U S **Department**
of Transportation

Research and
Special **Programs**
Administration

John A Volpe
National Transportation
Systems Center

WORKING PAPER

ITS User Acceptance Research on Transportation Managers

Report 1: A Summary of Current ITI Deployment Knowledge

March 2 1. 1996

Prepared for:
U.S. Department of Transportation
Intelligent Transportation Infrastructure Deployment Initiatives Group

Prepared by:
Sari Radin, Volpe Center
Jane Lappin, EG&G

ITS USER ACCEPTANCE RESEARCH ON TRANSPORTATION MANAGERS

ITS USER ACCEPTANCE RESEARCH ON
TRANSPORTATION MANAGERS

This paper reviewing the literature and noting ongoing projects is the first step in the transportation managers' marketing research study. It summarizes the relevant information on ITS available from other studies in the context of marketing research. In doing so. areas that have been sufficiently investigated are identified, as well as questions for which complete answers are unavailable. Subsequent research will build from this knowledge.

INTRODUCTION

Information that will be gathered through this user acceptance research project supports the USDOT ITI deployment program by systematically identifying

- Opportunities and obstacles that state and local transportation managers face in assessing, purchasing. installing, using, and integrating ITI products, and

- Factors that will facilitate or impede deployment of ITI innovations.

Transportation managers must make decisions about allocating funds among a variety of highway and transit projects, which may or may not involve ITS. Understanding how they make these decisions. and hots they perceive the benefits of ITI, is essential to forming effective deployment support strategies. Once the research has been completed, it will be possible to construct a detailed. segmented, national "map" of who is and isn't deploying ITI solutions, and why.

ITI products and services offer innovative solutions to transportation management challenges. An *innovative* product provides benefits that are not well understood by the intended users, and thus there are obstacles to the adoption of innovative products that are not present with products that offer a more simple improvement. Consider the difference between automating a paper-based records management system. and using the capability of the technology to re-engineer the system. One is an improvement, the second is innovative. Research on the rate of diffusion of innovative products has defined the obstacles to market that such products face. In considering the deployment opportunities and obstacles facing ITI innovations, these special issues must be addressed in addition to the more generic marketing research questions.

This paper provides current background on the question "what do we know about why various transportation agencies do or do not plan to deploy ITI", and provides a summary of what is known. The following section examines existing ITI deployment studies through the framework of a marketing research program on innovative products. In assessing the applicability of the existing data. two sets of questions form the analytical framework: basic research questions addressing who buys and why, and questions related only to the adoption and diffusion of innovation. such as those addressing risk and complexity. The final section recommends the next research steps to be taken to provide the Department with in-depth, generalizable knowledge about deployment of ITI innovations by transportation agencies in support of effective, targeted outreach and deployment policy.

BACKGROUND

USDOT recently commissioned a number of useful inventories and analyses of state and local transportation agencies' deployment of ITI. In addition, independent studies have been undertaken by ITS America and ITE. In contrast to last year at this time, the Department has (or. will have shortly) ITI deployment information, including

- An inventory of ITI deployments among the 75 largest metropolitan areas;
- Case studies of seven metropolitan areas, l-3 mil population, including all units of government, describing their current activities, attitudes, and plans for ITI deployment;
- A survey of traffic engineering agencies re: problems, training, operations, and maintenance;
- A survey of lead agencies at -50 EDP sites focused on the ITS planning process;
- Surveys focused on transit ITI deployment. largely quantitative; and,
- Focus groups with elected officials and city managers.

These studies were commissioned with different goals. and thus address a variety of issues that may or may not relate to marketing research. As a group. they provide a listing of many deployments. and anecdotal insight into the problems and ITI awareness of individual transportation managers and agencies. Examples of what we have learned from these studies include:

- Governments adopt ITS technologies for the same reasons they implement other solutions to problems they face: congestion management. customer service, safety, economic development, and air quality.

- The greater the population of the metropolitan area. the more likely the area is to adopt ITS technologies, regardless of federal funds availability.

- For many regions ITI is an extension of their existing and planned investments in advanced technologies.

- State departments of transportation appear to be embracing ITI innovations more quickly than cities. They are also more likely to have federal funding for ITI than local governments.

- Where the technologies make irrefutable economic and transportation sense they are more likely to be implemented. as with electronic toll collection systems.

- Establishing interjurisdictional transportation management systems is much more challenging and infrequent than is installation of systems controlled by a single agency

- Transportation managers and engineers need better information describing the benefits or cost/effectiveness of ITI so that they can compare them to more traditional transportation solutions.

- Transportation managers and engineers need better information on the purchase and life cycle costs of ITI components. including operating and maintenance costs.

While each study contains useful information, they were not designed to be assembled into a coherent, representational picture of the market. Such an ITI market picture, or map, would segment transportation agencies according to those attributes that related directly to their likelihood of ITI deployment, provide insight into transportation agencies' deployment motivations, and provide the basis for informed, directed deployment-support practices.

Findings from these studies have been synthesized and organized according to the needs of this marketing research study, and are provided at greater length in a later section of this paper. While these findings form a good base for further research, on their own they do not provide reliable, generalizable information. In order to provide actionable direction to the USDOT ITI deployment effort, data describing motivations must be quantified and organized around demographic characteristics like:

City size
Climate
Population density
Location in the U.S.
Location within a metropolitan area
Level of government
Size of budget

Some of the questions related to ITI deployment that the upcoming direct national research will answer are:

- What are the important problems that transportation managers need ITI to solve?

- What risks do the managers perceive in implementing ITI systems?

- How will the absence of federal ITS funding affect the rate of local ITI deployment? What sources will local governments draw upon to deploy ITI?

- Do transportation managers know the life cycle costs of various ITI innovations and the cost of not deploying ITI? How does their understanding, or lack thereof, affect deployment decisions?

- To what extent can IT1 be used on a trial or experimental basis, or is the agency making an all-or-nothing commitment?

- Do agencies deploy ITI components as part of a long-term transportation management investment program?

- Where interjurisdictional ITI deployments are in place, what context motivated the agreement, and what additional benefits (costs) accrue to each partner?

- What effect does the need for interagency cooperation have upon the rate of adoption of ITI deployment?

- What effect will the privatization of transit authorities and the construction of private toll roads have upon ITI deployment?

- Where ITI was deployed, what other options (technological or procedural) were considered to address the problem, and why was ITI chosen over these options? Where it hasn't been deployed, why not?

- Where ITI has been deployed, what was the response of the operators of the system to the new technology? If the technology was being implemented on a partial or trial basis, did the input of the operating and maintenance staff affect the full deployment?

WHAT WE KNOW ABOUT ITI ACCEPTANCE

The next three sections organize and summarize existing relevant ITI deployment data according to a marketing research framework. The first section presents what we know in answer to the basic marketing research questions of who buys what and why; the second section presents what we know towards influencing adoption and diffusion of ITI innovations; and the third section summarizes this data towards an actionable understanding of the rate of ITI adoption by transportation managers and agencies.

In Answer to Basic Marketing Research Questions

In performing marketing research on buyer behavior and characteristics for any market, the following broad questions need to be addressed. As they apply to ITI deployment, the answers to these questions support the development of targeted, effective outreach, education, and policy guidance.

- ***What does the customer buy***? What are the advanced technologies that "appeal" to transportation managers?

- ***Why do they buy.***? What are the motivations for buying advanced technologies? Are they replacing older technologies that served related functions? Are they venturing into new areas of services? Are they attempting to address new or existing problems through changing the technology? Are they addressing current problems or planning for the future?

- ***Who buys?*** Who initiates the purchase decision? Who must approve the purchase? How many individuals and organizations are involved in the purchase decision?

- ***How do they buy?*** What is the procurement process?Where do they get the money for the project? To what extent and which work do they contract out rather than doing in house?

- ***When do they buy.*?** Is it seasonal? How is it affected by the budget cycle?

- ***How much do they buy?*** Do they phase in the adoption of a new technology or do it all at once? What is the geographic coverage? What is the intensity of coverage (i.e. cameras per mile)? What portion of their budget is devoted to advanced technologies?

- ***How will buyer behavior and characteristics change in the future?*** How will moves toward inter-modal regional planning affect ITI? How will privatization of transit affect investment decisions? How will new funding sources and constraints make some investments more or less attractive (i.e. greater funds for operations and maintenance)?

There are many sources of relevant information on ITI that we have reviewed and synthesized for this paper. In addition to these studies summarizing deployment across governments, most state departments of transportation and some local ones have Web pages that in some cases give very detailed Information about their initiatives. A fuller description of all these studies is appended to this paper for reference.

- The Volpe Center "Assessment of ITI Deployment" describes deployment issues related to all ITS functional systems and technology in seven metropolitan areas.

- Public Technology, Inc. (PTI) work includes a survey of local government managers asking a variety of questions about ITS deployment, a brochure covering case studies, and focus groups of local politicians and city managers.

- The Institute of Transportation Engineers surveyed its members for information about FMS and ATMS operating and maintenance issues, and produced a series of white papers.

- Researchers at Oak Ridge National Laboratory (ORNL) are preparing an inventory of ITI deployment in the 75 largest metropolitan areas. They have posted some preliminary information from their study on the World Wide Web.

- The Volpe Center is completing a study on APTS deployment that lists by agency the number of vehicles, service type, and technologies adopted.[1]

- JHK is in the process of conducting research related to ITS planning, and has completed an overview of issues, barriers and problems of integrating ITS into the transportation planning process.

- ITS America has compiled information on ITI deployment related to electronic toll collection systems in the United States, ATMS deployment by state agencies, and transit AVL systems in the U.S. and Canada.

The information to be drawn from this research does not give conclusive answers about the full range of questions listed above. The primary reason is that the studies were not conducted with the idea of assessing the market, but in more cases were quantifying deployment or considering deployment issues in general. As a result, some of the relevant areas were investigated in a fairly general manner, rather than delving into the specifics needed to develop an effective deployment support program. In addition, much of the more relevant and defensible work that has been completed consists of case studies, which results in too small a sample size to draw conclusions at a very specific level. While the PTI survey asks many questions addressing the important issues, the results are not very useful because many of the questions were not clear or specific and the data are summarized in a manner that obscures their interpretation. There is no other survey that is as relevant, except the one being undertaken by ORNL, which is an inventory and does not address the respondents' reasons for adopting or not adopting.

Following is a summary of what these and other sources indicate about the basic marketing research questions.

What do they buy?

Transportation managers have been buying technologies identified with ITI for a number of years, although they are not always recognized as ITI. For instance in the PTI survey, although only about 24% of transportation managers reported using "ITS", over 40% indicated that they were using an advanced technology traffic signal control system. When the ORNL study is complete, it will provide a clearer picture of what systems, using which technologies, are being deployed.

The preliminary information available from ORNL on the Web[2] seems to indicate that the larger the area, the more likely it is to have a Freeway Operation Center. State programs seem to be implemented in smaller areas than local programs, both as a result of the program being

---

1 "APT.5 Deployment in the U.S."

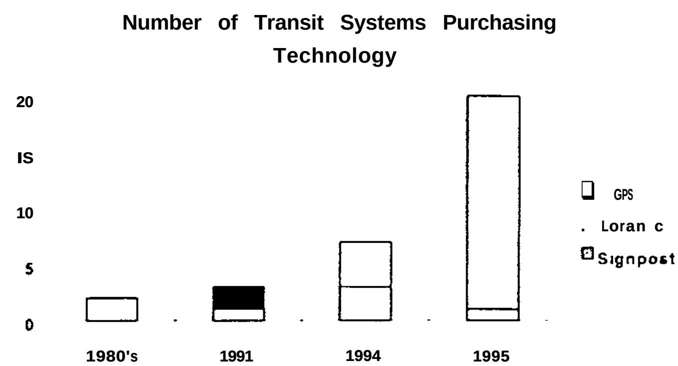
2 The information is posted at http://gordon.prg.utk.edu

statewide, and possibly because of less strict budget constraints. For instance, the Pennsylvania Turnpike has an incident management program operating statewide. including on the Northeast Extension in the Scranton area. No other ITI has been deployed in that area. The following table summarizes information from an arbitrary sample of 58 metropolitan areas from the preliminary data that is available on the Web site.

Deployment of ITS technologies by metropolitan area population

	Freeway Operation Center	Transit technologies (AVL, 2 way communication)	Traffic signal systems	Incident management	Electronic toll collection
< 500,000 population	20%	40%	40%	47%	40%
500,000 to 1,000,000	47%	26%	63%	37%	5%
1,000,000 to 2,000,000	83%	75%	58%	50%	42%
2,000,000 to 3,000,000	80%	60%	80%	80%	80%
> 3,000,000	100%	86%	71%	100%	86%

ITS America has summarized information about technologies being used by transit systems for AVL. As can be seen in the chart below, adoption of AVL is increasing rapidly, and there seems to be a shift from signpost technology to GPS starting in about 1995. In fact. San Francisco. which put signpost technology on 850 buses in 1985. is using GPS on 850 buses in 1995.[3] Very few systems use Loran C.



Why do they buy?

The Volpe assessment found a variety of motivations for planning or deploying ITI projects: to manage the system without increasing capacity (reduce congestion), to solve specific transportation problems, to improve safety and customer service, to spur or manage economic development. to increase efficiency in order to overcome decreasing resources, and to avoid complaints. A particular technology may be chosen considering compatibility with existing systems, operational stability, and operating and maintenance costs. As noted earlier in the paper, current data does not allow for correlations among these motivations and regional characteristics.

[3] ITS America Transit Automate Vehicle Locater Fact Sheet.

More specifically, the Volpe Center study found that state DOT officials are motivated by a need for congestion management, better utilization of the existing transportation system. and increased safety. Transit agency officials are motivated by a need to enhance customer service, improve operational efficiency, and cut costs. Municipal transportation officials are motivated by the desire to provide more reliable service with fewer financial and human resources. MPO staffs had very diverse responses to the question of motivation. Some of the more common answers include increased economic viability, enhanced mobility, safety, cost effectiveness, and more efficient use of the existing transportation system. County transportation officials are motivated by safety, customer service and environmental concerns. Law enforcement agency staffs are primarily motivated by public safety. Toll Authority officials consider themselves in competition with public facilities and are motivated by a need to provide the best possible customer service.

The agencies' stated motivations to deploy ITS had no correlation with the metropolitan area's actual level of deployment. Officials within the seven metropolitan areas interviewed listed similar motivations and yet the level of deployment of elements of the ITI differed dramatically. Because the study was not designed to elicit the specific sorts of information needed for marketing research, the best explanations for the differences were funding, politics, and agency priorities.

Who buys?

This section addresses the issue of uho initiates the demand for the product. but not the process of procurement. Procurement is covered in the following section on "how do they buy".

There are two levels to the question of who buys: what organizations or levels of government. and what staff within those organizations. State, county, and local governments buy ITI technologies. At the state level, the DOT (both central office and districts) and toll road authorities are the buyers of systems such as Freeway Management Systems (FMS), and Electronic Toll Collection (ETC) although the state police also can be involved for Incident Management Systems (IMS). Local governments have a department or part of a department that deals with transportation, which would buy ITI technologies such as Traffic Signal Control Systems (TSCS). Both local police and fire departments can be involved in implementation of IMS. Transit agencies buy technologies related to TMS.

Within those agencies, certain staff will be involved in the decision to buy. and others will not. The Washington State Department of Transportation considers technology transfer and innovation adoption to be something that is and should be a decentralized process because it is more likely to occur if the mechanisms used to introduce the innovations are generated and conducted from the users' work areas.' Consequently, it is probable that central office staff will be less likely to introduce specific technologies than District staff.

4 Washington State Department of Transportation. p. 43.

Even so, not everybody associated with the system will become involved. For instance. in a large organization, the planning. development and operation of traffic control systems are often the responsibility of the traffic function. Maintenance of traffic control systems could be combined with other maintenance functions in another part of the organization. In this case. maintenance would be unlikely to be involved in the planning and development stages of traffic control systems.5

How do they buy?

The buying process can be considered in three parts: planning and designing the project. determining the funding sources or mechanisms, and going through a procurement process to actually purchase the technology.

The Volpe assessment found that planning staffs consider ITI in developing Congestion Management System plans, and local traffic engineers routinely consider the most current signal technology. As part of the decision making process, they may discuss new technologies with staff in other places where it has been implemented, and use that information to inform themselves about the desirability and problems with that technology. ISTEA has strengthened the planning process, so that step will be increasingly important if the planning requirements are maintained through reauthorization.

State and local governments use money from most federal aid funds to plan and deploy ITI projects. According to PTI, federal funds are used by almost 60% of their respondents, city/county/local funds by 56%, state funds by 46%, and operating revenue/general funds by 33%. Volpe Center research found that several local governments have used 100% local funds when federal funds were unavailable.

The staff must get approval for their projects, and go through a procurement process. Gaining approval could involve management in their agency, possibly other agencies, and politicians such as the mayor. city council, county board, state legislature, or governor. In some places, they present the ITI projects independently for approval, in other places, ITI is mixed with other projects. It may be helpful to use innovative techniques in procurements. Under current practice, when they hire contractors, they may be required to separate the project into design and build phases, with different contractors for each.

When do they buy?

There does not seem to be much information available on when advanced technologies are bought. Seasonal considerations could come into play with respect to construction schedules, although the purchase decision could come at any time. The budget cycle of the agency could affect large projects especially, since the larger the project, the more likely it would need approval from the political process. Election years could affect the likelihood of adopting a risky (or flashy and exciting) new technology.

---

5 Leung and Yee. p. 44

How much do they buy?

From the perspective of a private company selling equipment, the question of how much would most likely be answered in terms of the number of units they could expect to sell. It doesn't matter where the units are deployed after the sale. For the transportation manager, the question of how much could have two components: a level of service, or density of technology applied over a geographic area. The manager would then choose the type and quantity based on providing that service. Both the sellers and the buyers in the market would also be interested in how much money the buyers are spending on each technology, perhaps in the context of the budget available.

Currently, there does not appear to be a comprehensive source of consistent data on how much of each type of technology the deploying agencies purchase. The information available soon from ORNL will improve that knowledge base. There does not seem to be a good measure of how much governments are buying by fraction of budget.

The information supplied by agencies for the surveys or case studies, which have been done, tends to be given in varying units. One area may describe geographic coverage, while another lists the number of cameras. ITS America has compiled fact sheets on the deployment of ATMS by state agencies, transit AVL, and ETC. The ATMS summary gives geographic coverage in most cases, number of units deployed in some cases, and no information on expenditures. The AVL summary gives technology and number of vehicles. The ETC summary lists toll agencies currently operating ETC systems. The following table illustrates the wide variation in the intensity of application of the most common technology for ATMS. There is no obvious variation by size of system. Since the design criteria vary from project to project, it is impossible to apply general factors to one measure to obtain the others.

Intensity of use of ATMS technologies[6]

	Loop detectors	CCTV	Ramp meters	Variable message signs
Number of agencies reporting deployment	20	21	15	21
Number of agencies reporting actual number deployed	6	15	13	15
Minimum per mile	6	0.01	0.72	0.10
Maximum per mile	59	2.14	2.29	3.13
Average per mile	30	0.55	1.22	0.81
Standard deviation	21	0.64	0.50	1.13

Some of the PTI case studies indicate that local governments may try a new technology in a limited way, with an eye to expanding use if it works. For instance, they may make changes to

[6] Summarized from ITS America ATMS Fact Sheet.

equipment just on one transit line, on parking meters in part of the city. or on signals or signs for only certain roadways. Some types of projects do not lend themselves to incremental adoption, however. For instance, the Clark County. Nevada decentralized traffic signal control system was replacing a centralized one. While it may have been possible to make the change gradually, it could have been difficult to truly evaluate a partially implemented decentralized system.

How will buyer behavior and characteristics change in the future?
As the budget constraints and regulatory environment constraining the purchasers of advanced technologies change, their behavior will change as well. For instance, some transit authorities are being partially or completely privatized. Private companies have different incentives from quasi public entities. Private toll roads are being built. Toll roads have different needs and potentially different budget constraints from roads operated by state highway departments.

Towards Influencing Adoption and Diffusion of Innovation

ITI products and services represent *innovative* solutions to transportation problems. In this context, innovative refers to the shift in approach, problem definition, and workplace behavior that the new product requires. The innovative aspects of ITI solutions provide both their most valuable and their most fearful characteristics. As a result, when assessing user response and demand for innovative products, other questions must be addressed in addition to those discussed above.

Diffusion of innovations
A variety of research on the adoption of transportation innovations has been conducted. The innovations were not necessarily primarily technological. For instance. several of the innovations involved training materials or procedures. Other innovations involved technology that was considered advanced at the time of the study. but is now out of date. This section summarizes the insights provided by three studies, and the resulting set of questions that should bc addressed to understand the diffusion of ITI.

Ettlie and Vellenga’ studied the adoption time period for 32 transportation innovations in private firms. Through performing statistical analysis on data obtained through case studies, they tested a number of factors that affect the amount of time that it takes an organization to adopt an innovation:

- Cost (to purchase, develop, and implement)
- Relative advantage of the innovation
- Compatibility to the values, experiences and needs of the adopting unit
- Complexity: perception of how difficult the innovation is to understand and use
- Trial-ability: the extent to which experimenting or limited testing is possible
- Observability: the degree to which the results of using the innovation are easily visible and easily communicated

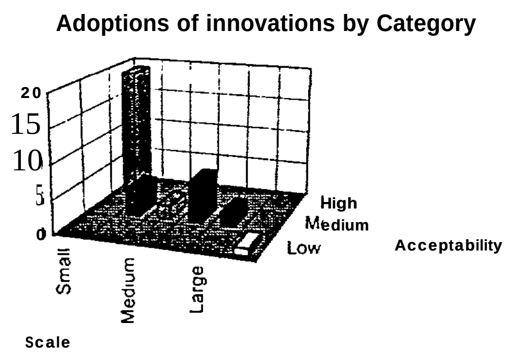
‘Ettlie and Vellenga, 1979.

- Organizational risk taking climate
- Regulation and governmental action
- Labor/union reaction

The single best predictor, however, of the amount of time required to progress from one stage of the decision process to the next was the cost of the innovation. Following cost, the complexity of the innovation, the organizational risk-taking climate, and union reaction were the next most important factors. They conclude that, at the level of the firm, the most important factor that the firm would be able to influence is the organizational risk-taking climate.

The UMTA, now FTA, initiated a program to increase the diffusion of innovations through identifying successful innovations and publicizing contacts at those agencies to other agencies which might benefit through adoption of the innovation. Analysis of the effectiveness of this Public Transportation Network (PTN) program indicates similar factors affecting the likelihood of adoption. Legislation requiring new service, or specific problems of concern to top management increased the probability of the agency implementing a new solution.[8] In addition, the researchers grouped innovations adopted under the PTN into six categories, which varied by scale, acceptability, and transferability. Scale referred to how costly, time-consuming, and complex the innovation would be to adopt, as well as how many people would be involved. Acceptability considered whether there were significant institutional barriers and whether it addressed high priority concerns. Transferability addressed how easily the program could be copied from one region to another, and how much adaptation would be required.

Out of 34 total, the most adoptions under PTN (19) were in the category with small scale. high acceptability, and high transferability. The fewest adoptions (1) were in the category with large scale. low acceptability and medium transferability. In the chart, scale and acceptability are represented on the x and y axes, while solid bars indicate medium transferability, and patterned bars denote high transferability. Since the PTN was designed to promote adoption of innovations, projects with low transferability were not included.



Some of the same themes were repeated by Robey and Bakr. After reviewing the adoption of two innovations by the Chicago Transit Authority, they produced several recommendations for easing the introduction of innovations. Their focus was on the adopting organization. Consequently, while they note that the availability of technological information and financial

[8] Harrison. Weeks. and Walb. P. 44.

support is crucial, they qualify that conclusion with the requirement that the organization must be structured in such a way that it is prepared to use the information and funds. They believe that. within the same agency, linking or integrating an innovative department with the department that would use the technology is the best method for introducing and adopting new ideas that are practical. In addition, preparing employees for job changes that result from the innovation is crucial to the acceptance and success of the innovation.

To summarize, innovations are most likely to be adopted if they are

- Directly applicable to a problem
- Low cost
- Small scale/Easily divisible
- Not complex
- Low risk
- Acceptable to workers

Innovations that require the fewest changes in job content or structure are most likely to be accepted well by workers. Organizations that are prepared to incorporate new ways of doing things, and willing to prepare employees for job changes. are most likely to adopt the innovations.

Applicability

Determining the applicability of ITI involves two steps: identifying the needs of the transportation managers. and comparing the capabilities of ITI functional systems and technologies to those needs. The better the match between needs and capabilities, the more applicable the functional system or technology is.

The PTI survey of local transportation managers can provide some insight into the needs of the transportation managers. It asked them to note which of a set list of problems they experience in their jurisdiction.' It did not ask the managers to rank the seriousness of the problems. Another point to note is that the survey did not segregate managers by their responsibilities. The question was answered from the perspective of the jurisdiction, not transit managers, traffic engineers, etc.

For cities with populations over 1,000,000, the two most commonly cited problems were neighborhood traffic control (70%) and speeding (70%). For cities with populations between 500.000 and 1,000,000, the two most commonly cited were rush hour traffic (89%) and air pollution (67%). For cities smaller than 500,000, the two most commonly cited problems were speeding (65%) and rush hour traffic (55%).

---

9 Stolen cars. transit security. neighborhood traffic control, traffic in residential neighborhoods, air pollution. noise pollution, rush hour traffic. parkin,g traffic signal coordination. lack of enforcement of traffic laws, adherence to transit schedules. personal safety of drivers. speeding. lack of weigh station. car jacking, toll backups, emergency response. dangerous intersections. lack of information on travel conditions. fleet management, and transportation liability

Following is a summary of responses for some of the issues that could be addressed by ITI technologies. The tables contain the percentages of managers reporting problems, broken down by population and place in the metropolitan area.[10] For most problems, the number of jurisdictions reporting the problem increases with population. Central cities and suburbs have more problems than independent areas. There was not a cross tabulation by population and type of jurisdiction, so it is not possible to determine if the patterns in problems are related.

Percent of areas reporting problem by population of jurisdiction

Population	Air pollution	Traffic signal coordination	Adherence to transit schedules	Toll backups	Emergency response	Lack of information on travel conditions
< 500,000	29%	44%	6%	2%	7%	17%
500,000 to 1,000,000	67	56	17	17	6	17
Over 1,000,000	40	50	20	10	20	40

Percent of areas reporting problem by place in metropolitan area

	Air pollution	Traffic signal coordination	Adherence to transit schedules	Toll backups	Emergency response	Lack of information on travel conditions
Independent	13%	23%	0	0	4%	12%
Suburban	35	46	6	4	7	22
Central	36	58	12	4	10	27

Cost

The diffusion of innovation literature indicated that innovations were more likely to be adopted if they were inexpensive. There are two ways to think about the cost of a technology: relative to competing technologies, and as a fraction of the budget of the purchasing agency. Since the cost as a fraction of the budget depends on how large the project needs to be, that issue will be addressed later under scale/divisibility.

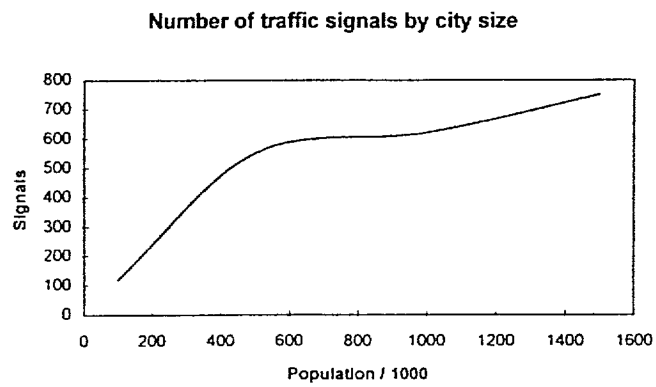
To compare the costs of competing options, the substitutes must be ranked against each other. In some cases, such as traffic signal systems or electronic toll collection, that is a fairly straightforward process. When comparing other systems, however, it becomes more complicated because there are not obvious substitutes.

[10] PTI Needs Assessment Results, question 4.

There are studies that cost out the components of ITI. As noted, in the section under "Risk", not all costs are clear at the outset, however. For instance, the full life cycle costs may not be clear until there has been some experience with operating and maintaining the system.

Scale/Divisibility

The size of a project depends to some extent on how easily it can be divided into a series of small projects. Divisibility, in turn, depends both on engineering and cost structure. If there are high fixed costs in order to get any benefit, followed by low costs to expand the system, the hurdle is in deciding to implement the system, not in expanding an existing system. ATMS may fall in this category because the control center would be expensive, but once it is in place, additional detection devices would be relatively inexpensive.



If there are low fixed costs in order to start deployment, but for engineering reasons the system won't yield significant benefits until a large portion is deployed, the actual fixed cost for a functioning system may be higher than it appears. For instance, a traffic signal control system would probably have relatively constant costs per traffic signal added to the system, but wouldn't show much benefit below some threshold size. Larger cities, in general, have more traffic signals, but not proportionate to size. The chart illustrates the results of an ITE survey that asked about the number of traffic signals.[11] As a result of this pattern, as a city gets larger, the cost of its signal system rises, but not as fast as its population. The larger population generates more traffic per traffic light, which makes it more important for the system to work efficiently. So there is probably a threshold of population, below which an advanced system is not a cost effective solution to traffic problems. On the relatively flat part of the curve, the advanced system becomes more cost effective as the population grows.

Risk

There are risks on both the cost and benefit sides of the decision to adopt or not adopt a new technology. For certain technologies, there has not been enough experience to predict how much it would cost to install, operate, or maintain. Installation costs can be determined by requesting bids, but operation and maintenance costs of a system may take longer to become apparent. The ITE survey asked engineers to estimate operating and maintenance costs for a sample freeway advanced traffic management system, consisting of a control center, variable/changeable message signs (VMS), television surveillance cameras, highway advisory radio transmitters, emergency crossovers, detectors, metered ramps, highway service patrols, and accident

---

[11] ITE Survey Results, p. 11.

investigation sites. The engineers responding estimated that annual operation costs for the control center ranged from $20,000 to $500,000. and estimated operation costs for the VMS from $3000 to $400,000. The engineers were fairly certain about operation costs for detectors, ramp meters, and CCTV. Similar patterns were found for maintenance costs. They could estimate costs reliably for technologies with which they had worked previously, but not for unfamiliar components of the system.

The other risk on the cost side of the equation is exposure to liability. The DOT 1994 report to Congress on nontechnical constraints and barriers concludes that liability risks do not present a significant barrier to implementation of ITI. The type of risks that public agencies face do not change from those faced under the current technologies, and can be controlled through sound engineering techniques. Pivnik, in a white paper for ITE, also notes the importance for risk management of developing and maintaining the expertise necessary for operation and maintenance of systems.

On the benefit side, uncertainty about performance of the system could also be perceived as risk. In addition to questions about whether normal operations of the system would meet expectations, reliability. and down time could also cause concerns.

Both institutions and individual professionals would be concerned with these issues. At the institutional level, the a bad investment could lead to bad publicity and increased expenses. At the individual level, a risky recommendation to adopt a technology could lead to career problems.

Complexity

Complexity has several facets. Individual technologies can be straightforward or complicated. Making connections between technologies can be easy or difficult. Systems can be simple or complex. Systems can involve only one agency or require coordination among many.

Individual technologies can appear complex when they are unfamiliar and require knowledge different from that needed to install or operate the current technology. ITI technologies require more knowledge of electronic and mechanical engineering and telecommunications than is standard in a university civil engineering curriculum. Engineers with these other backgrounds do not learn enough basic traffic engineering to effectively address transportation problems.‘?

Simple systems have few elements and few feedback loops. A stand alone technology, with no interactions with other elements is the simplest. An example of an advanced technology that fits this description is electronic toll collection. One of the next simplest types of systems is where there are interactions, but they go only one way. For instance, in a freeway management system, there are sensors, a control center, and traffic management tools. such as variable message signs. The information from the sensors are fed to the control center, where actions are taken that

12 Dudek. p. 30.

control the management tools. Depending on the exact technology, the control center can affect the function of the sensors (change camera angle. etc.). but for the most part. the interaction is one way down the chain.

The most complex type of system found in ITI is one in which many or all components within the system interact with each other. For instance, an integrated traffic signal control system is concerned with the interactions among traffic lights. The scale of a system can affect its complexity. Since there are more interactions than there are lights, counting the number of signals will underestimate the complexity of the system. Adding one signal to the system will add more than one interaction. The larger the system, the more potential interactions per additional signal.

Increasing the number of agencies involved increases the complexity of implementing the innovation. There are a number of ways in which agencies can be involved. A survey by ITE showed a range of local agency involvement in various aspects of ATMS, which is primarily run at the state level. According to the data from ITE, the degree of interactions among agencies for the different technologies indicates that in many cases, electronic toil collection is institutionally the least complex, while incident management is the most.

Local Agency Involvement in ATMS[13]

	Little or no involvement	Review and provide input to others	Integrate with local signal system	Major responsibility for implementation, operation, and maintenance
Freeway Control Systems	70%	7%	15%	7%
Ramp Metering	70	8	16	6
Electronic Toll Collection	90	4	4	1
Incident Management	35	17	32	17

Acceptability to Workers

In general, innovations that involve the fewest changes will be most acceptable to workers. Traffic signal control systems involve learning more about computer technologies than has been necessary with current systems. Electronic toll collection could lead to job losses. Incident management systems require more coordination across agencies.

13 ITE Survey Results, p. 14

Summary

The preceding section summarized ITI deployment information available from other field studies and organized the data according to a series of questions that define a marketing research framework for innovative products. The objective of this undertaking was to learn how much is known about underlying factors determining the rate of ITI adoption among transportation agencies. If appropriate information were available in response to each of the marketing research questions, it would be possible to construct a national ITI diffusion model that could effectively predict when and why transportation agencies would and wouldn't deploy ITS. From such information, it is possible to develop targeted outreach, training, and deployment guidance that can increase the rate of ITI adoption.

Of the framework of marketing research questions, the only question which the current research could address is "What does the customer buy?". The ORNL inventory could be matched with information available from the Census Bureau to provide data describing IT1 deployment in major metropolitan areas by general categories of types of government customers. A similar exercise could be performed with the Volpe Center APTS listing, giving more information on smaller places. When matched with survey information describing motivation and behavior, the correlation of actual ITI deployment data with demographic attributes would provide researchers with a basis to predict to what extent the demographic attributes can predict deployment decisions.

None of the ITI deployment questions addressed by the other studies have been researched in a manner that would allow them to be analyzed systematically, in conjunction with demographic and other attribute data on the jurisdictions. Case studies provide some insights into why and how certain technologies are being bought. broken down by level of government and location within a metropolitan area, but not by other characteristics, such as size of budget, climate, and population. The surveys provide some suggestive data related to the applicability of IT1 technologies, but the responses are only correlated to city size and location within a metropolitan area. What information is available to address the remainder of the questions discussed in this paper is not comprehensive and could not be correlated with any demographic information.

With a better understanding of the transportation agency market for ITI. outreach and training by the Department can be targeted to increase the rate of ITI deployment. The insights provided by existing ITI deployment studies can be used as a starting point for the case studies and survey in this research.

NEXT RESEARCH STEPS

The research approach described below has been chosen with two goals in mind:

- It will provide in-depth knowledge about adoption of innovations by transportation agencies relevant to deployment of ITI, and

- It will be generalizable to the entire population of transportation agencies.

These twin goals will be met by a research approach combining a small number of detailed case studies with large cross-sectional data gathering. The case studies will uncover and document the variety of factors influencing ITI deployment; this information will then form the basis of a carefully constructed, well-focused national survey of a large number of transportation agencies. It is expected that the entire study will require nine to twelve months.

Case Studies

A case study is an excellent tool for investigation of complex decision-making within an organizational context. Case studies of organizational decisions can be structured to collect information from multiple sources. The number of case studies to be conducted should be large enough to provide findings that transcend individual agency idiosyncracies, but small enough to be completed with reasonable time and budget constraints. A total of between 10 and 15 cases should be sufficient for this purpose.

In the interest of preserving time and funds, and building upon existing information, several (perhaps as many as half) of the sites to be selected as case studies shall be sites that have been investigated recently. This will enable the case study team to capitalize on existing knowledge and background information, and focus quickly on the specific study questions and the respondents best qualified to answer them.

It will not be necessary to wait for the outcome of the national survey for useful data. Results from the case studies will provide the ongoing USDOT ITI deployment effort with in-depth insight into local and state motivation and resistance.

National Survey

Building from the findings of the case studies. a national survey of public transportation agencies will be fielded to quantify relationships between regional deployment of ITI and attributes of the region and its transportation agencies, such as climate, size, location in relation to metropolitan center, and modality. The survey will include a broad cross-section of agencies so that survey results will be applicable to the full array of diverse transportation agencies that comprise the ITI market To obtain statistically reliable results, several hundred agencies will need to be included in the survey. Complete results from the national survey should be analyzed and available by February, 1997.

Sources

A Report to Congress: Nontechnical Constraints and Barriers to Implementation of Intelligent Vehicle-Highway Systems. Department of Transportation. June 1994.

Advanced Public Transportation Systems: APTS Deployment in the U.S.: Preliminary Draft. Volpe Center, January 1996.

DeBlasio, Allan; David Jackson and Anne McEwan, "Assessment of ITS Deployment Review of Metropolitan Areas," slides from a Volpe Center presentation November 13, 1995.

Dudek, Conrad L. "White Paper 2: Education, Training and Technology Transfer," Urban Traffic Engineering Issues and Answers: Operation and Maintenance of Electronic Traffic Control Systems Final Report. Institute of Transportation Engineers. June 1995.

Ettlie, John E. and David B. Vellenga. "The Adoption Time Period for Some Transportation Innovations". Manarement Science, Vol 25, No. 5, May 1979.

Fact Sheet: Deployment of Advanced Traffic Management Systems in the U.S. by State Agencies. ITS America. World Wide Web Page at http://www.itsa.org/facts/factdepl.html October 23, 1995.

Gordon, Steve, "Intelligent Transportation Infrastructure Deployment," World Wide Web page at http://gordon.prg.utk.edu.

Harrison. Francis D.; Ann Weeks and Carol Walb. Evaluation of the Public Transportation Network: Diffusion of Innovative Transit Practices. UMTA-MA-06-0049-87-2. Urban Mass Transportation Administration. August 1988.

Hebner, Paul and Sean Simon. Intelligent Vehicle Highway Systems U.S. Markets, Technologies & Opportunities-- 1993 - 2000 Analysis. Allied Business Intelligence. Inc. 1994.

JHK & Associates. Integrating Intelligent Transportation Systems into the Transportation Planning Process: An Overview of Issues, Barriers. and Problems, Technical Memorandum No. 2 (Task B Final Report) Prepared for Federal Highway Administration Office of Traffic Management and Intelligent Transportation Systems. November 1995.

Kinnear, Thomas C. and James R. Taylor. Marketing Research: An Applied Approach. McGraw-Hill Book Company, New York. 1987.

Lappin, Jane E.; Paula Figoni; and Suzanne Sloan. A Primer on Consumer Marketing Research: Procedures, Methods, and Tools. John A. Volpe National Transportation Systems Center. March 1994.

Leung. Stephen K. and Albert Yee. "Organizational Structure", Urban Traffic Engineering Issues and Answers: Operation and Maintenance of Electronic Traffic Control Systems Final Report. Institute of Transportation Engineers. June 1995.

Pivnik, Sheldon I. "Legal Aspects of Traffic Control System and Its Maintenance," Urban Traffic Engineering Issues and Answers: Operation and Maintenance of Electronic Traffic Control Systems Final Report. Institute of Transportation Engineers. June 1995.

Public Technology, Inc. Intelligent Transportation Systems (ITS) Needs Assessment Results. Fall, 1995.

Public Technology, Inc. Traveling with Success: How Local Governments Use Intelligent Transportation Systems. 1995.

Robey, Daniel and M. M. Bakr. Factors Influencing the Adoption of Management Innovations in the CTA. Urban Transportation Program, Marquette University. July 1976.

Stoppenhagen, Gloria R. Fact Sheet: Transit Automated Vehicle Locator Systems in the U.S. and Canada. ITS America. World Wide Web Page at http://www.itsa.org/facts/facttran.html. October 23, 1995.

Technology Transfer: A Strategy for Innovation Adoption at the Washington State Department of Transportation. WA-RD 97.1 Final Report. Washington State Department of Transportation. December 1986.

Zimmerman. Carol A. ITS User Acceptance Research -- Transportation Managers Proposal for Research. Unpublished draft, March 8, 1995

TABLE: Summary of Current ITS Deployment Studios

Source	Scope		Method	Contribution	Limitations
	Topics	Agencies covered			
Volpe Deployment Case Studies	Deployment issues related to all ITS functional systems and technologies	State and local governments in 7 metropolitan areas with popularions ranging from about one lo three million. Cities were selected based on several criteria: large enough to use all systems, distributed across FH WA regions, and covering a range of organizational and other characteristics.	Case studies, quantified deployment and qualitative perceptions	High level insights into motivations for deployment, planning processes, and barriers	Questions were very general, and not targeted to marketing research needs. Metro areas represented excluded smaller cities, which have lower levels of deployment.
ORNL National Survey of Deployments	Technologies associated with freeway operation, transit operators, traffic signal systems, incident management, and electronic toll collection	All governments in the 75 largest standard metropolitan statistical areas (population of the SMSA approximately 250,000 and greater)	Survey of governments: census of deployment	Specific, quantified inventory of the deployment of ITS functional systems and technologies	Not yet completed or verified. No information on motivations or perceptions

ITE member survey and white papers	Operations and maintenance issues associated with ATMS and FMS	1000 surveys mailed I I7 returned (85 cities 22 counties. 10 states) A large fraction of responses were from agencies outside of the 75 largest metropolitan areas	Survey of traffic engineering agencies quantitative measures of deployment. qualitative information on attitudes about problems, training, operation and maintenance	Baseline information presented from the perspective of the people who design and operate the systems	Small number of responses (possibility of response bias), not targeted to metropolitan areas of interest, very narrow questions not necessarily relevant 10 marketing research, summarized in a manner that prevents some interesting comparisons
JHK	Issues and barriers related to successful ITS planning and deployment, organized under the headings of organizational, leadership and management, personnel and facilities resources, technological, impacts and benefits, legal and regulatory, and financial barriers	46 to 50 EDP lead agencies	Literature review, Interviews with staff at FH WA, slates, MPOs and local governments	General ratings of breadth, impact, and potential for resolution of a wide range of issues related to ITI planning and deployment	No data included backing up assertions

ITS Technologies in Public Transit: Deployment & Benefits	Extent of deployment or desire for deployment, and definition of benefits for AVL/CAD, Smart Cards, Automatic Passenger Counters, Automatic Annunciation, Passenger Information Systems, and Adaptive Signal Control. Bus fleets only.	18 transit agencies having fleets of 800 buses or more, and 17 agencies having approximately 200 vehicles or less, selected from a list of the 100 largest transit bus fleet operators in the United States and Canada. The smaller agencies are not necessarily in the 75 largest metropolitan areas. Three of the large systems are Canadian.	Telephone survey of transit agencies. mostly qualitative information	A variety of anecdotes and insights into the benefits of implementing ITS for bus systems	Small sample, not necessarily representative of the Industry, limited information about reasons why systems were not adopted
Preliminary Draft Volpe APTS Deployment study being performed for FTA	Deployment of 15 ITS functional systems by agency, including number of vehicles and service type. All types of transit: fixed route, demand response, rapid rail, light rail, and commuter rail	464 transit agencies that have deployed ITS	Survey of transit agencies, Section 15 data: quantitative information, but data on functional systems limited to presence or absence, not extent	Listing of APTS functional systems used by agencies across all sizes of cities	Preliminary, unverified data No summarization or analysis. No information on systems that do not use APTS.
PTI Survey	Deployment and planned deployment of ITS functional systems, context, and obstacles	No summary statistics provided on how many governments received surveys and how many responded. At least 440 governments responded. No information on locations of the respondents. Not all governments answered all questions.	Survey of local government managers: factual and attitudinal questions	Topics of questions closely related to information needed for marketing research	Survey poorly designed and summarized, not credible, and no way to draw conclusions

PTI Focus Groups	General priorities, knowledge of ITS, evaluation of the core infrastructure, sources of information, extent of cooperation and collaboration with other governments and the private sector	Focus group 1. l7 from the eastern US; Focus group 2: 8 from the central US (two from Chicago) Focus group 3: 10 from all over the country	Three focus groups of local elected and appointed officials: opinion	Insights into attitudes of elected officials	Small sample
ITS America inventory	Electronic toll collection systems in the United States, ATMS deployment by state agencies, and transit AVL systems in the U.S. and Canada	35 toll agencies, 23 ATMS, 46 AVL system procurements	Compilation of information from news releases, reports, and personal contacts: inconsistent mix of quantitative and qualitative information	Cross section listing of deployment of functional systems or technologies	Unrepresentative, information available varies by deploying agency, no summarization or analysis