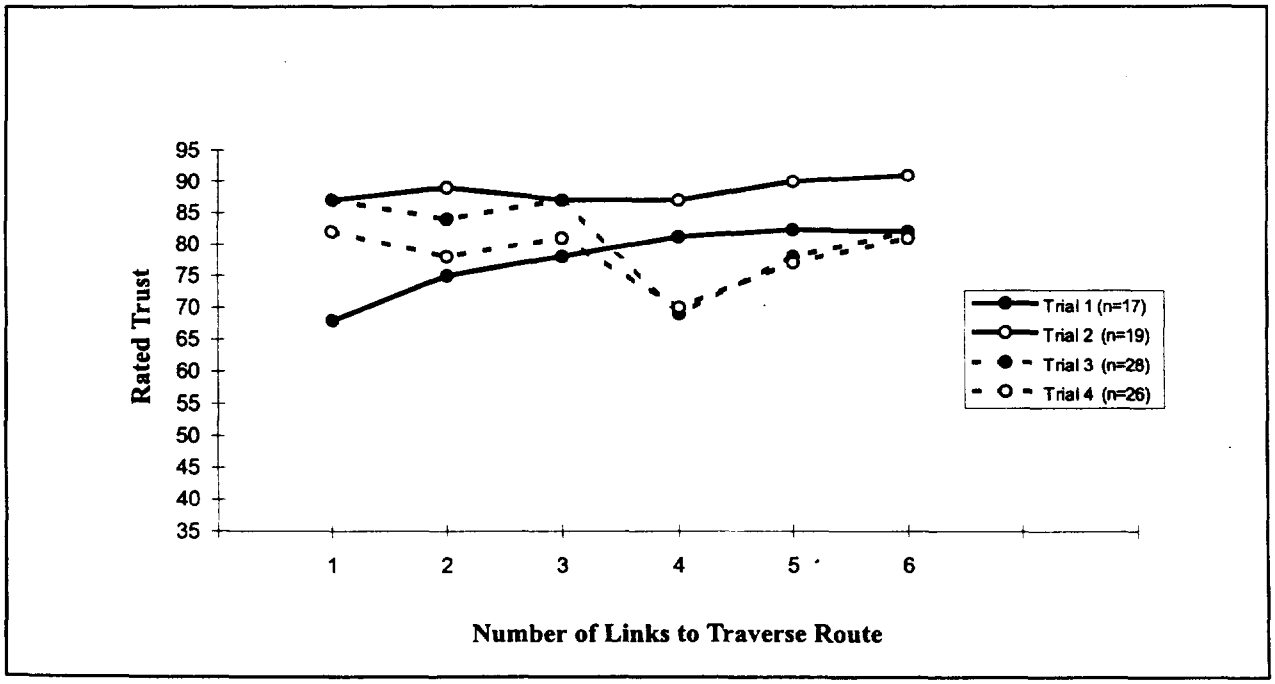


Figure 84. Mean rated trust for six links traversed.

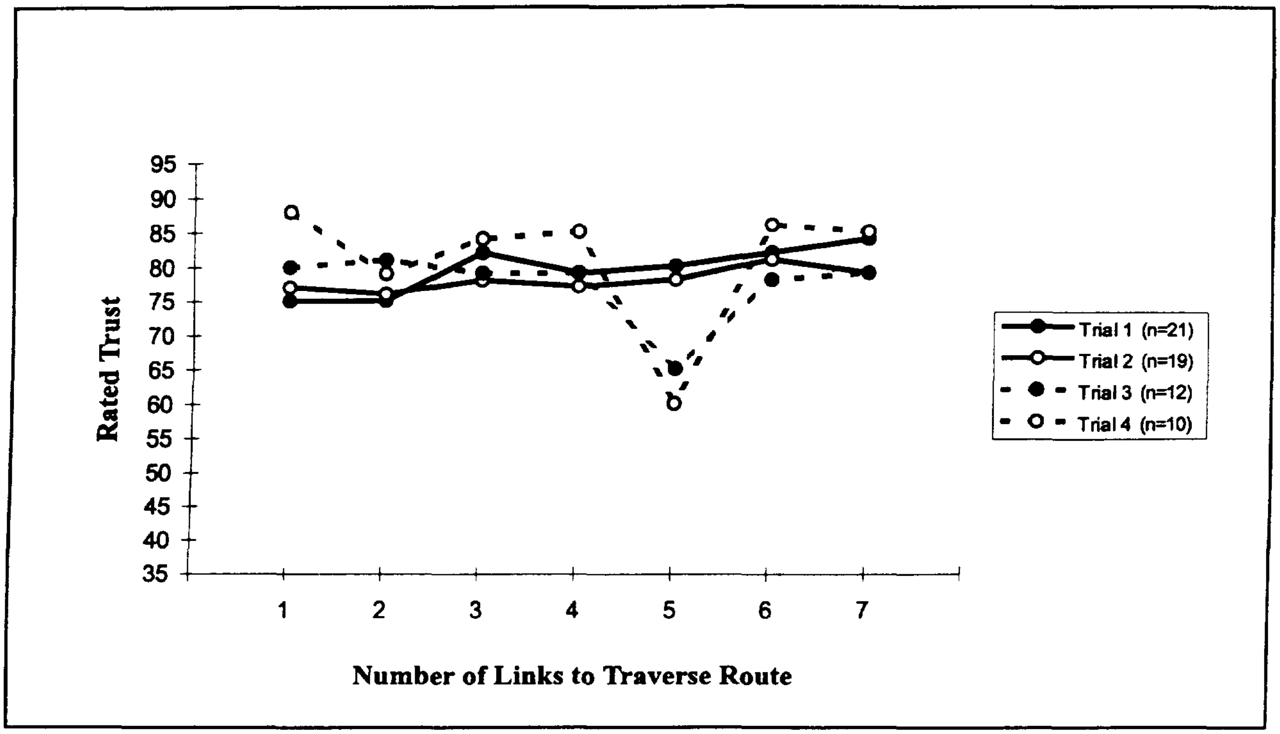


Figure 85. Mean rated trust for seven links traversed.

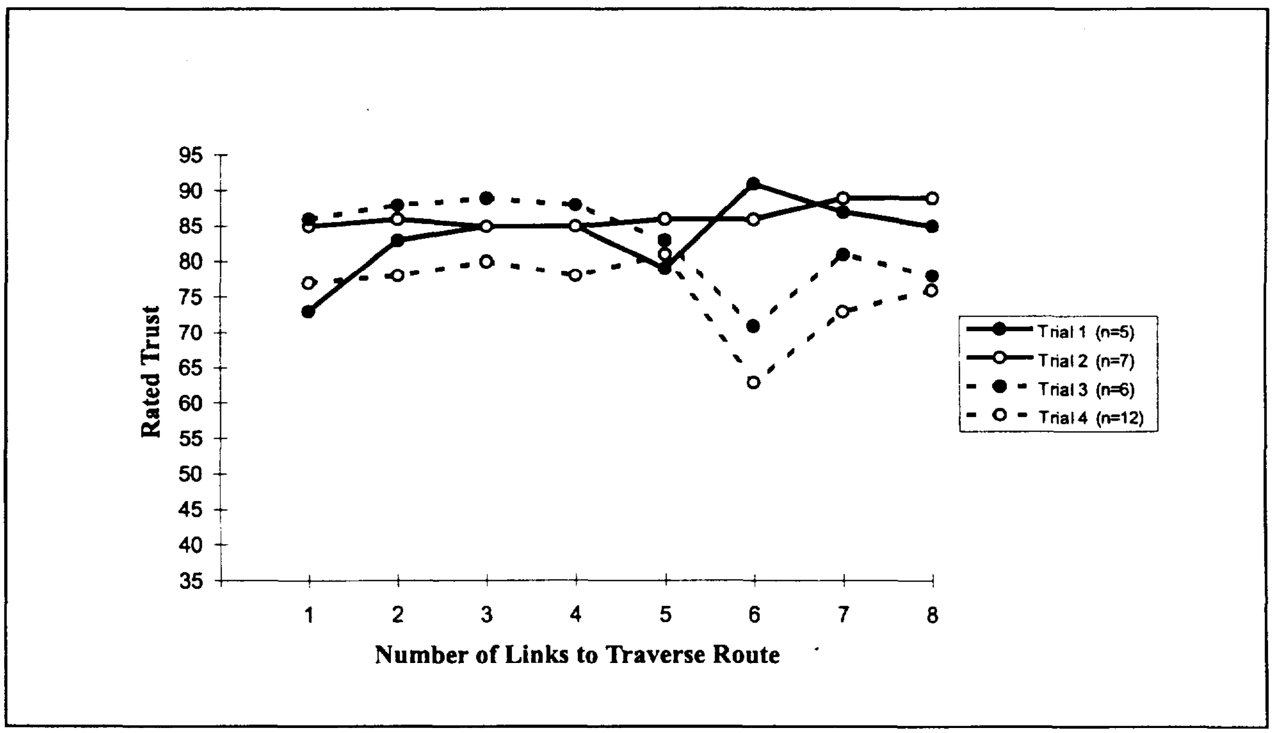


Figure 86. Mean rated trust for eight links traversed.

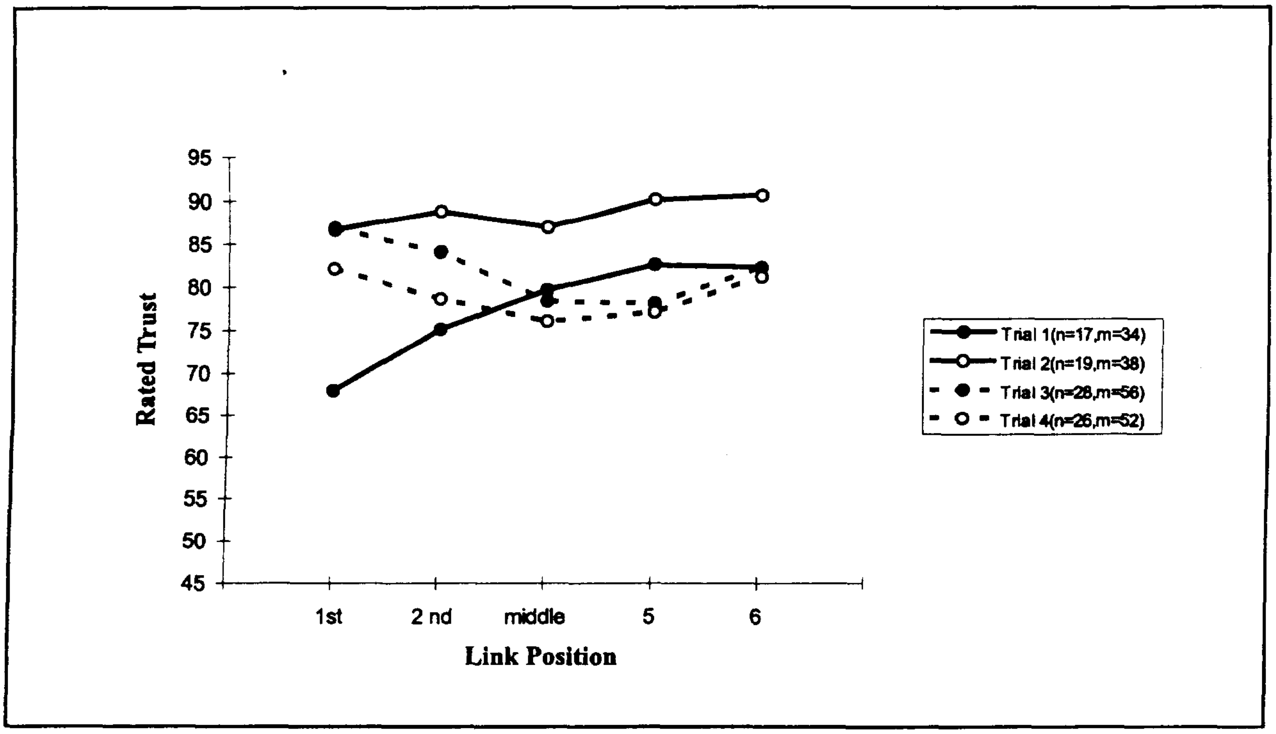


Figure 87. Mean rated trust, two middle links averaged.

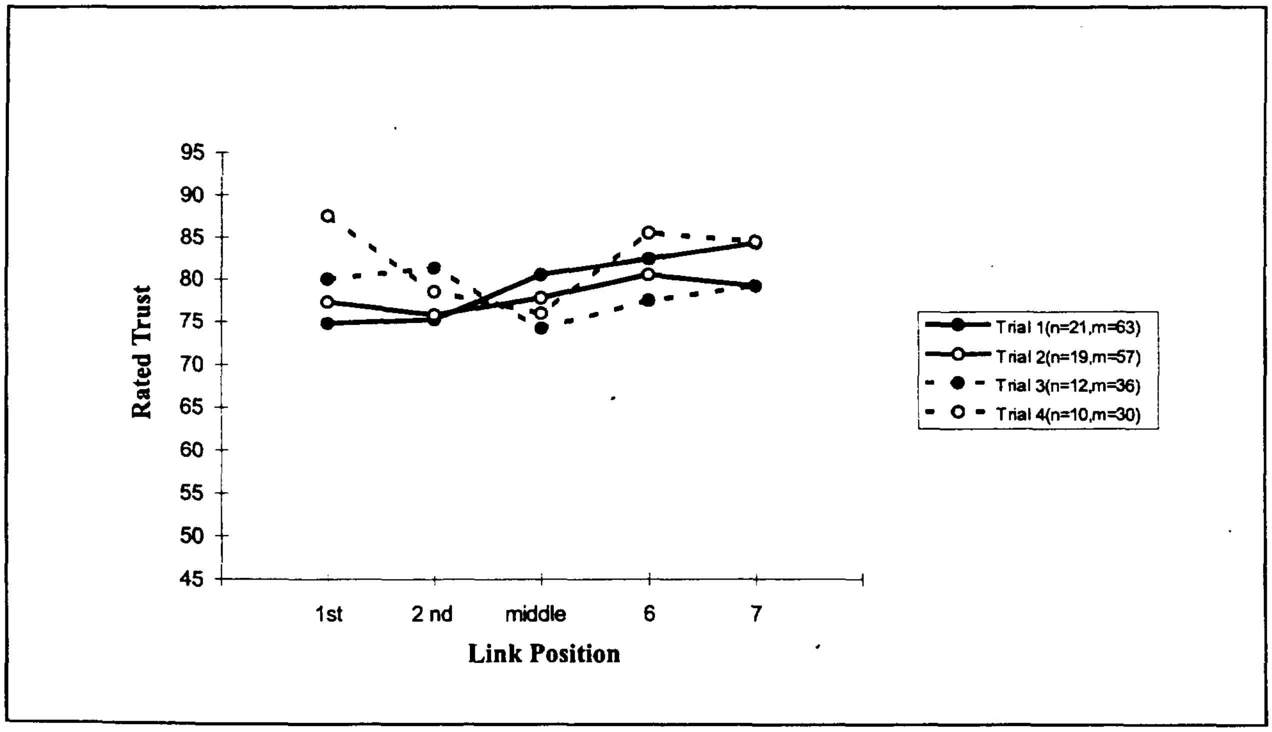


Figure 88. Mean rated trust, three middle links averaged.

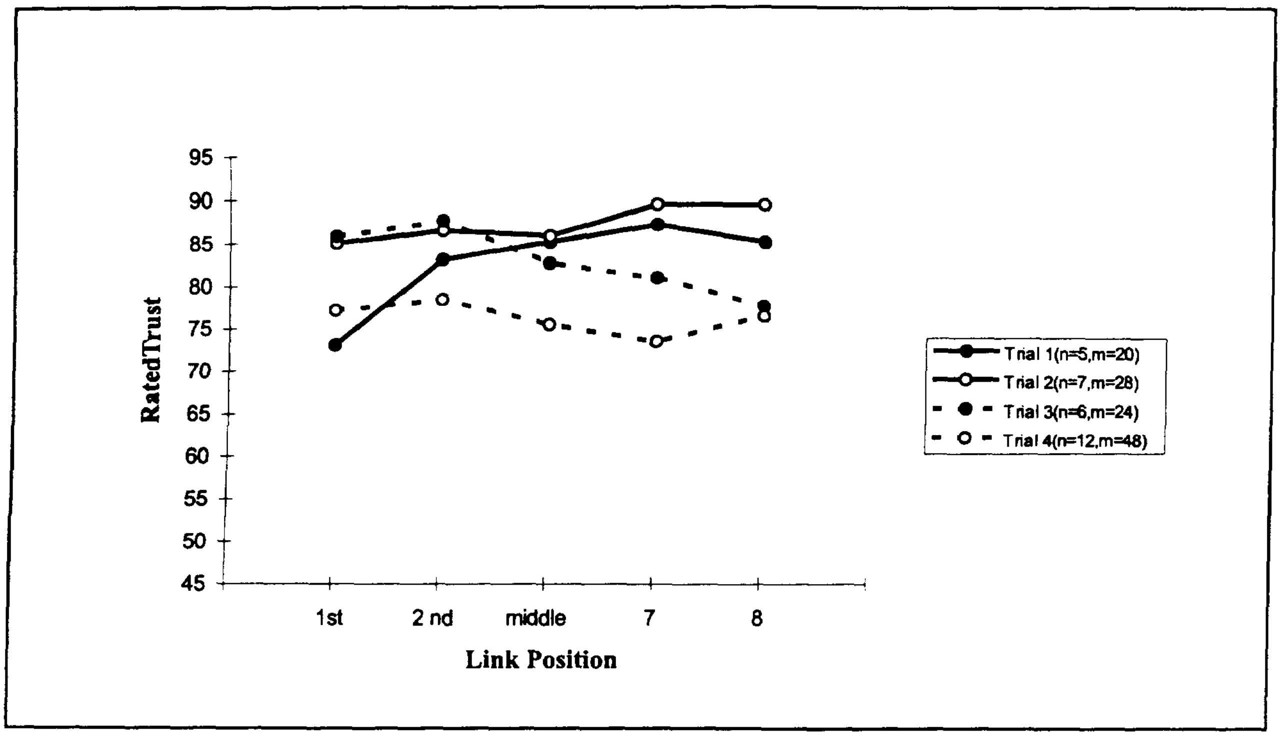


Figure 89. Mean rated trust, four middle links averaged.

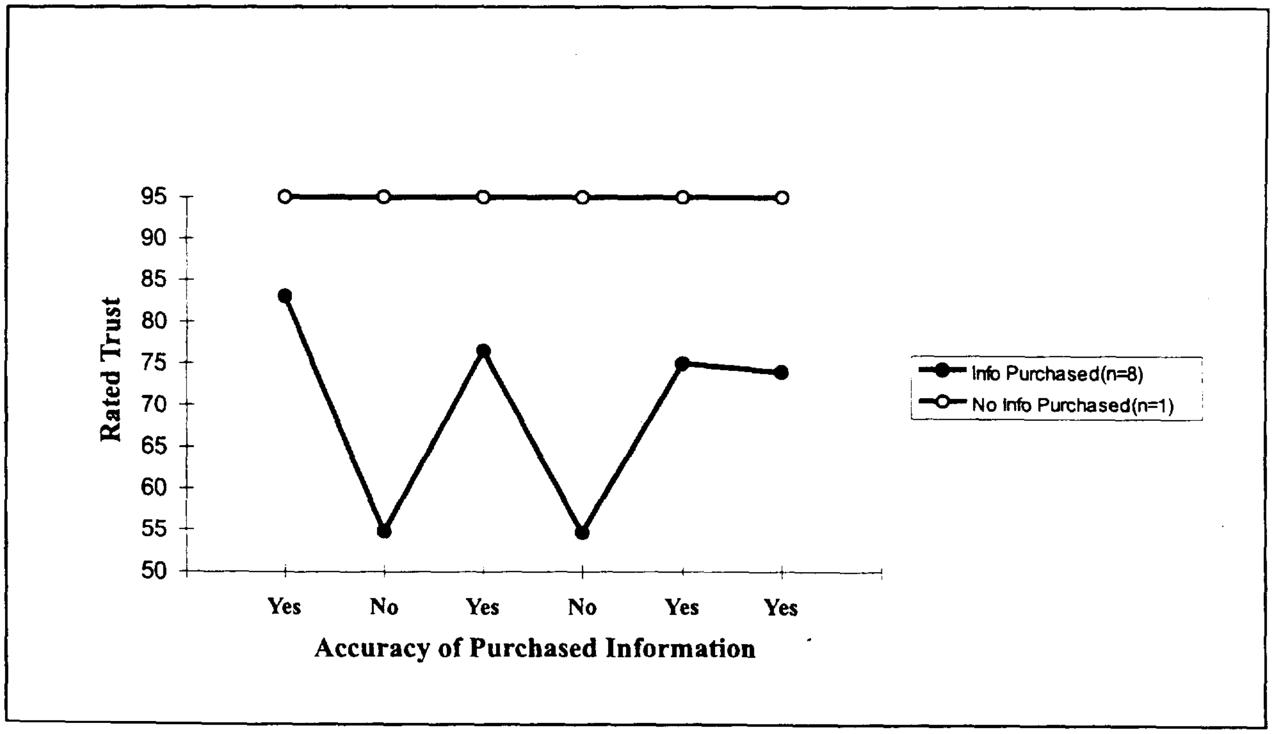


Figure 90. Mean rated trust comparing accuracy of purchased information for links traversed.

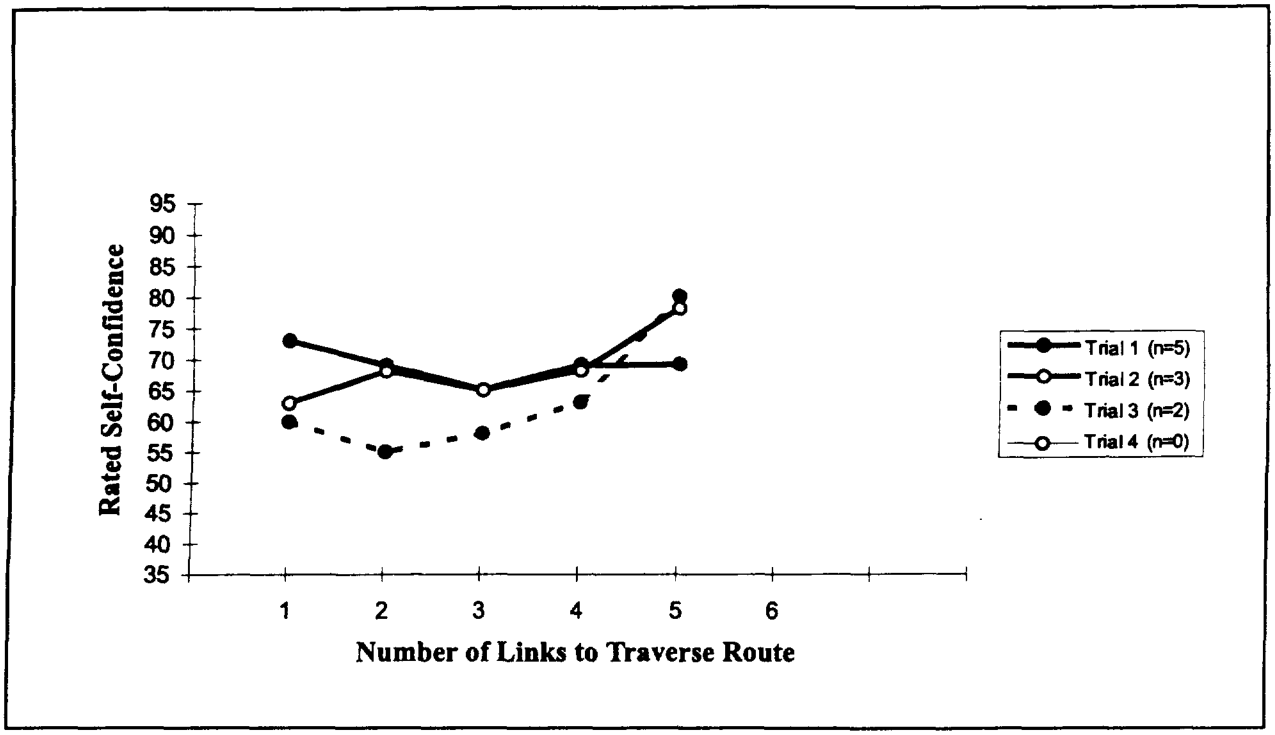


Figure 91. Mean rated self-confidence for five links traversed.

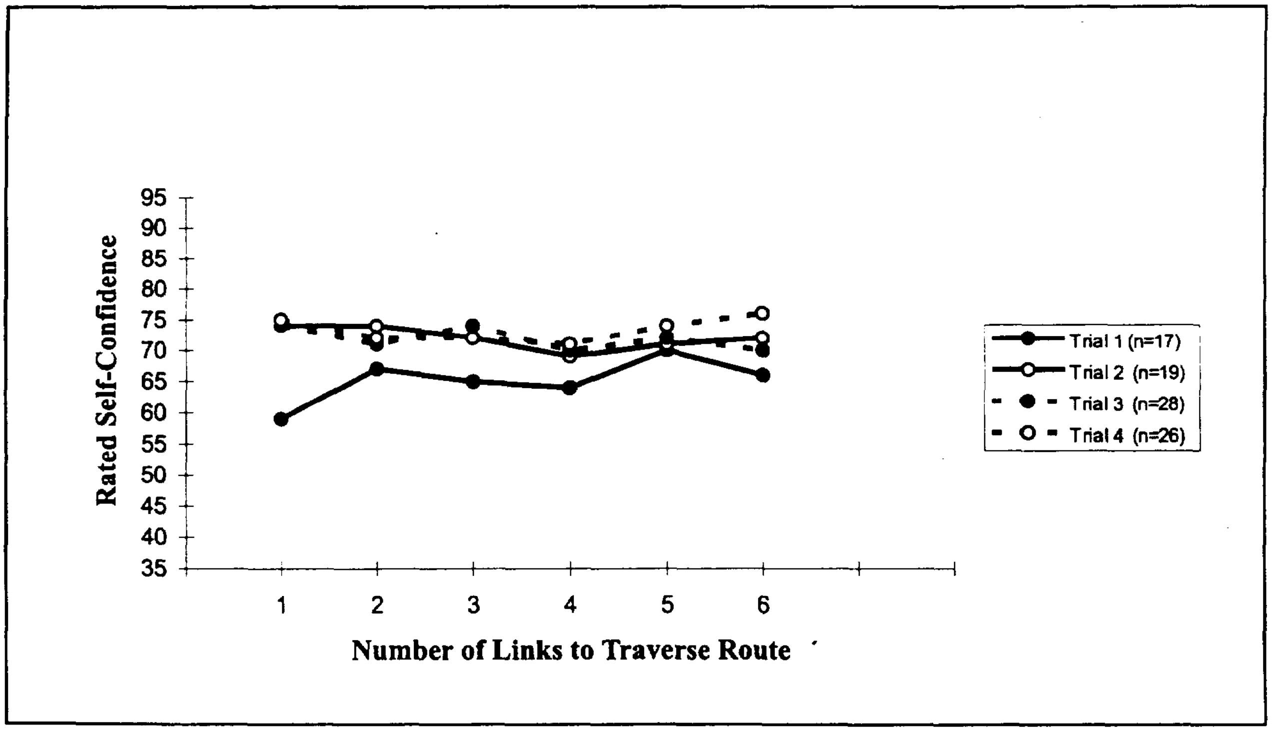


Figure 92. Mean rated self-confidence for six links traversed.

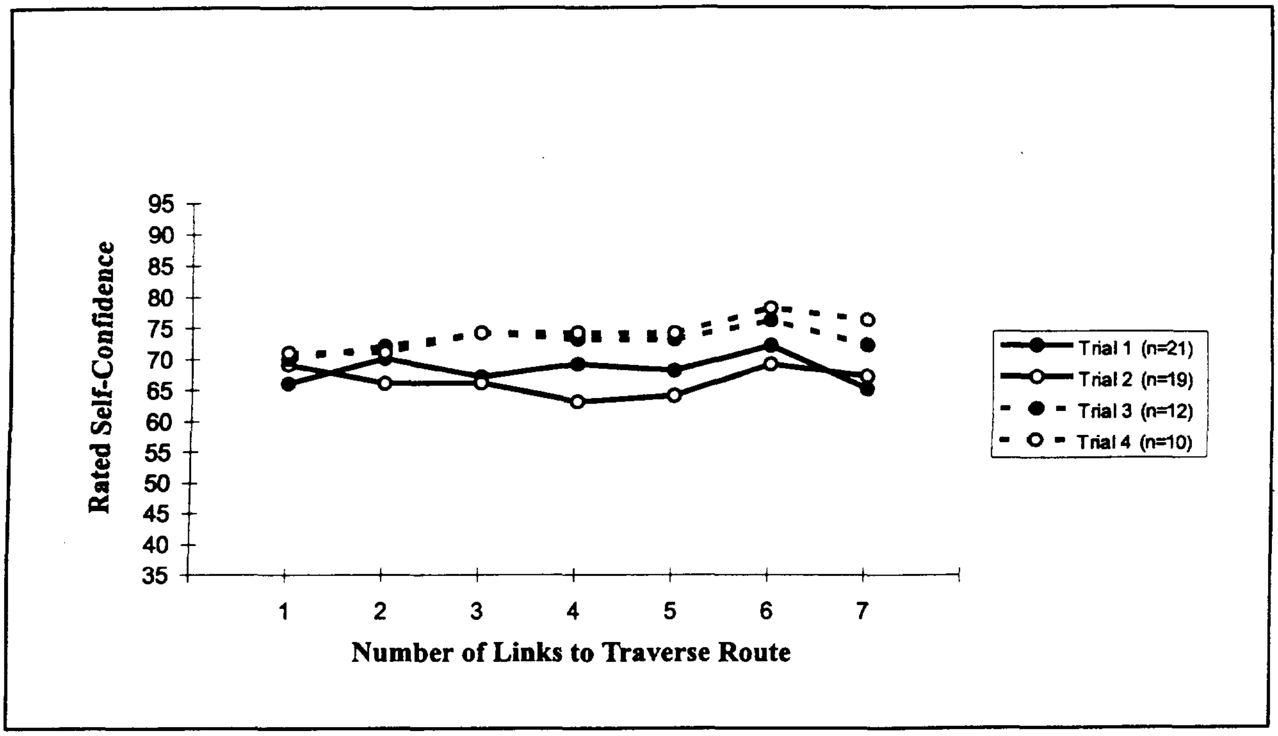


Figure 93. Mean rated self-confidence for seven links traversed.

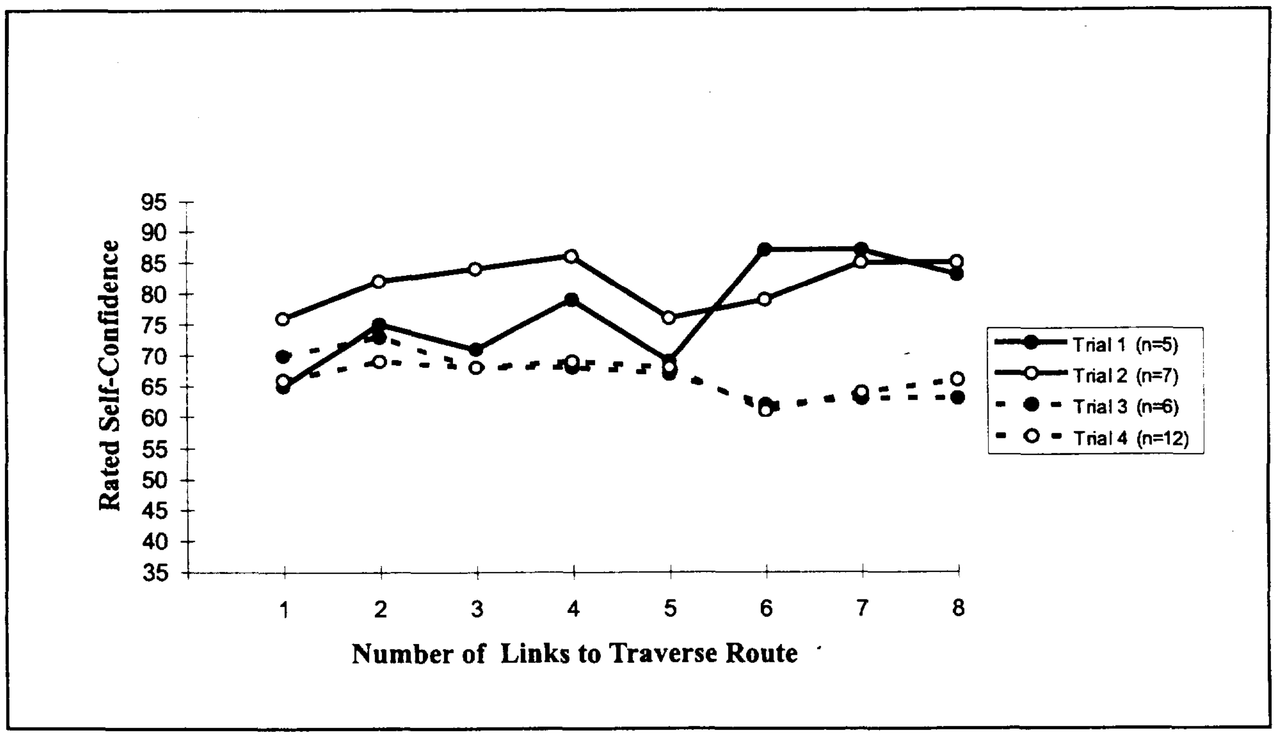


Figure 94. Mean rated self-confidence for eight links traversed.

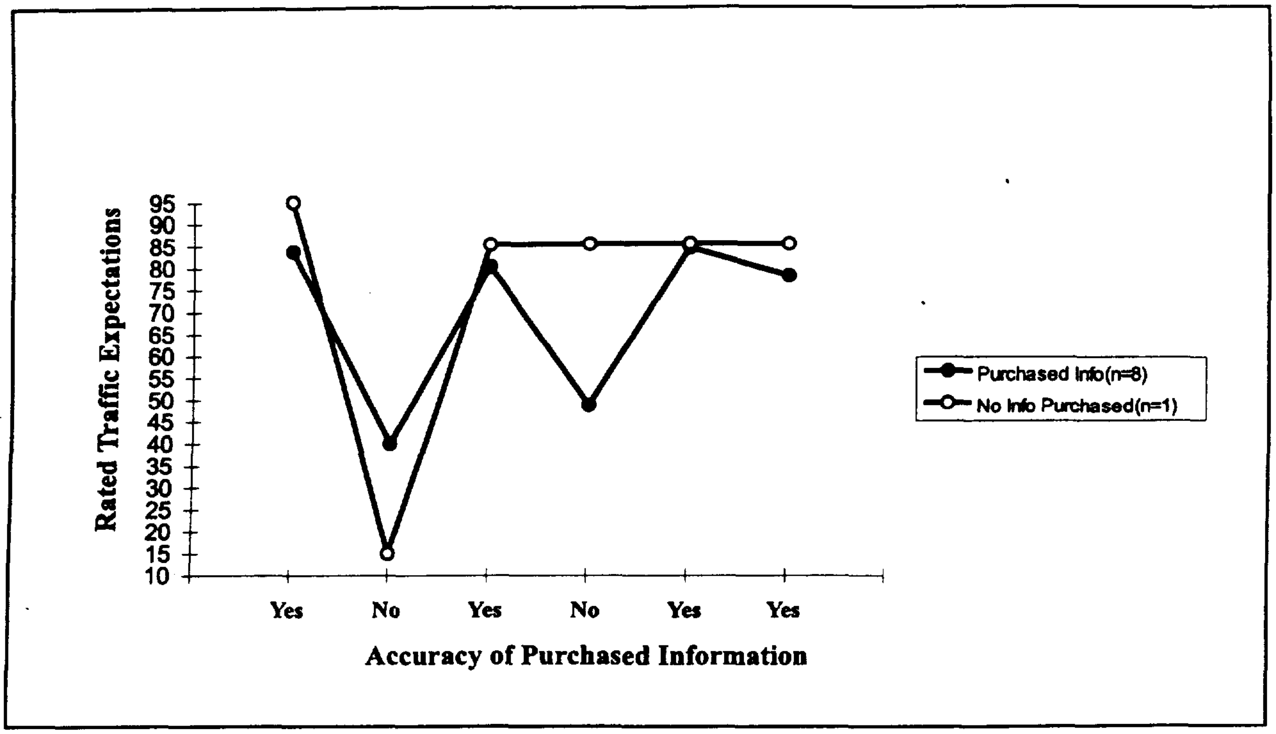


Figure 95. Mean rated traffic expectations across links with accurate or inaccurate information (Sequence 1).

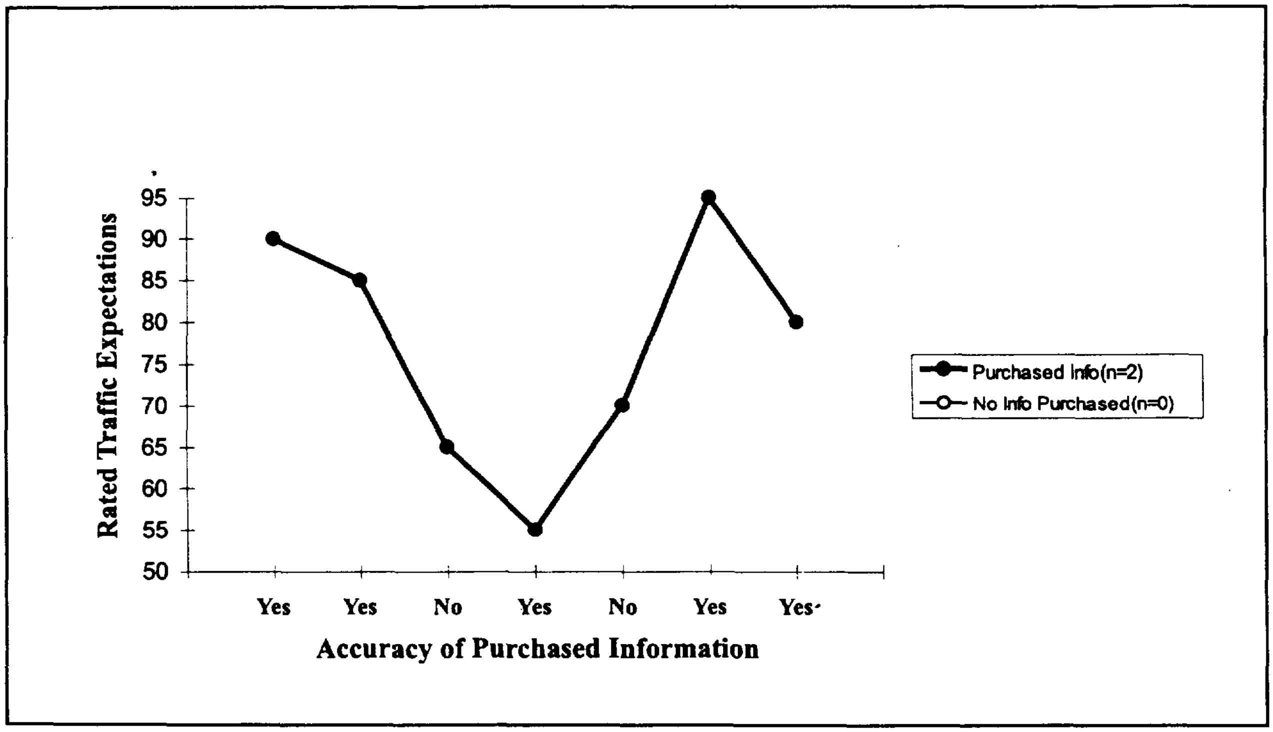


Figure 96. Mean rated traffic expectations across links with accurate or inaccurate information (Sequence 2).

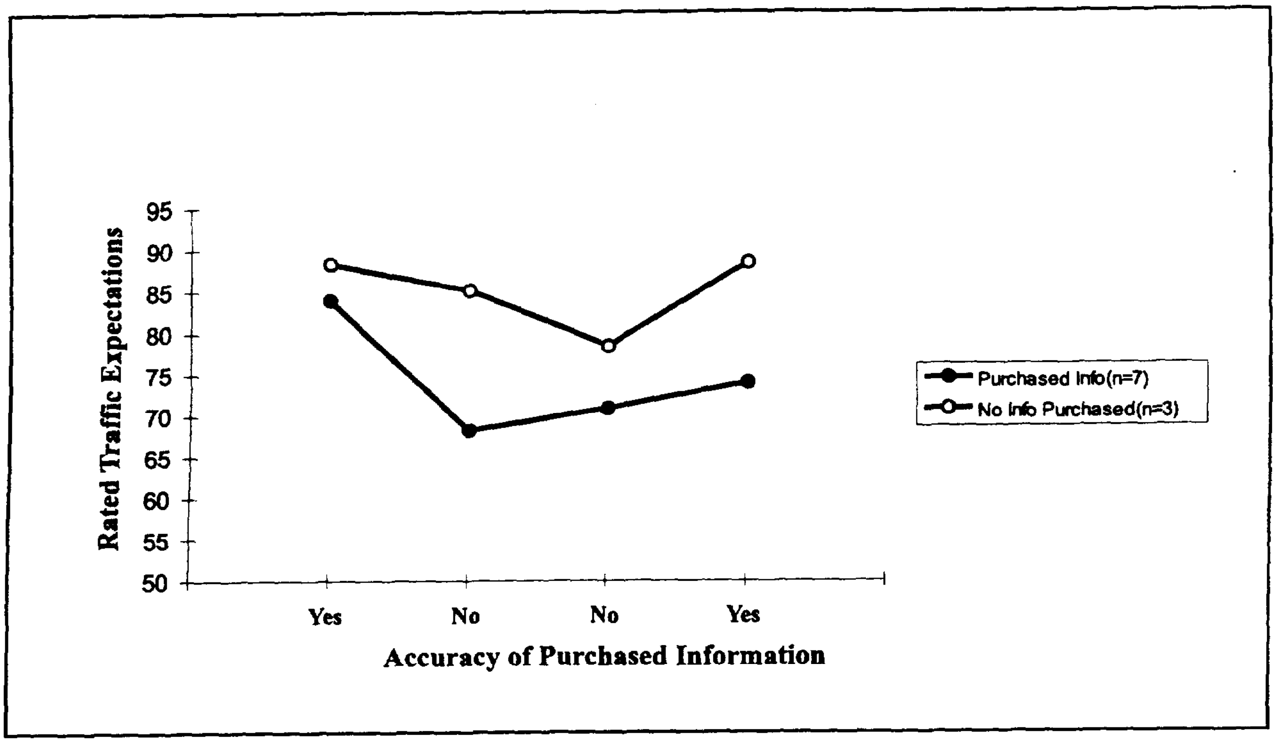


Figure 97. Mean rated traffic expectations across links with accurate or inaccurate information (Sequence 3).

ANOVA TABLES

Table 97. Analysis of variance for information cost.

INDEPENDENT VARIABLE	df	MS	F	p
Age	1	0.61	1.41	0.242
S(Age)	46	0.43		
Accuracy	1	0.07	0.41	0.523
Age X Accuracy	1	0.01	0.05	0.831
Accuracy X S(Age)	46	0.16		
Repetition	1	0.35	3.1	0.085
Age X Repetition	1	0.13	1.15	0.289
Repetition X S(Age)	46	0.11		
Accuracy X Repetition	1	0.78	9.65	0.003
Age X Accuracy X Repetition	1	0.08	0.94	0.338
Accuracy X Repetition X S(Age)	46	0.08		

Table 98. Analysis of variance for penalty cost.

INDEPENDENT VARIABLE	df	MS	F	p
Age	1	44.68	4.53	0.039
S(Age)	46	9.86		
Accuracy	1	294.87	32.42	< 0.001
Age X Accuracy	1	96.02	10.56	0.002
Accuracy X S(Age)	46	9.10		
Repetition	1	15.97	1.51	0.225
Age X Repetition	1	21.08	2.0	0.164
Repetition X S(Age)	46	10.56		
Accuracy X Repetition	1	68.57	5.03	0.03
Age X Accuracy X Repetition	1	12.95	0.95	0.335
Accuracy X Repetition X S(Age)	46	13.63		

Table 99. Analysis of variance for convergence.

INDEPENDENT VARIABLE	df	MS	F	p
Age	1	542.04	0.59	0.445
S(Age)	46	914.28		
Accuracy	1	16608.31	11.93	0.001
Age X Accuracy	1	11.46	0.01	0.928
Accuracy X S(Age)	46	1392.69		
Repetition	1	241.79	0.21	0.650
Age X Repetition	1	709.33	0.61	0.438
Repetition X S(Age)	46	1157.40		
Accuracy X Repetition	1	1885.26	2.55	0.117
Age X Accuracy X Repetition	1	547.63	0.74	0.394
Accuracy X Repetition X S(Age)	46	738.32		

Table 100. Analysis of variance for trust in the route guidance system.

INDEPENDENT VARIABLE	df	MS	F	p
Age	1	1631.30	0.69	0.409
S(Age)	46	2350.03		
Accuracy	1	613.20	1.73	0.195
Age X Accuracy	1	390.47	1.10	0.300
Accuracy X S(Age)	46	354.84		
Repetition	1	938.95	6.21	0.016
Age X Repetition	1	382.01	2.53	0.119
Repetition X S(Age)	46	151.14		
Link Position	4	316.96	4.00	0.004
Age X Link Position	4	58.01	0.73	0.571
Link Position X S(Age)	184	79.20		
Accuracy X Repetition	1	2859.76	22.51	< 0.001
Age X Accuracy X Repetition	1	25.11	0.20	0.659
Accuracy X Repetition X S(Age)	46	127.03		
Accuracy X Link Position	4	1378.82	16.12	< 0.001
Age X Accuracy X Link Position	4	22.91	0.27	0.898
Accuracy X Link Position X S(Age)	184	85.52		
Repetition X Link Position	4	71.10	0.92	0.452
Age X Repetition X Link Position	4	49.12	0.64	0.637
Repetition X Link Position X S(Age)	184	77.10		
Accuracy X Repetition X Link Position	4	364.45	6.11	< 0.001
Age X Accuracy X Repetition X Link Position	4	70.81	1.19	0.318
Accuracy X Repetition X Link Position X S(Age)	184	59.65		

Table 101. Analysis of variance for trust in the route guidance system: Purchased link information.

SOURCE OF VARIATION	df	MS	F	p
Linkpurc	1	65.021	0.263	0.608
Age	1	1267.701	5.125	0.024
Linkpurc X Age	1	2228.529	9.009	0.003
Residual	1260	247.380		
Total	1263	249.606		

Table 102. Analysis of variance for trust in the route guidance system: Information type.

SOURCE OF VARIATION	df	MS	F	p
Age	1	335.653	1.292	0.256
Type	3	9514.599	36.619	0.000
Age X Type	3	203.231	0.782	0.504
Residual	624	259.825		
Total	631	303.454		

Table 103. Analysis of variance for self-confidence: Purchased link information.

SOURCE OF VARIATION	df	MS	F	p
Linkpurc	1	509.189	1.443	0.230
Age	1	3993.028	11.314	0.001
Linkpurc X Age	1	9093.660	25.767	0.000
Residual	1260	352.914		
Total	1263	362.871		

Table 104. Analysis of variance for self-confidence: Information type.

SOURCE OF VARIATION	df	MS	F	p
Age	1	2854.894	8.131	0.004
Type	3	1501.729	4.277	0.005
Age X Type	3	700.298	1.995	0.114
Residual	624	351.103		
Total	631	362.160		

Table 105. Analysis of variance for traffic expectations: Purchased link information.

SOURCE OF VARIATION	df	MS	F	p
Linkpurc	1	956.198	2.646	0.104
Age	1	5402.856	14.950	0.000
Linkpurc X Age	1	5963.995	16.503	0.000
Residual	1260	361.394		
Total	1263	370.246		

Table 106. Analysis of variance for traffic expectations: Information type.

SOURCE OF VARIATION	df	MS	F	p
Age	1	1908.180	5.872	0.016
Type	3	14436.522	44.422	0.000
Age X Type	3	1140.610	3.510	0.015
Residual	624	324.985		
Total	631	397.857		

Table 107. Analysis of variance for trust minus self-confidence: Purchased link information.

SOURCE OF VARIATION	df	MS	F	p
Linkpurc	1	210.298	0.588	0.443
Age	1	9760.491	27.291	0.000
Linkpurc X Age	1	2318.748	6.483	0.011
Residual	1260	357.648		
Total	1263	366.560		

Table 108. Analysis of variance for trust minus self-confidence: Information type.

SOURCE OF VARIATION	df	MS	F	p
Age	1	5148.357	12.703	0.000
Type	3	4944.875	12.201	0.000
Age X Type	3	243.330	0.600	0.615
Residual	624	405.299		
Total	631	432.619		

APPENDIX F: EXPERIMENT 3 MATERIALS

ADVANCED TRAVELER INFORMATION SYSTEMS FOR COMMERCIAL VEHICLE OPERATIONS

Advanced Traveler Information Systems are being studied by the Federal Highway Administration in the hope of making private and commercial driving safer and more efficient. In many parts of the country, existing roads are overloaded with traffic, and in the most congested places, there is no land available for building new roads. The purpose of this study is to examine some of the ways that drivers might be helped to make better decisions on the road. For instance, we all have routes that we normally use because they are quicker and easier than other routes. Sometimes, though, there are traffic jams that we would just as soon go around. The kinds of systems that we will ask you to evaluate today would tell you about traffic tie-ups along your usual route and let you plan ways to avoid being caught in traffic.

At this point in time, the traveler information systems are expected to include many features, such as, navigation aids, warning and safety systems, administration aids, trip planning, and vehicle monitoring systems. Private vehicles and commercial vehicles may have different versions of these basic features. In addition, commercial vehicles will have features specific to the transportation industry, such as a monitoring system for the trailer, and a system that automatically registers for trip permits as you drive by. To provide these kinds of features, vehicles will be equipped with sensors, computers, and displays that will present information about your vehicle, the road and your route. For example, a dashboard display could be used to show maps or long text messages. A voice system might be available to read messages to you and to take voice commands from you. A computer system could be used to maintain large amounts of information and to help you get at it when you need it.

While you are here today, you will help us evaluate some of the different features that may become part of an advanced system. Some small parts of the advanced systems are available now, such as refrigeration monitors and weigh- in-motion systems. These are just small pieces of what you may eventually have in the cab, and the current versions of the systems will certainly change as they are incorporated into larger systems. As you complete the evaluations, you will be voicing your opinions about the kinds of systems that will help you in your work. <u>We would like you to use your experience as commercial drivers to help us decide which of these features would be valuable to you in doing your job.</u>

You will notice that there is no place for you to write your name on any of the evaluation forms that we are using. None of your answers or comments can be traced back to you, so none of your opinions can be passed on to your employer or to anyone else. The only form in which your answers will be made public is in research reports in which no one is identified by name as a participant, and any results are usually group averages and not individual responses. The research reports may include some of the comments that you choose to make, but your name will never be associated with them. There is only an ID number on all of the pages of this booklet. This lets us maintain confidentiality while keeping all of your evaluations together.

COMMERCIAL VEHICLE FEATURE DESCRIPTIONS

Before you can evaluate the features of an advanced traveler information system, we need to give you some definitions of what the features are. The advanced system features described below include examples to help you understand how each feature works and how you might benefit from it. However, these are only examples, if you can think of other ways that a feature would be helpful to you, please make a note of them. After you read the definitions, we will discuss them, and your notes will be helpful. The features are in alphabetical order.

BROADCAST SERVICES This feature gives you information about the services offered by local businesses. For example, if you were driving on an interstate highway, it would tell you where you could get food at the next exit, what time the restaurants open, and what kind of food they serve. This is similar to the billboards you see next to the highway or advertisements that you hear on the radio. The difference between this feature and the billboards or radio ads is that you can choose what kinds of information you want to see and what you don't want to see. For example, you could tell the system to tell you about service stations that sell diesel fuel and not stations that only sell gasoline.

CARGO TRANSFER SCHEDULING The cargo transfer scheduling feature gives you information about airplane, ship, train, and tractor trailer schedules that must be coordinated with your delivery or pick-up. For example, if you need to deliver cargo to a ship, the system would keep you posted on when the ship would arrive and when you could unload. If you need to pick up a load from a train arriving from another city, you would know when the train would arrive, where you should pick up your load, and when it would be ready. This information would be updated frequently so that you would know if there were any last minute changes in arrival, departure, or shipping information. This feature could be used while you are driving.

DISPATCH CONTROL This feature will help the dispatcher in locating vehicles, scheduling pick-up and delivery routes, communicating with drivers or customers, and transferring loads between carriers (e.g., from truck to airplane). This feature is similar to other features like route scheduling, vehicle location update, voice and message communications, and cargo transfer scheduling, but the dispatcher, not the driver, would use the system.

EMERGENCY AID REQUEST This feature sends a "mayday" signal to police, ambulances, fire trucks, and tow trucks. The signal would act like a beacon that would let emergency vehicles track you down. It would automatically send the signal in situations in which you may not be able to request help by yourself. For example, the system would send this signal if your vehicle rolled over. In other situations, you could use the system to request aid for others or yourself.

FLEET RESOURCE MANAGEMENT This feature shares information among dispatchers, drivers, and management. For example, the system might transmit information about the vehicle so that maintenance can be scheduled for trucks that need repair. Trip recorder data could be automatically sent to the payroll department to determine the amount of your next performance bonus. Driver information could also be transmitted to help schedule your next rest interval and your next run.

IMMEDIATE HAZARD WARNING This feature will tell you about temporary roadway hazards that are very close to your truck. This includes unsafe road conditions (ice, oil, gravel, sunken grades, etc), approaching emergency vehicles, stopped school buses, and accidents on the road. These are localized warnings that would serve the same purpose as flares and flashing yellow caution lights. For example, you might get a warning about stopped school buses when you are 1/4 mile from the bus. Emergency vehicles may transmit warnings up to 1/2 mile and give you the direction from which they are approaching. The advantage with this feature is that you would not have to see the hazard or hear a siren. The warning would be available at larger distances.

IN-VEHICLE ROADWAY CONTROL SIGNS The system will give you all types of current traffic control signs in the cab instead of at the side of the road. For example, you could get street names, interstate numbers, mile posts, and exit signs. You would get warnings about sharp curves, steep grades, merging traffic, and dead ends. Speed limits, stop signs, yield signs, and one-way street signs would be included, as would low clearance, bridge weight limits, narrow roads and bridges, and truck route signs. You could tell the system what information you want and how you want it presented. For example, you could tell the system to show you interstate mile markers every 20 miles. On the other hand, you could have the system give you both a voice warning and a visual message for critical information like low clearances that are less than one foot above your trailer height.

REGULATORY ADMINISTRATION This feature will keep records for regulatory requirements such as licenses, taxes, and permits, for the driver, the vehicle, or the cargo. It would also fill out and update the trucker's log book and trip sheet. This feature would have an electronic ID that operates while the truck is in motion. This would allow automatic toll collection, automatic payment of fees, and automatic registration for trip permits, all without stopping.

ROAD CONDITION INFORMATION This feature will provide information about on-going roadway hazards in an area that you select. For example, you could get information about bad weather, traffic jams, road construction projects, and road closures. Road condition could be reported for your current location, or you may request information about the next several hundred miles along your route.

ROUTE NAVIGATION This feature will probably include an electronic map that shows you the area in which you are driving. You can see a large area of the map with very little detail or smaller areas of the map with more detail. For example, the large area view would show only the interstates, primary, and major secondary roads. The view of a smaller area would show all of the roads in that area, business parks, airports, etc.

ROUTE SCHEDULING This feature will schedule multi-stop routes without the help of your dispatcher. You tell the system what pick-ups and what deliveries you have to make and it shows you the best route. The route would be designed to minimize your driving time, meet the delivery deadlines of your customers, and arrange the loading of your truck so that unloading is easier. If your delivery schedule changes while you are on the route, you can enter the new delivery information into the system and it will show you a new route. The truck must be parked before you can use this feature.

ROUTE SELECTION AND ROUTE GUIDANCE Once you enter your current location and your destination, this feature will show you several choices from which you select the best route. You can choose the quickest, the most scenic, the one with the fewest tolls, fewest stop lights, most interstates, etc, based on what is most important to you. Restrictions, such as weight, height, cargo, and truck routes, would be used to create the route choices. All of the information can reflect your current location, or you could use the system to plan a long-haul route. For example, if I-80 was closed at the Mississippi River, you might have the system plan the shortest detour from I-80 to I-70 and back.

Once a route is selected, the system could provide detailed directions to your destination. The directions for the detour from I-80 to I-70 could be as simple as I-55 South out of Chicago to I-70 through St. Louis to I-35 in Kansas City, then North to I-80 at Des Moines. Directions for city streets can be more detailed, for instance, by providing a warning one block before an upcoming turn. This level of guidance would allow you to change lanes to get ready for a tight turn.

The system could also show you an alternative route to your destination if conditions change after you have started driving. For example, if you select a route to a warehouse, and then, you hear on the radio that traffic is slow on that route, the system could re-route you from your current location. You would enter your current location and the location of the traffic jam and the system will show you a new route. As another example, your dispatcher might tell you to deliver a package in one part of town and then change his mind after you leave. In this case, you would enter your current location and the location of the new delivery, and the system will show you a new route. For complex re-routing, you may need to pull over to enter new information and select a new route.

SERVICES DIRECTORY This feature is similar to your local yellow pages. It contains the names, addresses, and telephone numbers of most of the businesses in an area. You can choose which directory listings you want to see. For example, you could ask for listings of public scales in the area. Or, you could request towing companies that are located in the last town you passed. You could even limit the search to those that will bill your company for towing instead of asking for cash on the spot.

VEHICLE/CARGO CONDITION MONITORING This feature will monitor the status of your vehicle and tell you about any potential or existing problems. This system would also be able to analyze problems with your truck and identify the cause of the problems. For example, this system could automatically perform the pre-trip inspection. Over longer time periods, the system would monitor air pressure, for instance, and alert you to a slow decrease in pressure that might indicate a failing brake system component. Cargo monitoring would include, for instance, temperature, humidity, vibration, and load balance. This feature would check your vehicle and cargo before driving and monitor continuously during a trip.

VEHICLE LOCATION UPDATE This feature will show you your location in what ever way makes the most sense to you. If you have an electronic map, the system could point to your location on the map. If you do not have a map, the system could tell you the name of the street you are on and the next cross street, or give you the closest highway milepost.

VOICE AND MESSAGE COMMUNICATION This feature allows 2-way voice communication. For example, a paramedic could call the hospital from the ambulance and tell them about the status of an accident victim. A long-haul trucker could call a dock manager to find out where to unload. With the message feature, if no one is there to answer, a message could be sent similar to the way that telegrams are currently used by some drivers. This feature could also include some "profile" information. For instance, some customers don't want to receive calls from a driver. They want to deal directly with the dispatcher. For this type of customer profile, your attempt to contact the customer would be re-directed to your dispatcher.

This feature allows 2-way or 1-way communication with your destination, your dispatcher, other drivers, repair stations, or your home. While you may now use cellular telephones and CB radios, you must be able to get in touch with someone before you can talk to them. With this feature you can send or receive messages without being in your truck. In other words, it has an answering machine that will take your messages and a timer that lets you send messages when you aren't there. Other drivers and your dispatcher could leave you messages that you would see when you returned to your truck. The system also allows you to send the same message to several people at the same time. For example, if you wanted to tell five other drivers about a bridge closure, you could send one message rather than five.

INSTRUCTIONS FOR FEATURE EVALUATION -- PART 1.

You have read the descriptions of the features on pages 2-5. These are brief descriptions of some of the things that may be incorporated into advanced traveler information systems. For each feature, we would like you to estimate its value to you in performing your job as a commercial vehicle operator.

We have assigned a value of 100 to the feature VEHICLE LOCATION UPDATE. For all of the other features, we would like you to estimate the value of that feature using any number greater than 0. Re-read the description for VEHICLE LOCATION UPDATE on Page 5, and then re-read the description for BROADCAST SERVICES, the first feature in the list on the next page. If you think that BROADCAST SERVICES are more valuable than VEHICLE LOCATION UPDATE then write a number greater than 100 in the blank next to BROADCAST SERVICES. If you think that BROADCAST SERVICES are less valuable than VEHICLE LOCATION UPDATE, then write in a number less than 100.

Once you estimate the value of the feature, write the number in the space to the left of the feature name. For example, if you thought that the IN-VEHICLE ROAD CONTROL SIGN feature was only 75% as valuable as VEHICLE LOCATION UPDATE, you would write 75 in the space provided. On the other hand, if you think that IN-VEHICLE SIGNS are twice as valuable as VEHICLE LOCATION UPDATE, write 200 in the space.

Work your way down the list of features on the next page, re-read any of the descriptions that you want to, and write an estimate for the feature in the blank space. The list on the next page is in the same order as the descriptions. Remember, you are estimating the value of the feature in performing your job. Take as much time as you need, and change your mind if you think of something new that is important.

Example

Value of Feature	Feature Label
100	Vehicle location update
200 ~~75~~	In-vehicle roadway control signs

Please provide only one value for each feature. Write your numbers clearly. If you change your mind, be sure to mark out the old number.

You may refer back to the descriptions on pages 2-5 when estimating the value of any of the features. If you have any questions about the procedure or the features please ask one of us.

Estimated Job Value	Feature Label
______	Broadcast services
______	Cargo transfer scheduling
______	Dispatch control
______	Emergency aid request
______	Fleet resource management
______	Immediate hazard warning
______	In-vehicle roadway control signs
______	Regulatory administration
______	Road condition information
______	Route navigation
______	Route scheduling
______	Route selection and route guidance
______	Services directory
______	Vehicle/cargo condition monitoring
_100__	Vehicle location update
______	Voice and message communication

INSTRUCTIONS FOR FEATURE EVALUATION -- PART 2.

We would like you to do the same kind of evaluation once more, only this time, we have assigned a value of 100 to the feature VEHICLE/CARGO CONDITION MONITORING. Everything else is the same.

We still want you to estimate the value of each feature in performing your job. The difference is that you now compare each feature to VEHICLE/CARGO CONDITION MONITORING instead of VEHICLE LOCATION UPDATE. Estimate the value of a feature using any number greater than 0. If you think that the feature is more valuable than VEHICLE/CARGO CONDITION MONITORING then the number should be greater than 100. If you think that the feature is less valuable than VEHICLE/CARGO CONDITION MONITORING then the number should be less than 100. Once you estimate the value of the feature, write the number in the blank space to the left of the feature name.

Please provide only one value for each feature. Write your numbers clearly. If you change your mind, be sure to mark out the old number.

You may refer back to the descriptions on pages 2-5 when estimating the value of any of the features. Again, if you have any questions about the procedure or the features please ask one of us.

Estimated Job Value	Feature Label
______	Broadcast services
______	Cargo transfer scheduling
______	Dispatch control
______	Emergency aid request
______	Fleet resource management
______	Immediate hazard warning
______	In-vehicle roadway control signs
______	Regulatory administration
______	Road condition information
______	Route navigation
______	Route scheduling
______	Route selection and route guidance
______	Services directory
_100__	Vehicle/cargo condition monitoring
______	Vehicle location update
______	Voice and message communication

FEATURE COMBINATIONS AND OPTION PACKAGES

When the individual features are combined into option packages, additional capabilities become available. For example, if an option package includes VEHICLE LOCATION UPDATE and EMERGENCY AID REQUEST, the mayday call would automatically give your location (Nebraska Interstate 80 - milepost 253). Without the VEHICLE LOCATION UPDATE, the mayday signal would act as a homing beacon, and emergency services would have to track you down. On the next few pages, we will describe several option packages that might be made available. Some of the additional capabilities will be described. If you think of any that we have not described, please make a note of them. Again, we will discuss the option packages, and your notes may be helpful.

DRIVER SAFETY OPTION PACKAGE

EMERGENCY AID REQUEST
IMMEDIATE HAZARD WARNING
IN-VEHICLE ROADWAY CONTROL SIGNS
ROAD CONDITION INFORMATION
VEHICLE/CARGO CONDITION MONITORING
VEHICLE LOCATION UPDATE
VOICE AND MESSAGE COMMUNICATION

This package of features is aimed at the safety needs of the driver in a variety of situations. In case of a serious accident involving your vehicle, the EMERGENCY AID REQUEST feature would automatically alert emergency services, and since VEHICLE LOCATION UPDATE is included, your current location would be sent as part of the alert. In less threatening situations, other features are intended to help you avoid problems. For example, other vehicles equipped with the emergency aid feature would also provide IMMEDIATE HAZARD WARNINGS about an accident that just happened. You would also be notified about other hazards, such as emergency vehicles approaching from behind you and a patch of gravel road around the next curve.

In-cab display of ROAD SIGNS would make sure that you don't miss important information because a road-side sign is missing. ROAD CONDITION INFORMATION would let you know well in advance of any adverse weather or traffic conditions. You could find out that chains are required on I-5 north of Redding. Since you have the vehicle location feature, you could ask the system for a reminder when you are within 10 miles of an area where chains are required, if they are still required when you get that far.

VEHICLE/CARGO MONITORING would keep you up to date on the condition of your vehicle, and alert you if anyone had tampered with it while you were out of the cab. Also, the monitoring system could send messages to your dispatcher about problems that need to be fixed. VOICE AND MESSAGE COMMUNICATION would allow you to keep in touch with your dispatcher and with other drivers, and it would allow you to call for any type of assistance that you might need.

DRIVER SERVICES OPTION PACKAGE

BROADCAST SERVICES
ROUTE NAVIGATION
ROUTE SELECTION AND GUIDANCE
SERVICES DIRECTORY
VEHICLE LOCATION UPDATE
VOICE AND MESSAGE COMMUNICATION

This option package combines information about enroute services with the navigation and communication systems. BROADCAST SERVICES includes information that is transmitted over a short range to tell you about roadside services available at the next interchange, for instance. This would include perhaps all restaurants, service stations, and lodging, with their hours of operation and prices. You could set up the system to tell you about only those things that are important to you, like diesel fuel prices. The SERVICES DIRECTORY feature gives you an in-vehicle yellow pages that you could use to find special services that may not be included in the broadcast services. The location of public scales could be found in the services directory. With the VEHICLE LOCATION UPDATE feature included, the services directory search could be restricted to cover, say, 5-10 miles around your current location. Since this package also includes the ROUTE NAVIGATION and ROUTE SELECTION AND GUIDANCE features, the location of a selected service could be shown on your electronic map with the closest one highlighted, and a route to it selected. Using the VOICE AND MESSAGE COMMUNICATION feature, you could pick the phone number out of the services directory and call to be sure it is open before you drive there.

MANAGEMENT OPTION PACKAGE

DISPATCH CONTROL
FLEET RESOURCE MANAGEMENT
REGULATORY ADMINISTRATION
VEHICLE/CARGO CONDITION MONITORING
VEHICLE LOCATION UPDATE
VOICE AND MESSAGE COMMUNICATION

The main benefits of this package lie in fleet management. The DISPATCH CONTROL and FLEET RESOURCE MANAGEMENT features would allow your company to keep track of your load and better coordinate with customer delivery requirements. The REGULATORY ADMINISTRATION feature would help the company keep track of permits, licenses, and fees and it would help you, the driver, by eliminating the need to stop at weigh stations, to pay tolls, and to get trip permits. VEHICLE/CARGO CONDITION MONITORING would provide information to you and to your dispatcher about the condition of your vehicle (oil pressure, air pressure, engine temp, etc.) and your cargo (load shifts, temperature, vibration, etc). Either you or your dispatcher could take any actions that might be needed to keep the vehicle in good running condition. In this package, VEHICLE LOCATION UPDATE would let your dispatcher know where you are. The VOICE AND MESSAGE COMMUNICATION feature would keep you in contact with your dispatcher and allow for transmission of regulatory information and of vehicle monitoring information.

NAVIGATION OPTION PACKAGE

CARGO TRANSFER SCHEDULING
ROAD CONDITION INFORMATION
ROUTE NAVIGATION
ROUTE SCHEDULING
ROUTE SELECTION AND ROUTE GUIDANCE
VEHICLE LOCATION UPDATE
VOICE AND MESSAGE COMMUNICATION

The navigation package provides a full range of services for route planning, route following, and drive-time handling of detours. The core of the option package is the ROUTE NAVIGATION feature. This feature has an electronic map which would show streets, secondary roads, freeways, interstates, towns and cities, and state boundaries. What you would see on the map depends on the scale you select and on the area you choose. The map could show Northern California or a street map of Santa Clara.

If you have a delivery to make on Lawrence Expressway in Santa Clara, you could mark the location of your delivery, and the ROUTE SELECTION feature would identify route options for you from your current location. Using roadway restrictions and ROAD CONDITION INFORMATION about construction, weather, traffic congestion, and accidents, the system would show you suggested routes, along with estimated travel time. After you select your preferred route and begin driving, the ROUTE GUIDANCE feature would alert you to upcoming exits and turns so you would have time to get into the proper lane. Also, if any new road condition information comes in, the system would suggest ways to get around any problems. For instance, the system might suggest diverting to the Central Expressway to avoid an accident on 101. Since the VEHICLE LOCATION UPDATE feature is included in the package, the system knows your current location, and a change in route could be automatically selected.

As you drive, the system would monitor your progress, monitor road conditions, monitor incoming messages, and coordinate with your ROUTE SCHEDULE. While enroute, the system could receive a message from your destination stating that all loading docks are occupied and that you would have at least a one-hour wait before unloading. You could then ask the system to identify any other delivery that you could make during the next hour, select your route to the new destination, and send a message to the next delivery point saying that you will arrive earlier than planned. After making the re-scheduled delivery, the system might alert you that you probably don't have enough time to make your next delivery and still meet the schedule for a transfer to an air cargo service. The system would again re-plan your deliveries to go from your current location to the drop point for the air freight, and then on to the next delivery point.
STOP HERE

OPTION PACKAGE EVALUATION

We would like you to evaluate the option packages that were just described by comparing them to a package that contains all of the features, the COMPLETE FEATURE PACKAGE. As in the earlier evaluations, the complete feature package has been given a value of 100. For each of the other packages, assign a number that reflects the value of that package compared to the complete set of features. If you judge the package to be of less help than the full set of features, give it a number less than 100. If a package is more helpful to you than the full set, give it a number larger than 100.

_______ COMPLETE FEATURE PACKAGE
_______ DRIVER SAFETY OPTION PACKAGE
_______ DRIVER SERVICES OPTION PACKAGE
_______ MANAGEMENT OPTION PACKAGE
_______ NAVIGATION OPTION PACKAGE

INSTRUCTIONS FOR FEATURE PAIR COMPARISON

On the next 10 pages, there are pairs of features shown inside of boxes. We want you to compare the two features and tell us which feature in the pair would help you the most in doing your job. Then tell us how much less of a help the other feature is. For example, for the pair

FLEET RESOURCE MANAGEMENT ______ <--> ______ IMMEDIATE HAZARD WARNING

you would decide which of the two is most helpful, and write a 100 in the blank closest to that feature name, for example,

FLEET RESOURCE MANAGEMENT _100__ <--> ______ IMMEDIATE HAZARD WARNING

This indicates that FLEET RESOURCE MANAGEMENT is more help to you in doing your job than IMMEDIATE HAZARD WARNING. Next, you would write another number in the other blank, a number between 1 and 99 to indicate how helpful the second feature is compared to the first. If HAZARD WARNINGS are only half as helpful as FLEET RESOURCE MANAGEMENT, write 50 in the blank.

FLEET RESOURCE MANAGEMENT _100___ <--> __50__ IMMEDIATE HAZARD WARNING

If the two features are just about equal in helpfulness (both very helpful, both not very helpful, or just equally helpful) put a 99 in the other blank.

YOU MUST PICK ONE OF THE TWO AND GIVE IT A 100. THEN, YOU MUST GIVE THE OTHER ONE A NUMBER BETWEEN 1 AND 99. Please do not skip any. Each of the feature pairs is different, there are no repeats.

At the end of each page, please stop and check to be sure that you completed all of the feature pairs on that page.

VEHICLE LOCATION UPDATE ____ <--> ____ BROADCAST SERVICES

ROUTE NAVIGATION ____ <--> ____ ROUTE SCHEDULING

CARGO TRANSFER SCHEDULING ____ <--> ____ DISPATCH

BROADCAST SERVICES ____ <--> ____ CARGO TRANSFER SCHEDULING

DISPATCH CONTROL ____ <--> ____ FLEET RESOURCE MANAGEMENT

ROUTE NAVIGATION ____ <--> ____ EMERGENCY AID REQUEST

REGULATORY ADMINISTRATION ____ <--> ____ IMMEDIATE HAZARD WARNING

EMERGENCY AID REQUEST ____ <--> ____ REGULATORY ADMINISTRATION

CARGO TRANSFER SCHEDULING ____ <--> ____ ROAD CONDITION INFORMATION

SERVICES DIRECTORY ____ <--> ____ ROUTE NAVIGATION

VOICE/MESSAGE COMMUNICATION ____ <--> ____ ROUTE SELECTION & GUIDANCE

BROADCAST SERVICES ____ <--> ____ ROUTE SELECTION & GUIDANCE

PLEASE CHECK THIS PAGE FOR COMPLETENESS

ROAD CONDITION INFORMATION ____ <--> ____ SERVICES DIRECTORY

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ VEHICLE/CARGO MONITORING

VEHICLE LOCATION UPDATE ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

ROAD CONDITION INFORMATION ____ <--> ____ VEHICLE LOCATION UPDATE

ROUTE SCHEDULING ____ <--> ____ VOICE/MESSAGE COMMUNICATION

IMMEDIATE HAZARD WARNING ____ <--> ____ BROADCAST SERVICES

REGULATORY ADMINISTRATION ____ <--> ____ FLEET RESOURCE MANAGEMENT

ROUTE NAVIGATION ____ <--> ____ DISPATCH

ROUTE SELECTION & GUIDANCE ____ <--> ____ ROAD CONDITION INFORMATION

FLEET RESOURCE MANAGEMENT ____ <--> ____ CARGO TRANSFER SCHEDULING

REGULATORY ADMINISTRATION ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

EMERGENCY AID REQUEST ____ <--> ____ SERVICES DIRECTORY

PLEASE CHECK THIS PAGE FOR COMPLETENESS

ROUTE SCHEDULING ____ <--> ____ REGULATORY ADMINISTRATION

DISPATCH CONTROL ____ <--> ____ VOICE/MESSAGE COMMUNICATION

IMMEDIATE HAZARD WARNING ____ <--> ____ EMERGENCY AID REQUEST

EMERGENCY AID REQUEST ____ <--> ____ BROADCAST SERVICES

REGULATORY ADMINISTRATION ____ <--> ____ ROAD CONDITION INFORMATION

VOICE/MESSAGE COMMUNICATION ____ <--> ____ VEHICLE/CARGO MONITORING

IMMEDIATE HAZARD WARNING ____ <--> ____ ROUTE SELECTION & GUIDANCE

IMMEDIATE HAZARD WARNING ____ <--> ____ CARGO TRANSFER SCHEDULING

ROUTE SELECTION & GUIDANCE ____ <--> ____ ROUTE SCHEDULING

SERVICES DIRECTORY ____ <--> ____ BROADCAST SERVICES

DISPATCH CONTROL ____ <--> ____ EMERGENCY AID REQUEST

VEHICLE LOCATION UPDATE ____ <--> ____ VEHICLE/CARGO MONITORING

PLEASE CHECK THIS PAGE FOR COMPLETENESS

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ IMMEDIATE HAZARD WARNING

ROUTE SCHEDULING ____ <--> ____ BROADCAST SERVICES

BROADCAST SERVICES ____ <--> ____ DISPATCH

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ FLEET RESOURCE MANAGEMENT

REGULATORY ADMINISTRATION ____ <--> ____ CARGO TRANSFER SCHEDULING

VEHICLE LOCATION UPDATE ____ <--> ____ VOICE/MESSAGE COMMUNICATION

DISPATCH CONTROL ____ <--> ____ IMMEDIATE HAZARD WARNING

REGULATORY ADMINISTRATION ____ <--> ____ BROADCAST SERVICES

BROADCAST SERVICES ____ <--> ____ VEHICLE/CARGO MONITORING

FLEET RESOURCE MANAGEMENT ____ <--> ____ IMMEDIATE HAZARD WARNING

VEHICLE/CARGO MONITORING ____ <--> ____ SERVICES DIRECTORY

VEHICLE/CARGO MONITORING ____ <--> ____ ROUTE SELECTION & GUIDANCE

PLEASE CHECK THIS PAGE FOR COMPLETENESS

IMMEDIATE HAZARD WARNING ____ <--> ____ ROAD CONDITION INFORMATION

DISPATCH CONTROL ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

IMMEDIATE HAZARD WARNING ____ <--> ____ ROUTE NAVIGATION

FLEET RESOURCE MANAGEMENT ____ <--> ____ BROADCAST SERVICES

REGULATORY ADMINISTRATION ____ <--> ____ ROUTE NAVIGATION

VOICE/MESSAGE COMMUNICATION ____ <--> ____ SERVICES DIRECTORY

ROAD CONDITION INFORMATION ____ <--> ____ ROUTE NAVIGATION

CARGO TRANSFER SCHEDULING ____ <--> ____ EMERGENCY AID REQUEST

DISPATCH CONTROL ____ <--> ____ REGULATORY ADMINISTRATION

IMMEDIATE HAZARD WARNING ____ <--> ____ ROUTE SCHEDULING

DISPATCH CONTROL ____ <--> ____ ROAD CONDITION INFORMATION

CARGO TRANSFER SCHEDULING ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

PLEASE CHECK THIS PAGE FOR COMPLETENESS

VEHICLE/CARGO MONITORING ____ <--> ____ CARGO TRANSFER SCHEDULING

VOICE/MESSAGE COMMUNICATION ____ <--> ____ BROADCAST SERVICES

SERVICES DIRECTORY ____ <--> ____ DISPATCH

SERVICES DIRECTORY ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

VEHICLE LOCATION UPDATE ____ <--> ____ EMERGENCY AID REQUEST

ROUTE SELECTION & GUIDANCE ____ <--> ____ FLEET RESOURCE MANAGEMENT

VEHICLE LOCATION UPDATE ____ <--> ____ SERVICES DIRECTORY

VEHICLE/CARGO MONITORING ____ <--> ____ ROUTE NAVIGATION

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ ROAD CONDITION INFORMATION

ROUTE NAVIGATION ____ <--> ____ ROUTE SELECTION & GUIDANCE

ROUTE SCHEDULING ____ <--> ____ VEHICLE LOCATION UPDATE

ROAD CONDITION INFORMATION ____ <--> ____ VOICE/MESSAGE COMMUNICATION

PLEASE CHECK THIS PAGE FOR COMPLETENESS

ROUTE NAVIGATION ____ <--> ____ VOICE/MESSAGE COMMUNICATION

SERVICES DIRECTORY ____ <--> ____ CARGO TRANSFER SCHEDULING

ROAD CONDITION INFORMATION ____ <--> ____ FLEET RESOURCE MANAGEMENT

SERVICES DIRECTORY ____ <--> ____ FLEET RESOURCE MANAGEMENT

ROUTE SCHEDULING ____ <--> ____ CARGO TRANSFER SCHEDULING

SERVICES DIRECTORY ____ <--> ____ IMMEDIATE HAZARD WARNING

FLEET RESOURCE MANAGEMENT ____ <--> ____ EMERGENCY AID REQUEST

ROAD CONDITION INFORMATION ____ <--> ____ BROADCAST SERVICES

VOICE/MESSAGE COMMUNICATION ____ <--> ____ CARGO TRANSFER SCHEDULING

IMMEDIATE HAZARD WARNING ____ <--> ____ VEHICLE/CARGO MONITORING

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ ROUTE SELECTION & GUIDANCE

SERVICES DIRECTORY ____ <--> ____ ROUTE SELECTION & GUIDANCE

PLEASE CHECK THIS PAGE FOR COMPLETENESS

ROUTE SELECTION & GUIDANCE ____ <--> ____ CARGO TRANSFER SCHEDULING

CARGO TRANSFER SCHEDULING ____ <--> ____ ROUTE NAVIGATION

VEHICLE LOCATION UPDATE ____ <--> ____ DISPATCH

EMERGENCY AID REQUEST ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

CARGO TRANSFER SCHEDULING ____ <--> ____ VEHICLE LOCATION UPDATE

DISPATCH CONTROL ____ <--> ____ ROUTE SCHEDULING

BROADCAST SERVICES ____ <--> ____ ROUTE NAVIGATION

ROUTE SELECTION & GUIDANCE ____ <--> ____ VEHICLE LOCATION UPDATE

ROUTE NAVIGATION ____ <--> ____ VEHICLE LOCATION UPDATE

VEHICLE/CARGO MONITORING ____ <--> ____ ROUTE SCHEDULING

BROADCAST SERVICES ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

VEHICLE/CARGO MONITORING ____ <--> ____ DISPATCH

PLEASE CHECK THIS PAGE FOR COMPLETENESS

SERVICES DIRECTORY ____ <--> ____ REGULATORY ADMINISTRATION

VEHICLE LOCATION UPDATE ____ <--> ____ FLEET RESOURCE MANAGEMENT

EMERGENCY AID REQUEST ____ <--> ____ ROAD CONDITION INFORMATION

ROUTE NAVIGATION ____ <--> ____ FLEET RESOURCE MANAGEMENT

VEHICLE LOCATION UPDATE ____ <--> ____ IMMEDIATE HAZARD WARNING

ROAD CONDITION INFORMATION ____ <--> ____ ROUTE SCHEDULING

ROUTE SELECTION & GUIDANCE ____ <--> ____ DISPATCH

VOICE/MESSAGE COMMUNICATION ____ <--> ____ EMERGENCY AID REQUEST

VEHICLE/CARGO MONITORING ____ <--> ____ REGULATORY ADMINISTRATION

VOICE/MESSAGE COMMUNICATION ____ <--> ____ FLEET RESOURCE MANAGEMENT

ROUTE SCHEDULING ____ <--> ____ EMERGENCY AID REQUEST

REGULATORY ADMINISTRATION ____ <--> ____ ROUTE SELECTION & GUIDANCE

PLEASE CHECK THIS PAGE FOR COMPLETENESS

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ ROUTE SCHEDULING

IN-VEHICLE ROAD CONTROL SIGNS ____ <--> ____ ROUTE NAVIGATION

EMERGENCY AID REQUEST ____ <--> ____ VEHICLE/CARGO MONITORING

ROUTE SELECTION & GUIDANCE ____ <--> ____ EMERGENCY AID REQUEST

VOICE/MESSAGE COMMUNICATION ____ <--> ____ IMMEDIATE HAZARD WARNING

ROUTE SCHEDULING ____ <--> ____ SERVICES DIRECTORY

FLEET RESOURCE MANAGEMENT ____ <--> ____ ROUTE SCHEDULING

VEHICLE/CARGO MONITORING ____ <--> ____ FLEET RESOURCE MANAGEMENT

VOICE/MESSAGE COMMUNICATION ____ <--> ____ REGULATORY ADMINISTRATION

VOICE/MESSAGE COMMUNICATION ____ <--> ____ IN-VEHICLE ROAD CONTROL SIGNS

VEHICLE LOCATION UPDATE ____ <--> ____ REGULATORY ADMINISTRATION

VEHICLE/CARGO MONITORING ____ <--> ____ ROAD CONDITION INFORMATION

PLEASE CHECK THIS PAGE FOR COMPLETENESS

DRIVER DEMOGRAPHICS

Some of you are primarily long-haul drivers and some of you are mainly local delivery drivers. We expect that this job difference will affect how you answer the evaluations that we have asked you to do for us. Also, the amount of experience that you have as a commercial driver may make a difference in your evaluations. Other factors, like age, income, and education can have an effect, as well. To allow us to sort the results of this survey and to look at how these factors influence your opinions, we ask that you complete the following set of questions about your background and experience. Your responses will be kept in the strictest confidence. Please check off the one choice on each line that best applies to you.

1. Age

___ 21-35 years ___ 36-45 years ___ 46-55 years ___ 55+ years

2. How would you classify your current job:

___ Local ___ Long-haul

3. Education (highest level completed)

___ less than 12 ___ high school ___ some college __ college degree +

4. Years of commercial driving experience

Local: ___ 3 or less ___ 4-8 ___ 9-15 ___ 16-25 ___ 25+

Long-haul: ___ 3 or less ___ 4-8 ___ 9-15 ___ 16-25 ___ 25+

5. Estimated annual income

___ $30000 or less ___ $30-40000 ___$40-50000 ___ $50000+

6. Experience with computer systems

___ none ___ very little ___ occasional use ___ frequent use ___ daily use

All of us involved in this survey thank you for your help. We hope that this will make a difference in the advanced technology that will arrive during the next ten to twenty years. If you wish to make any further comments or observations, please use the back of this page.

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