

**USE OF ADVANCED TRAVELER INFORMATION SYSTEMS
TO MINIMIZE SINGLE-OCCUPANT DRIVING**

by

Jeffery L. Ottesen

Professional Mentor

Don Capelle

Parsons Brinkerhoff Quade & Douglas

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Department of Civil Engineering
Texas A&M University
College Station, Texas

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SUMMARY

Americans have developed an affection for the automobile. Automobile users enjoy freedom to come and go when and where they want, and to travel how fast they desire while savoring the privacy of their own space. The convenient use of the automobile, however, is also a primary cause of critical traffic congestion problems.

Several strategies exist to reduce traffic congestion and minimize the negative effects thereof. Three strategies are thoroughly discussed: 1) Making Multi-Occupancy Modes Competitive with the Automobile, 2) Travel Demand Management (TDM), and 3) Intelligent Vehicle-Highway Systems.

Multi-occupancy transportation modes are made competitive with the automobile by first identifying those qualities that public and plural (carpooling, vanpooling, and rideshare programs) transportation must possess to attract ridership, and then molding the alternative mode of travel to the individual. Research suggests that the individual also possesses characteristics that make a particular transportation mode attractive. Thus, emphasis should also focus on strengthening the link between the travelers' attributes and multi-occupancy modes.

Travel Demand Management (TDM) can effectively reduce negative impacts on the environment, minimize use of the automobile, shorten trip travel times, and reduce costs associated with transportation. Efforts to quantitatively measure the effectiveness of TDM programs have resulted in the development of a new measure: Number of Vehicle Trips per 100 Travelers. This value measures the number of vehicle trips not taken by an automobile to support the person movement of a population. This single measure of effectiveness (MOE) is derived by including many other MOEs for various objectives, and captures the essence of TDM--minimizing automobile use. Not all tactics within TDM minimize automobile usage, however; optimized traffic flow is another objective of TDM.

Many of the objectives established by TDM are shared by Intelligent Vehicle-Highway Systems (IVHS). A comparison of both programs reveals, however, that IVHS contains two functional components that compete with one another. Advanced Traveler Information Systems' (ATIS) primary objective is to increase system (traffic) flow. This objective is accomplished by providing drivers real-time information regarding traffic conditions during their trips, such that drivers can choose a route that most quickly and conveniently gets them to their final destination. This added information actually stimulates single-occupant driving. On the other hand, Advanced Public Transportation Systems (APTS) promote maximum multi-occupancy mode travel. The primary objective here is to minimize automobile use overall, rather than just spread the traffic demand out over space and time. Therefore, a form of merger is required between ATIS and APTS to eliminate the conflict within IVHS, and ultimately promote the fundamental purpose of TDM.

Evaluation of all three strategies suggests that one ubiquitous objective could relieve congestion on a long-term basis: **minimize single-occupant driving**. This objective

encompasses desires of the three strategies to promote use of multi-occupancy transportation modes, minimize automobile use, and reduce congestion.

The advent of ATIS provides an excellent opportunity to minimize single-occupant driving. Prototype examples of existing ATIS, however, only promote further dependence upon the automobile. This dissent can be corrected through implementation of a few innovative actions:

Incentive Savings Program

A national surplus fund is needed to finance an incentive savings program. Generation of the fund requires cooperation between both private and government agencies. Theory behind the program offers savings on the purchase of transportation goods and services (e.g., gasoline, auto-maintenance, public transportation passes, etc.) to those people who use multi-occupancy modes of transportation.

Records are kept through the use of "Smart" cards. (Presently, smart cards function as an effective tool for APTS.) The cards would be issued individually to everyone in the community. The cards act as an information storage bank, and may also be used to ride transit and cover parking charges.

Each commuter is allotted a fixed number of drive-alone miles per week based upon their location of work and residence. Mileage is deducted for each trip taken as a single-occupant driver. Mileage amounts are retained (at different rates) if an alternative, multi-occupancy transportation mode is used.

The ATIS serves as the trip mileage record-keeper, and also provides information to drivers regarding carpooling opportunities during the commute.

Personalize Information to Promote Multi-Occupancy Travel

Information can be "tailored" to a particular audience and made available to the driver through the on-board ATIS. The system would operate normally, but also provide additional information that promotes multi-occupancy mode travel. The information given would be directed to the driver and be presented in a way that is relevant only to that individual. This information would also trigger parallel thought processing within the motorist's mind. In this way, the public would begin thinking about using alternative modes of transportation. Over time, motorists may choose to use a multi-occupancy mode of travel because of the real-time information given to them about their individual driving situations.

Parking Demand Pricing

ATIS can also be used to track dynamic pricing of (downtown) parking. Based upon parking demand, charges for parking could vary per every five minutes, for example. Guaranteed reserved parking for carpools, vanpools, and ridesharers at a fixed rate would be provided. Reductions in VMT by partial-trip mode diversions are possible.

ATIS as a Marketing Tool

Marketing techniques similar to those used on television may have future application in ATIS. Advertisements promoting rideshare programs and multi-occupancy transportation modes could be done by national sports stars or popular public figures, and displayed through ATIS.

IVHS must not be perceived as "THE" solution, or even "A" solution to today's congestion problems. IVHS is merely an integral part of a fully functional travel management program. Only when all elements of this program, including each individual citizen, are working together to achieve an established vision, will the environmental impacts lessen, traffic flow more freely, and economic productivity increase.

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INTRODUCTION

America's transportation programs have entered the 21st century. Most of the national interstate system is complete, yet congestion continues to rise. The era of building our way out of congestion is no longer feasible. Robert Farris, a former FHWA Administrator states (1): "We can no longer completely build our way out of the congestion crisis . . . Time is too short, money is too scarce, and land is often not available." The focus now is to increase mobility, protect the environment, improve safety, and maximize use of existing transportation facilities.

Federal legislation supports these objectives. The 1990 Clean Air Act Amendment requires that National Ambient Air Quality Standards for ozone and carbon monoxide be met. This law could mandate that non-attainment areas reduce vehicle-miles travelled.

Other efforts also attempt to reduce vehicle emissions and vehicle-miles travelled. Transportation control measures (TCMs) utilize management of system capacity (transportation system management) and travel demand (travel demand management) to reduce congestion through public transportation and various forms of rideshare programs. Intelligent Vehicle and Highway Systems (IVHS) are presently being designed to optimize traffic flow.

Advanced Traveler Information Systems, a fundamental component of IVHS, can help minimize use of the automobile by using real-time information. Real-time information can also be used to promote multi-occupancy travel mode usage. This report will show how Advanced Traveler Information Systems can use real-time information to deter single-occupant driving.

The paper begins by identifying a primary source of traffic congestion problems: Americans' affection for the automobile. Then, three commonly used strategies designed to reduce congestion are presented: 1) making multi-occupancy transportation modes competitive with the auto, 2) TDM, and 3) IVHS technology. Evaluation of these strategies reveals that alleviating congestion might best be accomplished by minimizing use of the automobile, rather than optimizing traffic flow, and that the two terms are not necessarily synonymous. Several innovative ideas are then presented that focus on minimizing auto usage. The report concludes by offering several recommendations that focus on deterring single-occupant driving for future consideration

AMERICANS' AFFECTION FOR THE AUTOMOBILE

Use of public transportation (bus, streetcar, rail) has been on the decline since the late 1940s (2). Plural transportation (carpool, vanpool, and rideshare) is also on the downfall. In 1985¹, over 74 percent of all work trips were driven alone (3). This value is 5 percentage points higher than drive-alone work trips for 1980. Transportation officials believe that this increase in single-occupant trips came from rideshare programs (3).

Table 1 provides an aggregate profile of trip making in metropolitan America (4). The study was completed in 1986, so these results apply comparably to our day. For both home-to-work trips and all trips taken, at least 54 percent are made by single-occupant drivers. Outside of the metropolitan areas where housing densities are low and distances between business centers are greater, dependence on the automobile is stronger still.

Table 1. Aggregate Profile of Trip Making
in Metropolitan America (4).

Mode of Trip Making	Share of All Trips	Share of Home-to-Work Trips
By auto and van drivers [drive-alone]	54.3%	74.5%
By auto and van passengers	27.0%	11.7%
By public transportation	2.9%	6.2%
By walking, motorcycle, bicycle, other means	5.8%	7.6%

Furthermore, vehicle occupancies have declined approximately 21 percent over the past 4 years (5). Thus, Americans' affection for the auto grows stronger even today.

In order to deter single-occupant automobile use, one must first understand why so many choose it as their primary mode of transportation. Several studies have addressed this issue. One particular study of commuter attitudes conducted at the University of Minnesota compiled the following list of the 10 top factors favoring the auto (6):

- Reliability,
- Able to leave when you desire,
- Shortest door-to-door time,
- Able to stop when you wish,

¹Transportation data from the 1990 census is not available until 1994.

- Weather protection,
- Adequate space to carry items,
- Transfer not needed,
- Independence,
- Clean vehicle, and
- Able to travel at own speed.

It is important to note that the list given above is not in rank order. Each factor is important, and to differing degrees at various times of the day, week, or year. People are simply not consistent; different needs apply to different trips. Automobile users enjoy freedom to come and go when and where they want, and how fast they desire to travel while savoring the privacy of their own space.

Just as the private automobile offers several amenities favorable to human travel, motorists themselves possess different characteristics which make them compatible with the private automobile. A research project completed by the Washington State Transportation Center (TRAC) studied commuter behavior and information needs relevant to the design and development of a motorist information system for the Seattle area (7). TRAC found that commuters (sample size 3893) could not be classified as a single, homogeneous audience, but rather could be divided into four subgroup classifications. The subgroups are labeled: 1) route changers (RC), willing to change routes before or during their commute but unwilling to change departure time or transportation mode (20.6%), 2) non-changers (NC), unwilling to change departure time, route, or transportation mode (23.4%), 3) route and time changers (RTC), willing to change route and departure time, but not transportation mode (40.%) and 4) pre-trip changers (PC), those unwilling to change route while driving, but willing to change time, route, or even mode prior to leaving their residence (5.9%). Table 2 summarizes these classifications.

Table 2. Seattle Commuter Classifications (7).

Willing to Change...		RC (20.6%)	NC (23.4%)	RTC (40.%)	PC (15.9%)	% Yes
Route	Before	Yes	No	Yes	Yes	76.6
	During	Yes	No	Yes	No	60.7
Departure Time		No	No	Yes	Yes	56.0
Travel Mode		No	No	No	Yes	15.9

The intent of the Seattle study was to identify what kind of information could be used in an ATIS system to improve system flow. Their results indicated that they could target any one subgroup, provide them real-time information that would cause the commuter to alter his travel plans, and significantly improve traffic system flow.

As shown in Table 2, only 15.9 percent of the commuters were willing to change travel mode. This result most often is interpreted as the greatest stumbling block for multi-occupancy transportation modes (and sadly, ridership reflects this translation).

As will be shown later, ATIS can turn this perspective around. What better place is there to target single-occupant drivers and market use of multi-occupancy transportation modes other than in the privacy of each commuters' vehicle?

STRATEGIES DESIGNED TO REDUCE CONGESTION

Increasing usage of the private automobile has led to many of the congestion problems found today. Many efforts have attempted to remedy the auto's effect on mobility by developing strategies that are designed to reduce congestion. Three of the most commonly used strategies are discussed below: 1) making multi-occupancy modes competitive with the automobile, 2) travel demand management, and 3) intelligent vehicle-highway systems.

Making Multi-Occupancy Modes Competitive with the Automobile

Multi-occupancy modes of transportation face a very formidable challenge in competing with the private automobile. Numerous studies have attempted to identify those factors necessary for alternative modes (particularly transit) to increase their use, i.e., draw the single-occupant driver away from the auto. One author, albeit reluctant to admit, found an unfavorable acronym to describe the results of many of these studies: **SCARCE** (6). **SCARCE** stands for:

Safety--	in terms of accidents, passenger safety from theft and physical violence, and vandalism;
Comfort--	including ride quality, adequate environmental controls, aesthetics of facilities, and noise and exhaust emission rates;
Accessibility--	includes adequacy of route distribution, service frequency, and ease of use;
Reliability--	relates to breakdown rates, availability of other services, and guarantee of a fixed arrival;
Cost--	means reasonable fares, and set comparably (preferably less) to the cost associated with the same trip if made with an automobile;
Efficiency--	includes high average speeds with minimum delays and dwell times.

The presence (and absence) of each of these factors affects a person's transportation mode choice.

Research has also been done to determine the factors that influence an individual's propensity to carpool or vanpool (8). Results indicate that location of child care centers, travel times, cost, availability of an automobile (in event of emergency), and parking situations all affect the commuters' decisions. Groups unlikely to rideshare include

individuals working at small, isolated firms, people with irregular work hours or fluctuating schedules, and those who use their cars during the day.

Like drive-alone commuters, plural and public transportation users possess particular characteristics as well. They too cannot be categorized into one homogenous audience, but rather into one of two categories (6):

Users

Captive Users: ride transit because they have no alternative mode of transportation;

Choice Users: choose transit over an alternative mode because of cost, convenience, preference, etc.

Commuters who do not choose multi-occupancy travel modes are classified into two categories also:

Non-Users

Choice Non-Users: choose not to ride transit for whatever personal reason; and

Forced Non-Users: require use of their automobile for work (e.g., utility worker, carpenter, realtor).

From these classifications and those identified in the Seattle study, it is clear that regardless of what is done to the transportation mode or its user, some people require (forced non-users) or demand the individual use of an automobile. Forced non-users have no other option than to drive alone. Choice non-users, however, serve as an enormous market for promoting multi-occupancy mode use. A key then, is to provide this target audience reasons not to drive alone. From the Seattle study, this audience represents over 84 percent of the entire single-occupant commuting population.

A comparative look at the factors required for multi-occupancy transportation with those listed for automobile preference indicates that the lists are very similar. This similarity offers insights to how characteristics of multi-occupancy transportation modes and their users may be made perceptually equivalent to the automobile.

Much of past effort in promoting multi-occupancy mode use involves molding that alternative mode to the commuter. In effect, multi-occupancy modes seek to capture the individual, whose eyes and personalities remain fixed on the private automobile, by trying to match the attributes possessed by the auto. A major flaw in this approach is that the attributes of the commuter are not completely addressed. Figure 1 illustrates this point. In the top of the figure, both the private automobile and the commuter possess attributes which bring them together. The union is strong because of the dual compatibility between both elements. The bond between multi-occupancy modes and the commuter, however, is not as strong. Here, the multi-occupancy mode attempts to conform to the commuter, but the commuter's characteristics do not combine as directly with those of multi-occupancy

modes. Consequently, use of multi-occupancy transportation modes is less than use of the private automobile.

Thus, there are two primary elements involved in a commuter's chosen mode of travel: 1) the attributes of the travel mode, and 2) the attributes of the commuter. The greater the similarity between the two elements, the greater the use of that travel mode. The TRAC Seattle study supports this observation. Recall that only 5.9 percent of all commuters surveyed were willing to change their mode of travel. Overall, the characteristics of the commuters were better matched with the traits possessed by the automobile, hence commuters preferred to drive alone. In this case, one might expect only minor reductions in drive-alone commutes with even massive improvements (e.g., reduced fares, increased service, upgrading facilities and vehicles) made to the alternative modes of travel. Unfortunately, this appears to be the case nationwide, particularly with rail transit (9) and to some extent bus services (10).

Figure 1 is also applicable for single-occupant drivers, not just commuters. The term "commuter" was used because of the implication of frequently taken, similar trips. Trips taken by single-occupant drivers may also be served by multi-occupancy modes, but perhaps not as frequently as commuter trips.

The focus now should be to strengthen the bond between the commuter's attributes and multi-occupancy modes. In other words, find a way to cause the commuter to turn to multi-occupancy travel modes as a chosen alternative over the automobile. As will be shown later, ATIS provide an excellent opportunity to inform the single-occupant driver (the largest audience of all commute and metropolitan trips) of alternative travel modes and the consequences of choosing them. Use of this information may actually stimulate drivers to minimize use of their automobiles.

Travel Demand Management

TDM is a significant part of a transportation control measure (TCM) plan (See Figure 2). TCMs attempt to manage both a transportation system's supply (capacity, e.g., the physical network of streets and highways) and demand (requirement, e.g., the number of vehicles desiring to use the system supply) to achieve increased mobility, reduced congestion, and lessened pollution effects on the environment. Travel demand management, therefore, focuses on reducing the traffic requirement on the transportation system.

According to Orski, [travel] "demand management can best be described as a set of actions aimed at decreasing the volume of traffic and vehicle miles of travel (VMT) by influencing the manner in which people travel to work" (12). He goes on to list three

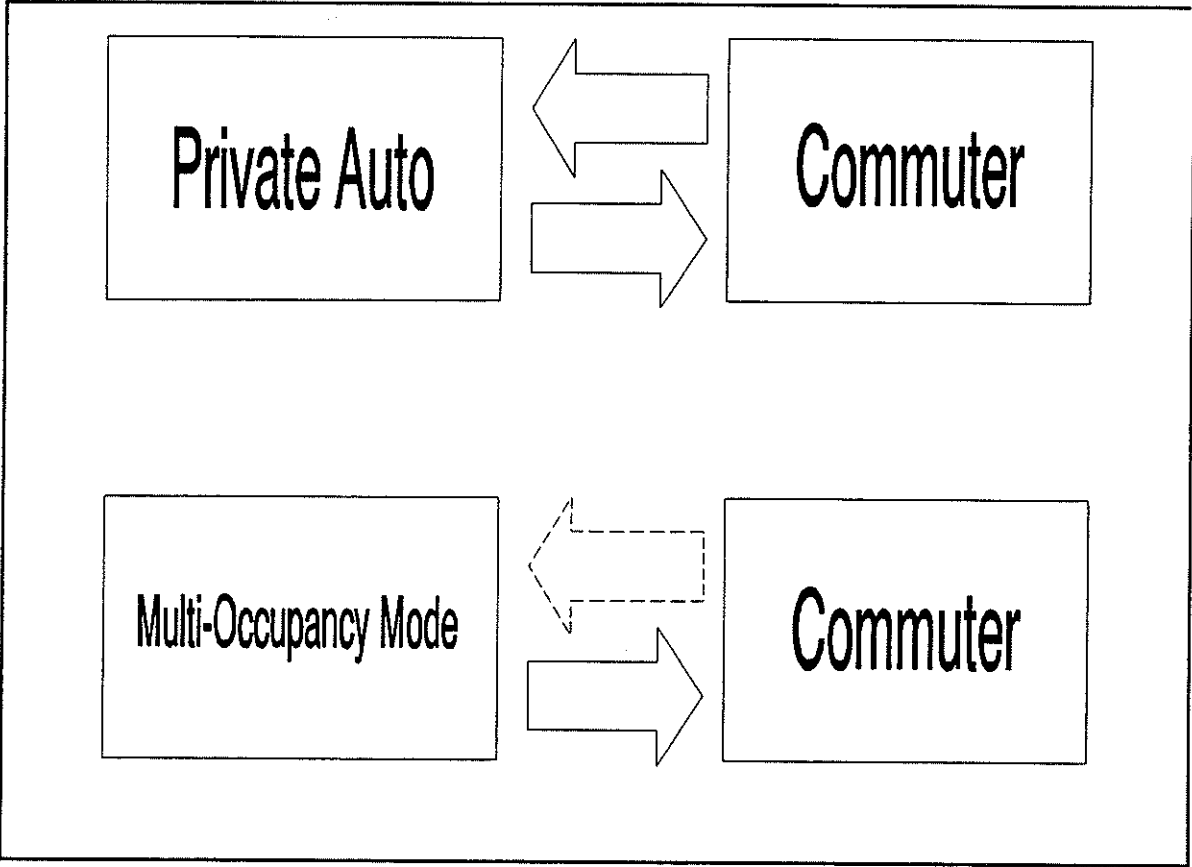


Figure 1. Commuter Relationships with the Private Auto and Multi-Occupancy Modes.

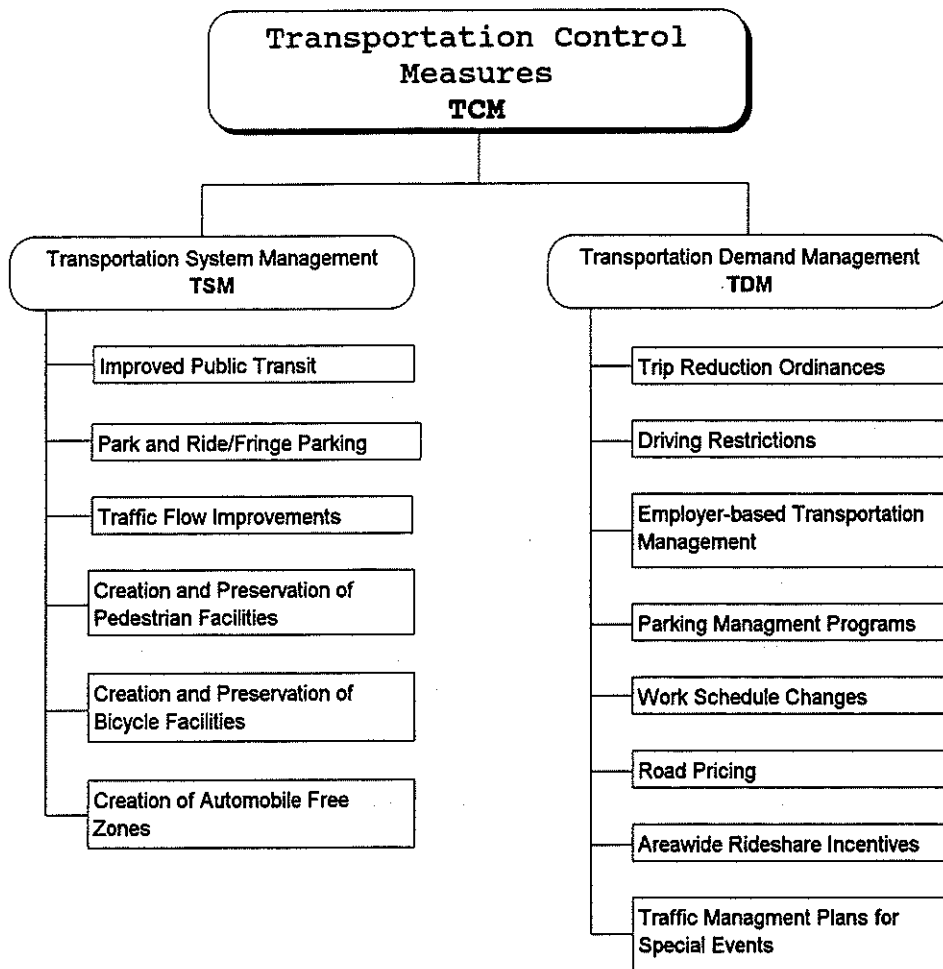


Figure 2. Transportation Control Measures (11).

components of an effective demand management effort. Specifically, this endeavor should: (1) offer a wide choice of travel alternatives so that commuters can choose an option that best meets their needs; (2) provide incentives [and disincentives] to use those alternatives; and (3) secure broad private sector support and participation in demand management programs.

Travel demand management, then, is a process which also includes "both the transportation actions which affect the travel time, cost and other considerations that shape travel behavior, as well as a specialized way of implementing these actions, through often innovative legal and institutional approaches" (13). Presently, hundreds of programs of different forms attempt to promote TDM. Figure 3 identifies some of the actions available. Focus of the comprehensive list given in Figure 3 should lie in understanding what each action attempts to accomplish, not how each action specifically operates.

The success of any TDM program is highly dependent upon the actions that are applied. Each geographic area is different and no single successful action or combination of actions is necessarily applicable to another area. To date, few studies have been completed which quantify the accomplishment of TDM programs. Furthermore, a single, fixed measure of effectiveness (MOE) has not been defined to measure the benefits of such programs. Given the broad definition of TDM, identifying one MOE as an attainment indicator may not be feasible.

According to the definitions of TDM given above and the list of actions shown in Figure 3, several principal objectives are perceived. TDM programs attempt to: 1) increase mobility; 2) reduce congestion; 3) lessen negative effects on the environment; 4) reduce traffic volumes; 5) decrease vehicle-miles travelled; 6) minimize travel times; and 7) keep travel costs low. Each objective given, however, requires a different MOE to quantify the benefits realized upon fulfilling the requirement. Table 3 lists example measures of effectiveness for a few of these objectives.

Again, identifying a single MOE for such an immense subject seems absurd, but given the often enormous cost and effort associated with generating data, a single measurement is in order.

Urban Mobility Corporation often uses employee surveys, focus group interviews and first-hand monitoring of TDM programs to generate a MOE they call the **Reduction in Drive-Along Commuters** (12). This value is the percentage point reduction in number of drive-alone workers during commute hours. An extensive evaluation of various demand management programs revealed that "well-conceived and aggressively promoted demand management programs, that offer a choice of travel options and provide incentives tailored closely to the preferences of the client groups, can result in a 10 to 15 percentage point shift in mode of travel, from driving-alone to ridesharing and transit". (Note that these results are comparable to those conclusions drawn in Seattle.)

COMSIS Corporation conducted a study for the Federal Highway Administration to determine the effectiveness of TDM programs (13). Eleven different organizations throughout California, Connecticut, and Washington were evaluated. Recognizing the

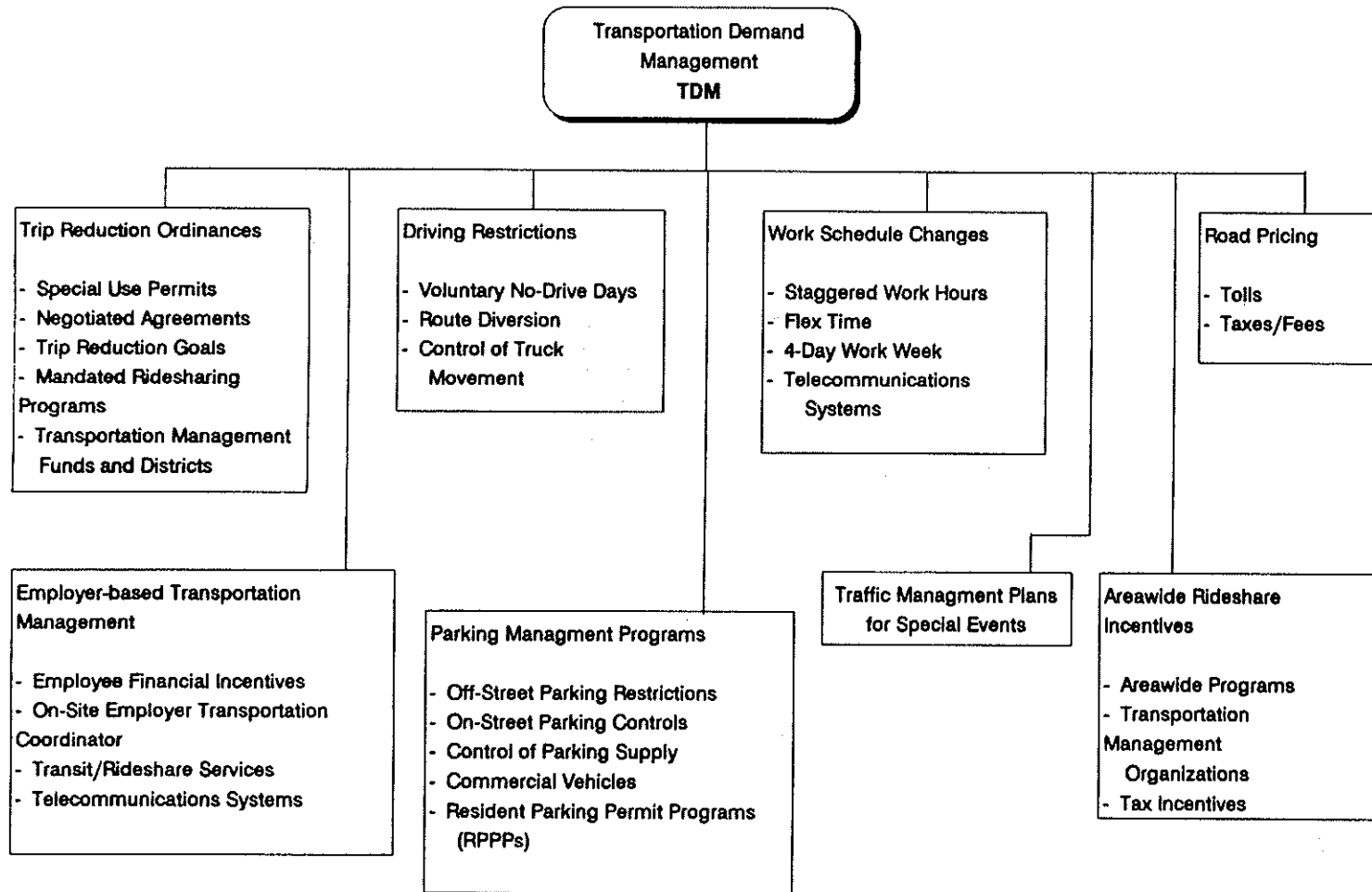


Figure 3. Transportation [Travel] Demand Management Strategies (11).

Table 3. Example Measures of Effectiveness for Various Travel Demand Management Objectives (14, 15).

Objective	Measures of Effectiveness
Lessen Environmental Impacts	<ul style="list-style-type: none"> • Air pollution emissions • Non-attainment areas for air quality standards • Maximum concentration of pollutants • Tons of emissions
Minimize Auto Usage	<ul style="list-style-type: none"> • Intersection vehicle turning movements • Number of carpools • Number of vehicles by occupancy • Person miles of travel • Person trips • Traffic volume • Vehicle miles of travel • Transit mode split
Minimize Travel Time	<ul style="list-style-type: none"> • Person hours of travel • Point-to-point travel time • Vehicle delay • Vehicle hours of travel • Vehicle stops
Minimize Travel Costs	<ul style="list-style-type: none"> • Parking cost • Point-to-point out-of-pocket costs • Transit fares

potential for response bias in survey data, COMSIS Corporation developed a special index from existing survey data²: **Number of Vehicle Trips per 100 Travelers** (trip generation index). The index represents "the rate at which vehicle trips are generated by a particular travel population". The population can be the total travelers in a corridor or activity center, or the employees in a business park. The index estimates vehicle trip generation from modal split. Evaluation sites are placed on an equivalent basis by assuming occupancy levels for each mode:

- Drive Alone = 1 vehicle trip for every person trip
- Carpool = 0.4 vehicle trips for every person trip (assumes 2.5 persons per carpool)
- Vanpool = 0.083 vehicle trips for every person trip (assumes 12 persons per vanpool)
- Transit = 0.033 vehicle trips for every person trip (assumes 30 persons per vehicle)
- Bicycle/Walking = no vehicle trips per person trip.

An index reading of 100 indicates that everyone in the travel base is driving alone. Lower indices indicate "increased efficiency through the use of high occupancy modes, and in particular, [signify] *vehicle trips not taken* to support the same level of person movement".

Another value known as the **net trip reduction** is generated from the differences in indices found before and after a TDM program is in effect. This MOE offers satisfactory results for programs which attempt to alter traveler mode choice, but must be adjusted to measure **peak hour vehicle trip generation** when dealing with work hours management.

The study substantiates three important points regarding the accomplishment of TDM programs:

- TDM can **significantly** reduce low-occupancy vehicle trip demand at a site, in a corridor, or within a subarea;
- The degree of success is directly determined by the specific components of the TDM program; and
- To inspire use of the key TDM actions, either some type of legal pressure is necessary, or the individual firm must have a readily apparent, economic self interest in adopting these measures.

Many of the MOEs listed in Table 3 are encompassed within or can be derived implicitly from the trip generation index developed by COMSIS Corporation. The index relies upon survey data, which is often labor intensive, but provides a useful means of measuring TDM program success. Perhaps then, the best single MOE in demand management involves the reduction of trips made by single-occupant vehicles. After all,

²COMSIS Corporation attempted to minimize response bias by using information from surveys where the rate of response was at least 35 percent, and by comparing survey results developed from comparable procedures applied at different points in time.

travel demand management as a whole appears to focus on alleviating Americans' fancy of the automobile, and the COMSIS Corporation MOE captures this fundamental objective in a single value. Further research and observation of TDM programs will reveal whether this index is valid for many other programs currently in effect throughout the United States.

Overall, TDM aspires to reduce congestion by one of three methods: 1) weaken the link between the automobile and the driver, 2) strengthen the link between multi-occupancy modes and the driver, or 3) spread the travel demand on the system out over space and time. The first method is seen in TDM strategies such as trip reduction ordinances, parking management programs, and road pricing. By eliminating a few of the features that make the automobile attractive to the drivers, drivers are more likely to use a multi-occupancy transportation mode. The second method uses rideshare and transit subsidies as incentives to draw travelers to alternative transportation modes. Thus, methods 1 and 2 attempt to minimize automobile use as a means of reducing congestion. The third method, however, does not attempt to minimize auto usage, but rather disperse the traffic demand out over space and time. This dispersion is accomplished through staggered work hours and route diversion plans.

Each method, when effectively functioning, does reduce congestion somewhat. An inherent problem exists, however, for spreading the demand out over time and space; eventually, the capacity of the existing roadway network is exceeded. Orski (12) identifies this problem presently by saying that,

"...the slack is gone. Most suburban road networks operate at or above design capacity, even small increases in traffic produce an immediate and dramatically disproportionate effect on congestion levels."

"In many metropolitan areas, endemic traffic congestion is no longer confined to main radial corridors, but pervades the entire highway network."

"The traditional "peaks" and "troughs" of the daily traffic count profile have been replaced by a high plateau that rises steeply in the early morning and continues throughout the day, into the evening hours."

It appears that long-lasting relief from traffic congestion can only be attained by minimizing use of the automobile, or stated another way, by stimulating use of multi-occupancy travel modes. Therefore, the single MOE developed by COMSIS Corporation does capture the "purest" objective of TDM: to minimize single-occupant automobile use.

Intelligent Vehicle-Highway Systems

IVHS includes a wide range of technologies and ideas, and is commonly separated into five different functional areas (16, 17):

- Advanced Traffic Management Systems (ATMS) permit real-time adjustment of traffic control systems and variable signing for driver advice. Their application in selected corridors has reduced delay, travel time, and accidents.
- Advanced Traveler Information Systems (ATIS) allow drivers to know their location and how to find desired services. ATIS permit communication between the driver and ATMS for continuous advice regarding traffic conditions, alternate routes, and safety issues.
- Commercial Vehicle Operations (CVO) select from ATIS those features critical to commercial and emergency vehicles. They expedite deliveries, improve operational efficiency, and increase safety. CVO will be designed to interact with ATMS when ATMS is fully developed.
- Advanced Public Transportation Systems (APTS) encompass the application of advanced electronic technologies to the deployment and operation of high occupancy, shared-ride vehicles, including conventional buses, rail vehicles, and the entire range of para-transit vehicles.
- Advanced Vehicle Control Systems (AVCS) apply additional technology to vehicles to identify obstacles and adjacent vehicles, thus assisting in the prevention of collisions in safer operation at high speeds. AVCS will interact with the fully developed ATMS to provide automatic vehicle operations.

IVHS shares many of the same goals held by TDM, and each functional area focuses (to some degree) on attaining the proposed objectives. Figure 4 illustrates how these objectives compare with TDM and each functional area within IVHS. This figure was generated by extracting the goals and objectives listed in IVHS AMERICA's *Strategic Plan for Intelligent Vehicle-Highway Systems in the United States* (17) and comparing them with the objectives of TDM.

At present, it appears that IVHS is concentrating more on congestion management, improved mobility, and driver safety rather than actually minimizing single-occupant automobile use--the essence of TDM. The vision established by Mobility 2000 (16) remains fixed even today with its successor: IVHS AMERICA.

"...Urban areas will more efficiently manage their existing streets and freeways through improved traveler information and traffic control systems. Rural and urban area travelers will benefit from improved security, comfort, and convenience. Experience gained from better management of existing facilities will further improve the design and use of new facilities. With

the time and energy saved through enhanced travel efficiency, the cost of producing goods and services will decrease, resulting in improved industrial profitability and international competitiveness.

"All vehicle operators will benefit from more efficient and less stressful travel. Through IVHS, drivers may access routing information that allows them to select a route based on speed, fuel efficiency, scenic views, interesting places, or many other variables. Older drivers will have more mobility because advanced technologies can augment vision and judgement, for instance at night or during bad weather. Significant improvements in service levels and transportation information systems will increase the attractiveness of transit, car pooling, van pooling, and other multiple-occupancy vehicle systems.

"Measured, quantified improvements to mobility include: reduced congestion, accommodation of increased travel and higher trip speeds, reduced motorist confusion and aggravation, augmented and enhanced driver capabilities, reduced cost in the transportation element of producing goods and services, and reduced driver fatigue and frustration."

IVHS AMERICA adds to this vision (17):

"A primary function of IVHS is to provide for a smoother traffic flow, allowing vehicles to reach their destinations with fewer stops and delays. These systems better utilize the capacity of the network by shifting traffic from routes of inadequate capacity to routes with excess capacity. Thus, the economic benefit of increases in potential overall traffic volume without a corresponding increase in congestion can be achieved. Information provided to drivers on congested routes will improve travel times, as will routing information. . . Commercial and transit vehicles, as well as private automobiles, will benefit from reduced congestion. Also, changes in travel and land use patterns, with enhanced real estate values, can result from IVHS implementation."

It is apparent that emphasis is placed on handling greater traffic volumes, i.e., increasing capacity, and making the trip quicker and more convenient for the single occupant motorist, rather than motivating drivers to change modes of travel to reduce VMT and traffic volumes. Thus, the link between the automobile and the single-occupant driver is actually made stronger. Have we become so caught up in the fantasy of high-technology that we have lost sight of our primary goal? The answer to this question, of course, is no--well, at least not completely.

As Figure 4 illustrates, if IVHS lacks promotion of any of the objectives, minimizing auto usage and keeping travel costs low suffer most. Presently, the United States accounts for about half of the world's automobile travel (1). Increasing air pollution and its effects on the environment, excess fuel consumption, and deteriorating public health are issues which must finally be addressed. Again, separation of the auto and the single-occupant driver can perhaps best deter these ill effects. It is logical to think that using IVHS to merely optimize traffic flow will eventually evolve back into Orski's description of today's congestion problems.

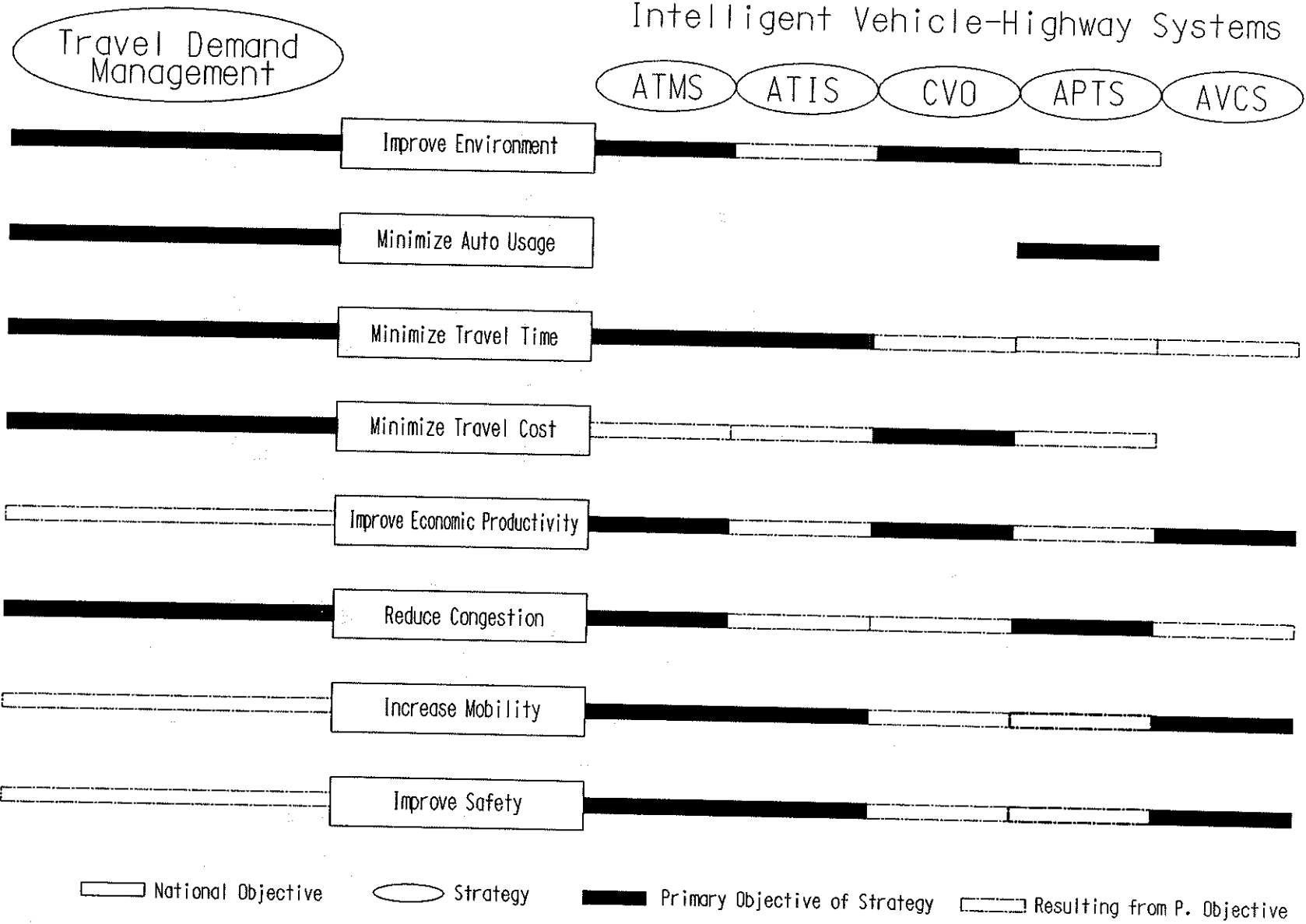
In terms of costs, IVHS technologies are expensive to develop and implement. IVHS AMERICA estimates a twenty-year program of development and deployment to cost \$215 billion dollars (17). Approximately 79 percent of this expenditure is expected to come from consumers. This cost appears extremely high considering that IVHS would produce only marginal benefits to traffic flow (5 percent), reduced fuel consumption (3 to 2 percent), and lessened pollution (8 to 5 percent) (18). Furthermore, the assumptions regarding driver behavior used to generate these figures were moderately optimistic.

IVHS will undoubtedly press forward and mature slowly. Public acceptance of it, however, may not readily occur. John Naisbitt, author of the long-running nationwide best-seller *Megatrends* (19) during the mid 1980s, explains how people tend to backlash at the introduction of new, high-technology. Americans in particular often enjoy doing business and other activities directly with other people--as if all had need of "human touch" and personal interaction. Therefore, not only will cost hinder the acceptance of IVHS, so may the sting of its new, high-technology.

How can IVHS be used to motivate the single-occupant driver to voluntarily use an alternative mode of transportation? Advanced Public Transportation Systems are expected to promote greater use of multi-occupancy modes. Proponents of APTS believe that "success in diverting travelers from single occupancy vehicles depends on the quality and effectiveness of pre-trip information" (20). Recent increases in operations which provide trip planning information support their theory.

APTS are exploring automated telephone services, direct computer links, and cable television information systems as means to provide plural and mass transportation users with real-time information and best-route/mode scheduling. "Smart Traveler"³ programs (20) in Houston, Minneapolis/St. Paul, and California each use cable TV and videotext terminals to give commuters real-time information before they leave home or the office, and enable them to choose alternate travel modes and routes. The Smart Traveler program in Bellevue, Washington (20) uses mobile communications, such as cellular telephones to optimize carpooling, vanpooling, and rideshare opportunities. Bellevue's program focuses on better utilizing the existing high-occupancy vehicle (HOV) facilities.

³"Smart Travelers" are those people who have access to real-time information that is accurate, reliable, and timely in order to make travel decisions that involve high-occupancy vehicles and transit.



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Figure 4. Objectives Comparison: Travel Demand Management and Intelligent Vehicle-Highway Systems (12,13,17).

APTS possess great potential--of which initial pilot study results are indicating (20). At present, however, even these systems cannot fully minimize automobile use. For example, APTS presently do not address how a traveler's need for day-care are satisfied, or provide a vehicle to those transit users who may need an automobile during the day. Consequently, travel demand management programs still must play a significant role.

Despite the noble intent of APTS, public transportation is not the majority's primary transportation mode choice (6). Advanced Public Transportation Systems need support from their IVHS counterparts. Because Americans favor their automobiles so much, the auto seems to be the best place to "entice" the single occupant driver to choose an alternative mode of travel.

In summary, all three strategies attempt to reduce congestion although in slightly different ways. Evaluation of the three strategies suggests that one ubiquitous objective could relieve congestion on a long-term basis: **minimize single-occupant driving**. This objective encompasses desires of the three strategies to promote use of multi-occupancy transportation modes, minimize automobile use, and reduce congestion.

Each strategy has its strengths and, more importantly, a fundamental weakness. A renewed perspective can be derived from combining each of these strategies: A key to eliminating congestion depends upon minimum use of the automobile and optimized use of multi-occupancy transportation modes. This idea is not new to the transportation profession, but serves as a "back-to-the-basics" cry for rejuvenated efforts to realize this perspective.

ATIS AS A TOOL FOR MINIMIZING AUTOMOBILE USE

ATIS, a functional piece of IVHS, can be used as a means to minimize automobile usage and promote multi-occupancy travel modes. Advent of ATIS technology provides an opportunity to strengthen the now frail bond between the single-occupant driver and multi-occupancy modes through use of real-time information.

IVHS AMERICA defines Advanced Traveler Information Systems⁴ as systems that,

"acquire, analyze, communicate, and present information for use in assisting surface transportation travelers in moving from a starting location (origin) to the desired destination. The systems provide such assistance in the manner that best satisfies the traveler's needs for safety, efficiency, and comfort. The travel may involve a single mode of transportation, or it may link multiple modes together during various parts of the trip".

Emphasis of ATIS lies with making the traveler feel safer and more comfortable while completing the trip in the least amount of time. According to the definition, however, ATIS must also link multiple (or alternative) modes of transportation together. Promoting alternative mode travel is the primary function of APTS, and as mentioned previously, an essential part of providing long-lasting results in congestion reduction efforts. Therefore, ATIS and APTS must somehow be joined together despite their dichotomous relationship; after all, their functional objectives overlap.

A combined relationship between ATIS and APTS does not presently exist. Observation of current forms of Advanced Traveler Information Systems throughout the world illustrate this point. Table 4 lists many of the ATIS programs in effect throughout the world and gives brief descriptions of the information they provide the driver. Los Angeles' Pathfinder and Orlando's TravTek programs were the first two IVHS implementations in the U.S. (21). Each of these programs uses an on-board microcomputer to estimate expected delay for a given path. The system provides the driver with alternative routes to minimize these delays. Other forms of ATIS include simple one-way communication of real-time traffic information to motorists through radio, such as Highway Advisory Radio (HAR) in the U.S. and Autofahrer Rundfunk Information (ARI) in Europe.

Success of ATIS in minimizing single-occupant driving depends upon the integration of precepts that promote multi-occupancy mode travel during its development. According to IVHS AMERICA (17), development of ATIS is proposed to occur in three stages: 1)

⁴Mobility 2000 first used the word "Driver", as in Advanced *Driver* Information Systems. IVHS AMERICA changed this term to "Traveler" in an attempt to broaden the scope, i.e., include transit users, of whom Advanced *Traveler* Information Systems addressed (17). This paper concentrates on information directed towards the driver and the passengers within an automobile, although ATIS will be used throughout the report.

Table 4. Active Advanced Travel Information Systems (23,25,26).

ATIS	Beginning Operation Date	Site	Navigation	Route Guidance	Real-Time Traffic Congesiton	General Traffic Information	Trip Services	Pretrip Planning	Personal Communication	Emergency Communication
Pathfinder	Jun-90	Santa Monica, CA	X		X					
TravTek	Jan-92	Orlando, FL	X	X	X	X	X	X		X
AMTICS	Apr-88	Tokyo	X		X		X		X	X
RACS	Mar-87	Tokyo & Yokahama	X		X		X		X	
AUTOGUIDE	1990s	London	X	X						
ALI-SCOUT	1980s	Munich & Berlin	X	X						
Travelpilot IDS	1990s	Sold worldwide	X	X				X		
ADVANCE	1992	Chicago	X	X	X	X	X	X		X

Information Stage, where emphasis is on providing each traveler with information to improve their individual travel and decision making, e.g., navigational maps and route guidance; 2) Advisory Stage, which supplements static information with up-to-date (real-time) information; and 3) Coordination Stage, where the infrastructure and vehicles will automatically exchange information to optimize the flow and safety of traffic over the entire network.

Much has already been accomplished in the Information Stage. Many private companies such as ETAK, Inc. (22) and Trimble Navigation, Ltd. (23) presently have accurate navigational systems on the market. Trimble Navigation, Ltd. incorporates the Global Positioning Satellites (GPS) program into its navigation system, (24) while ETAK, Inc. uses on-board sensors, a microcomputer and CDROM to track the vehicle's location. Each of the systems identified in Table 4 possess navigational capabilities.

The Advisory Stage, though scheduled to begin in 1994, has already been implemented to some degree into the TravTek project. In this stage, the in-vehicle systems will do more than just inform the driver of conditions. Best-routes are chosen by the system based upon real-time information. TravTek uses the CORFLO model to develop travel times from real-time information.

The final stage is the Coordination Stage. Here, the ATIS system operates independently using information given to it by the ATMS. The vehicle and the infrastructure communicate together providing the motorist with the optimum performance in traveling from one place to another.

Chicago is presently designing the Advanced Driver and Vehicle Advisory Navigation Concept (ADVANCE). Once operational, ADVANCE will be the best example of a fully functional ATIS system (25). The system will consist of a video screen, a microcomputer, a data communications radio, and a GPS receiver. The vehicle's exact location and travel time status will be known at virtually all times (See Figure 5). The equipped vehicles will act as probes in the traffic flow and relay that information back to a traffic information center (essentially an ATMS), where the information will be processed and the best possible routes determined. Finally, this information will be returned back to the probe (and the general public via radio communications), thus allowing the driver to change route to shorten delays.

A "merger" of APTS with ATIS must begin with the Advisory Stage. With present systems operating in this general stage of development, however, this link has not been made. Even with Chicago's ADVANCE program, the most advanced ATIS project of present time, deterrents for single-occupant driving are not given. Planning and action to create the ATIS-APTS link must occur now if IVHS is truly to accomplish its purpose. This connection also provides opportunity for TDM and multi-occupancy modes to strengthen the weaker bonds they have with single-occupant drivers.

Information is a key to decision-making, and conceivably the answer to solving congestion problems. Well-informed drivers can make decisions which lead to safer, more efficient travel (26). Thus, it has been a long-time goal to give the traveler up-to-date

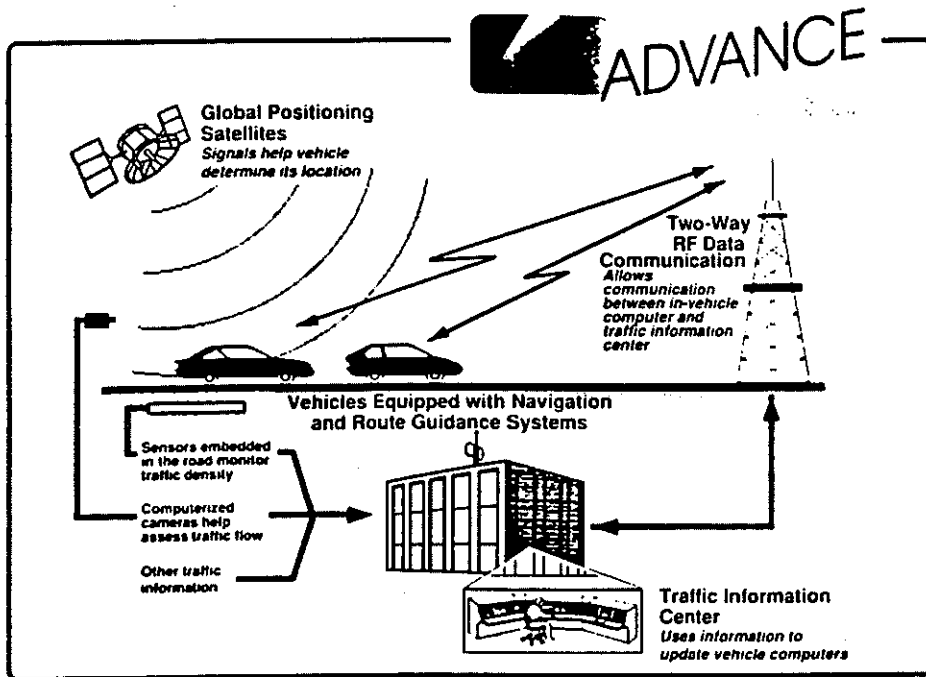


Figure 5. Advanced Driver and Vehicle Advisory Navigation Concept (Chicago, IL) (25).

information regarding traffic conditions as the trip is in progress. At last, ATIS provide the means to give travelers this information. Sadly, this information (as presently used) most often promotes further automobile use.

It is evident that the already predominant mode of transportation, namely the automobile, is only becoming more attractive with the emergence of ATIS technology. On the other hand, just as ATIS can promote automobile use, it can also be used to effectively foster use of alternative modes of transportation--plural and mass transportation. Proper use of real-time information is the determining factor.

STRATEGIES DESIGNED TO MINIMIZE SINGLE-OCCUPANT DRIVING THROUGH ATIS

Four different strategies are recommended to promote single-occupant drivers to choose an alternative multi-occupancy mode of travel: 1) create an incentive savings program, 2) personalize information for each driver to promote use of multi-occupancy modes, 3) instigate a dynamic parking demand pricing program, and 4) use ATIS as a marketing tool. Each of these strategies assumes that alternative modes of transportation (e.g., plural and/or public transportation) are available somewhere along the route of the driver's trip. Furthermore, each person has a fully-operational, advanced on-board ATIS system which provides two-way communication and transfer of real-time information between the driver and the roadway infrastructure. These strategies were developed by the author through pondering the material read during the literature review.

Incentive Savings Program Using "Smart" Cards

The advent of "Smart" cards opens yet another opportunity for ATIS. Smart cards store real-time information regarding a person and their related travels. Smart cards are expected to be an integral part of APTS (17, 20). The cards will be used for cashless fare transactions, parking charges, toll roads and bridges, and even telephone usage. (This application has proven successful in Europe and is becoming more readily available in the U.S.) For application in ATIS, the cards can be used to store information regarding origins and destinations of trips taken.

Vehicles in the future will no longer require the use of metal keys for ignition or to unlock its doors. A "Smart" card can be used in its place. Encoded within the card are bits of information regarding the driver's residence and work locations, occupation type, and number of work-related miles to be traveled daily. As the commuter begins the daily trip to work by starting the car, information is read from the smart card by the ATIS. Based upon the personal information on the card, each person is allotted a certain percentage of drive-alone miles per month or week. People whose residence is farther from their work place than others would be allotted more drive-alone miles, but all would not be allotted enough for them to drive alone every day. Each drive-alone trip taken to work would subtract that distance traveled from the allotted amount. If the commuter chose to carpool or take public transportation, however, either a scaled reduction or no mileage would be deducted for that trip.

"Savings" would originate from *not* paying the full retail price for transportation-related goods and services, e.g., gasoline, oil, public transportation passes, and auto-maintenance. For example, those who retained a certain percentage of their allotted mileage for the week or month would pay less than the "regular" price for a gallon of gasoline.

A primary concern with this proposal is to identify who would absorb the lost revenue cost. Rather than creating a loss of revenue, a surplus of funds is needed. This surplus could be generated by a slight increase in the price of gasoline, for example, by a

cooperative agreement between private industry (oil companies) and federal legislation (additional tax). In this way, the single-occupant drivers fund the savings received by multi-occupant mode travelers proportionally to the amount of fuel they consume while driving alone. Any action to create a surplus, if funded by consumers, must be done on a national level. This way, the initial cost increase is imposed on everyone. As the program progressed, however, only those individuals choosing not to participate in the program would be actually paying the higher price. Savings would go to those who choose to use multi-occupancy transportation modes and those not exceeding their allotted mileage.

A portion of the surplus must also be used to compensate oil refiners' loss of market demand. Michael Hardy, General Manager of Transportation for Giant Industries in Scottsdale, Arizona, estimates that a proportional relationship between loss of market demand and compensation for profit margin per gallon of gasoline might be appropriate. For example, if 15 percent of the market demand for gasoline were taken away, a 15 percent increase in profit margin could compensate for the refiners' losses (27). On average, a refiner's profit margin on a gallon of gasoline is only two cents. With the amount of volumes involved, however, even a 15 percent increase could mean hundreds of millions of dollars.

The mere thought of imposing another gasoline price-hike stirs up the wrath of virtually all Americans. These are drastic times; congestion is becoming worse everyday. Perhaps extreme measures are in order. Recall that one of the conclusions drawn from the COMSIS Corporation study showed that the most effective TDM programs were those mandated by government ordinance. The same precedent would most likely be necessary to realize the full potential of an incentive savings plan.

Many other benefits are possible through using a smart card with an incentives savings program. The ATIS system could monitor carpooling and public transit trips. Each person in the carpool could insert their smart card into the ATIS of the driver's vehicle to receive credit (maybe better stated as "no credit") for the trip. The same card could be used for public transportation and the service (gas) stations such that the driver never needs to worry about having correct change or being caught short-of-cash.

Crediting rates could vary based upon the transportation mode taken. For example, riding a bus for a 20-mile commute may count as "No Miles Deducted" while carpooling the same trip might only deduct 5 of the 20 miles. The same type of system could be used for all trips taken in the metropolitan area, for both commuters and those just going shopping.

Use of a personal identification number (PIN), similar to the system used by all major credit/banking cards today, could be used to ensure system integrity. Methods of verifying validity of smart cards could be developed as well. Portions of the enormous IVHS proposed budget could be used to finance the many administrative and technical jobs this effort requires.

This incentive savings program uses the full potential of high-technology--something at which people seem to backlash (19). By the same token, this recommendation also promotes multi-occupancy modes of travel, which actually promotes personal interactions

with others. Indeed, the program may stimulate the creation of a favorable social environment.

Unlike the procedure of spreading out travel demand over space and time, the incentive savings proposal motivates reduced automobile use system wide. The program sends the message, "Find an alternative multi-occupancy mode and receive savings," rather than, "Change your departure time or chosen route of travel to avoid congestion." It is no longer acceptable to drive alone when (and if) other modes are available. Nevertheless, those who choose not to participate in the program simply do not receive the benefits.

A major flaw in this strategy lies with its implementation. Regardless of how beneficial the program may be, increased costs for transportation-related services are generally perceived as additional taxation. Strong public opposition is virtually inevitable the very instant a price increase becomes known. Also, Americans strongly resist the feeling of being monitored. This syndrome is commonly referred to as "Big Brother is watching"; a sense of personal privacy is lost when your every move is being recorded. Already, reports have stated that the TravTek project levies this feeling upon some of its users (28). Thus, an aggressive marketing campaign must precede an incentives savings program, and this too may not be enough to generate public acceptance.

Finally, ensuring equity in this program depends upon an equitable allotment of drive-alone miles. The allotment must consider the potential travelers have to take multi-occupancy travel modes, as well as information pertinent to the travelers trip purpose, and trip origin and destination. At present, no such methodology exists, and certainly many unseen obstacles would complicate the effort to develop such a procedure.

Personalize Information to Promote Multi-Occupancy Mode Travel

Much research has been done (and continues to be performed) in the area of human factors and the driving task. ATIS provides an even greater challenge to human factors researchers. A primary issue of study deals with the optimum amount of (additional) information a driver can process without sacrificing safety. One conclusive statement is considered correct: drivers have some spare capacity for information processing during normal vehicle operation (29). The amount of this excess capacity varies (and sometimes is exceeded) depending upon the difficulty of the driving task due to presence of traffic, roadway geometric features, and abilities of the driver (30). This strategy attempts to utilize the additional processing capacity, however meager it may be, to promote use of multi-occupancy travel modes.

Information is collected by a driver by several different means. Engineering psychology refers to the presentation sources of this information as "displays" (29). Displays may be either visual, audio, and even olfactory (smell). Motorists, of course, rely most upon visual displays.

Findings of research efforts, conclude that humans process visual information in one of two ways: serial processing or parallel processing. Understanding the difference between

the two types offers insights of how information may optimally be presented to an individual, i.e., how the individual will comprehend the most from information given them.

Serial processing occurs when information is processed sequentially by an individual. Sequential processing occurs because the required information falls outside their range of foveal vision, and the person must move their eyes to "focus" on one thing at a time. Parallel processing, in terms of automobile drivers, involves the simultaneous absorption, comprehension, and control of information from both foveal and peripheral vision, or from more than one source. For example, during a trip a motorist's foveal vision may be focused on a vehicle ahead such that the motorist can prevent running into the back of the ahead vehicle. But, simultaneously the driver's peripheral vision is giving him information about his own vehicle position on the roadway. Through using both foveal and peripheral vision as information inputs, parallel thought processing occurs--the driver remains a safe distance behind the ahead vehicle *and* stays safely in the travel lane (29).

Humans are generally believed to be serial processors who can quickly switch attention levels back and forth from two (or more) information sources. This theory, however, has not been completely substantiated by research (30). Another school of thought suggests that humans, in particular motorists, operate in both modes, though not simultaneously, while driving. In this context, parallel processing is much more efficient than serial processing in that more information is properly received, interpreted, and acted upon. ATIS can use this human trait to reduce single-occupant driving.

As mentioned previously, drivers are sensitive to various factors (travel time, cost, convenience, etc.) at differing degrees of importance. ATIS could be used to educate drivers (especially commuters) about these factors in relation to their own status. For example, suppose a commuter were required daily to be to work at a fixed time. To this person, travel time might be of highest priority. The ATIS would keep a running log of travel times for each trip made between work and residence. Each morning, a comparison of average trip times between driving alone and the same trip made on an alternative mode could (automatically) be displayed. This single piece of information may seem trivial alone, but add a little more information regarding cost, for example, and the message could motivate a mode change.

A comparison of the related costs associated with the different travel modes could also be given in cumulative form. It may be that the commuter sees that an extra \$60 dollars were spent on driving alone last month for approximately equal travel times if a bus were taken. This too may seem meaningless, unless the same results had been occurring for one year. The commuter now sees a running total of \$720 dollars difference. The combined effect of travel time and cost information may just be enough to motivate a change.

This example, accompanied with results from the Seattle study, suggest that information can be made more effective if tailored to a particular audience. Looking back at the three strategies designed to reduce congestion reveals that each of these tactics assumes the driving population to be a single, homogeneous audience. This assumption is incorrect, as has been demonstrated, hence each strategies' effectiveness is limited to the

proportion of the total audience who finds that approach appealing and useful. ATIS provides an excellent opportunity to personalize information for many different types of people. Furthermore, ATIS can stimulate parallel thought processing and possibly even change drivers' perspectives regarding the trips they take.

TRAC divided its Seattle commuters into four subgroups based upon survey results. This same process could accompany the purchase of a new ATIS system. Upon installation, the ATIS could ask the driver to respond to a list of questions, which would ultimately classify that person into a subgroup audience type. Information displayed to the driver could then be custom made to address the factors deemed most important to that individual. As in the example above, the system would provide information relative to comparing different modes of transportation, or other forms of data, such as the MOEs listed in Table 3, which promote usage of multi-occupancy transportation modes.

This type of information would only be displayed upon the beginning and at the end of a trip, unless parallel thought processing could be stimulated while the vehicle was in motion without sacrificing safety. Either way, the information would stimulate the human mind to operate in parallel mode such that the driver *thinks* about alternative modes of transportation during the trip. Over time, single-occupant drivers may become tired of "paying the price" for driving alone and opt to use an alternative transportation mode occasionally, or even everyday.

Success of this idea demands that the performance of alternative transportation modes be competitive with the automobile, and that the information provided to the driver is reliable, timely, and accurate. Thus, present efforts to provide priority access to transit vehicles, HOV operations, and the like (TCMs) must continue. Care should be taken to see that the growth and implementation of IVHS does not exceed the ability of multi-occupancy modes to compete with the automobile. IVHS represents new, uncharted territory which may only make America's passion for the automobile stronger.

Another concern with this idea involves humanitarianism. Is it morally correct to tap a person's mind and then only feed it information that promotes the desires of another person (in this case, the transportation engineer)? While some may welcome the additional information, others may perceive it as a form of brain washing (31). Obviously, much more work in human factors must be completed before such a strategy could be acceptable.

Parking Demand Pricing

A few ATIS systems in Japan show drivers where city parking is available. This amenity could also include a real-time demand pricing algorithm such that the charge for downtown parking varies based upon the daily demand placed upon it. Origin-destination links and departure times are known by ATIS upon initiation of the trip. The greater the demand at a particular lot, the higher the price to park there for the day. Prices would dynamically change at periodic intervals of say, five minutes for single-occupant drivers. Fixed prices and guaranteed parking spaces would be provided for carpools, vanpools, and rideshare programs. This information would be provided to the driver via the ATIS throughout the duration of the commute.

A program of this type is targeted primarily at (see Table 2) the 60 percent of commuters who stated they were willing to change routes during their commute. Changing their route may include pulling into a park-and-ride facility, picking up a few carpoolers, and taking a HOV lane into their reserved parking space. In this way, partial trip reductions would add to an overall area reduction of VMT and single-occupant vehicle use.

A major milestone of this strategy is to create a predictive algorithm that accurately estimates arrival times for trips. Due to varying congestion and roadway conditions, drivers would change their routes possibly as many as 10 times during a trip. Accounting for this type of variability would be an arduous, if not impractical, task.

ATIS as a Marketing Tool

Finally, ATIS can be used as a marketing tool to promote use of multi-occupancy modes. Free advertisements which promote activity in environmentally-conscious, special interest groups might be allowed to appear on an ATIS monitor. A national sports star or popular public figure could help springboard a national carpooling program. Much of the same marketing techniques used in television may have some application in ATIS to deter single-occupant driving.

Eventually, all metropolitan areas must comply with air quality standards. Whether this standard is met voluntarily, or by legal mandate, America must minimize its use of the automobile.

CONCLUSIONS

Despite efforts to make multi-occupancy modes of transportation competitive with the automobile, Americans still prefer and choose to drive alone. Travel Demand Management can effectively reduce negative impacts on the environment, minimize use of the automobile, shorten trip travel times and reduce costs associated with transportation. These objectives are shared by the advent of Intelligent Vehicle-Highway Systems. IVHS, however, contains two functional components that compete with one another, namely ATIS and APTS.

Advanced Traveler Information Systems' primary objective is to increase system (traffic) flow. This objective is accomplished by providing drivers real-time information during their trips regarding traffic conditions, such that the driver can choose a route that most quickly and conveniently gets them to their final destination. The added information, however, actually stimulates single-occupant driving. Advanced Public Transportation Systems promote maximum multi-occupancy mode travel. The primary objective here is to minimize automobile use overall, rather than just spread the demand out over space and time. Therefore, a form of merger is required between ATIS and APTS to set IVHS in line with objectives that minimize single-occupant driving.

ATIS systems present a new opportunity--an opportunity to dilute Americans' affection for the automobile. New innovative ideas, such as an incentive savings program, are needed to achieve this goal. ATIS can "tailor" information to a particular audience, thus using those factors deemed most important to an individual to promote use of an alternative mode of transportation. Dynamic pricing schemes for parking can also be used through ATIS.

It is important to realize that with all new, and perhaps even great ideas, new problems emerge also. The greatest stumbling block apparent with implementation of new ATIS techniques is that of public acceptance. Until Americans individually decide to minimize their use of the automobile, success rates of new programs are likely to be equivalent to those programs already in effect, while costing much, much more.

Unfortunately, once a particular luxury becomes a standard part of life (such as owning an automobile), legal mandate is essentially required to regulate its use. Americans, of all people, should be able to take control a situation and act without being compelled to do so. As a model nation, the United States can pave the way for implementation of new, highly effective programs which reduce ill effects on the environment through minimized automobile use.

IVHS must not be perceived as "THE" solution, or even "A" solution to today's congestion problems. IVHS is merely an integral part of a fully functional travel management program. Only when all of the parts, including each individual citizen, are working together to minimize single-occupant driving, will congestion conditions significantly improve.

Finally, new beginnings begin with investigation, acceptance, modification and trial of new, innovative ideas. Despite all present efforts to reduce congestion, conditions continue to deteriorate. Under these circumstances, new ideas may not seem so outrageous after all.

RECOMMENDATIONS

Several items are recommended for future consideration. First, present efforts (particularly TDM as a whole and IVHS) to develop programs which reduce congestion should continue, but continue with a "back-to-the-basics" approach. The primary focus should lie with minimizing use of the automobile and single-occupant driving. These objectives may be accomplished by strengthening the bond between the driver and the multi-occupancy mode, and weakening the drivers' affection for the automobile. Either way, exceeding a transportation network's capacity is avoided, rather than prolonged.

Second, dichotomies in the development of IVHS, in particular ATIS and APTS, must be eliminated. If IVHS is to deter single-occupant driving, all of their functional elements must work together and form a concentrated effort to do so. Minimizing single-occupant driving will result in both minimized automobile use and optimized traffic flow. Multi-occupancy modes would then be very competitive with the automobile.

Third, provide more research opportunities for development of new, innovative strategies and programs that minimize automobile use through IVHS technology. The present strategic plan is not necessarily the best plan attainable.

Finally, direct public and real-time information campaigns towards particular audience groups, rather than treating all drivers as one homogeneous constituency. The advent of ATIS makes this recommendation viable. Research suggests that by so doing, a greater driver response rate is possible.

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Jeff L. Ottesen received his B.S. in Civil Engineering from Brigham Young University in April 1991. He worked 19 months with DeLeuw, Cather & Co. before becoming a Graduate Research and Teaching Assistant within the Texas A&M University System. His professional interests include: highway geometric design, traffic operations and safety, and IVHS/ATIS technologies.

