0-5079-P3

Implementation Issues and Strategies for Deployment of Traveler Information Systems in Texas

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Project 0-5079:
Use of Traveler Information to Enhance Toll Road Operations

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<tr><td>Abstract:
This research product provides in-depth analysis of the benefits and costs of Advanced Traveler Information Systems (ATIS) deployment to enhance toll road operations in Texas, the implementation issues of ATIS, and funding opportunities for ATIS implementations. A case study of cost-benefit analysis was conducted using the Austin transportation network. The evaluation results show that ATIS deployment proposed in a previous simulation study is cost-effective. A practical framework for ATIS implementation was developed. In general, Texas TMCs are capable of providing the traveler information desired by the public. The funding opportunities for ATIS deployment are generally from the public sector. The funding opportunities from the private sector are very limited and need substantial marketing effort. Several business models are reviewed. It was found that most TMCs in Texas are using the Public-Centered Operations model. There is significant scope left for private sector involvement.</td><td>Keywords:
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TABLE OF CONTENTS

1. INTRODUCTION

The potential of Advanced Traveler Information System (ATIS) to divert traffic to toll roads has been demonstrated in two previous products of this research project (namely 0-5079-P1 and 0-5079-P2). This product addresses the implementation. Specifically, the technical and financial issues are presented here so that ATIS could be better used to enhance both freeway and alternative toll road traffic operations in Texas.

Current ATIS technologies include Internet, telephone, in-vehicle, and roadside-based systems, each with unique strengths and weaknesses. For example, while a number of positive outcomes have been observed from the installation of roadside dynamic message signs (DMS), there are potential shortcomings as well. Once constructed, the technology is not nimble to advances and may be very costly to operate and maintain. The infrastructure is static and expensive, and impact is limited to a small area around the sign. In addition, the amount of information that can be provided is very limited. In fact, many drivers never get the whole message unless they are already in congestion. Internet and telephone based ATIS have shortcomings, too. Internet-based systems are primarily for pre-trip planning, but users may not have access to information that is relevant to their trip, or the information may be stale by the time the trip is made. Telephone-based systems have similar weaknesses, plus requiring the user to know whom to call. Phone use also requires some “visioning” while talking, which is the reason why phone use impairs driver performance and traffic safety. Many states have moved to ban cell phone use while driving.

In addition to evaluating the cost effectiveness and requirements for deploying current technologies, the research team reviewed newer technologies under development in the national Intelligent Vehicle Infrastructure (IVI) initiative. For example, push technology is known to be more successful than demand-based systems because people prefer to be passive users rather than having to act to receive information. To facilitate motorists, a Vehicle Positioning System (VPS) on-board unit (OBU) with an autonomous positioning system such as a Global Positioning System (GPS) is able to “announce” itself within a network, and information customized for location can be fed to the unit (Figure 1.1).

Figure 1.1: Onboard Unit with GPS

In this product, the costs and benefits of deploying traveler information are evaluated. Costs include installation, operating, and maintenance. The benefits to toll road are estimated on the basis of increased traffic on the toll road, and resulting increase in toll revenue. The benefits of reduced congestion on the non-tolled system are also evaluated. While congestion relief benefits may not translate directly into revenues, they can justify funding for deployment.

Funding opportunities will also be explored in this product. For example, the Federal Highway Administration (FHWA) has funded operational field tests to determine contribution of an ATIS deployment/technology to ITS America National Program Plan. ATIS deployment trials, called metropolitan model deployment initiatives, have been conducted in Seattle, Phoenix, San Antonio, and New York since 1996. These projects comprise a range of data collection and sharing technologies, incremental improvements to existing incident management capabilities, and enhancements to existing ATIS offered in a region (Wunderlich 2000). The new SAFETEA-LU legislation has provisions for ITS funding. Since providing traveler information to toll road users is found to have high payback, all sources of funding including funding from the private sector are examined. These results indicate that it would be beneficial to the Texas Department of Transportation (TxDOT) to pursue more resource for ATIS deployment.

2. COSTS AND BENEFITS OF ATIS

The costs associated with an ATIS deployment usually include installation costs and operation & maintenance (O&M) costs. The benefits of an ATIS deployment can be categorized into two types: benefits to travelers and benefits to transportation agencies. Understanding the cost and benefit structures of various ATIS deployments would help TxDOT in decision-making on ATIS investments.

2.1 Costs of Various ATIS Technologies

The cost of an ATIS deployment includes installation cost and O&M cost. Installation cost is usually the total of published ATIS unit prices plus any additional labor or materials required to satisfactorily complete the installation. All ATIS systems can be considered depreciable properties. Therefore, the unit cost of an ATIS deployment can be measured by its capital cost, which is usually the total of the purchase price, the cost of any upgrades or improvements, and soft costs such as interest, legal and accounting fees, etc.

O&M costs include those major components required to operate and maintain a facility, i.e. labor, fuel, electricity, equipment and material. In order to apply any O&M costing methodology to a specific facility, it is necessary to make adjustments that consider the life of the facility, its physical condition, type of construction and the accessibility to the site/costs, costs of utilities/services and if required, programming costs.

The ITS Joint Program Office of the U.S. Department of Transportation has surveyed nationwide ITS projects and developed a cost database for various ITS equipment. This database provides the ITS professional community with quick and easy access to costs data to be used in developing cost estimates of ITS deployments. Table 2.1 shows an example of the roadside information equipment costs in terms of capital cost and O&M cost. In general, the installation costs and O&M costs vary depending on where the ATIS project is deployed and what equipment is used.

Table 2.2 presents a summary of equipment costs for an in-vehicle information system. Table 2.3 presents a summary of equipment costs for information kiosks and personal devices. Table 2.4 shows the equipment costs for information service providers.

Table 2.1: Equipment Costs for Roadside Information

Unit Cost Element	Life Years	Capital Cost $K, 2004 Dollars	O&M Cost $K, 2004 Dollars	Description
Roadside Message Sign	20	39 - 59	2 - 3	Fixed message board for HOV and HOT lanes.
Wireline to Roadside Message Sign	20	6 - 8		Wireline to VMS (0.5 mile upstation).
Variable Message Sign	10	47 - 117	2.4 - 6	Low capital cost is for smaller VMS installed along arterial. High capital cost is for full matrix, LED, 3-line, walk-in VMS installed on freeway. Cost does not include installation.
Variable Message Sign Tower	20	25 - 120		Low capital cost is for a small structure for arterials. High capital cost is for a larger structure spanning 3-4 lanes. VMS tower structure requires minimal maintenance.
Variable Message Sign - Portable	14	21 - 25	1.1 - 1.8	Trailer mounted VMS (3-line, 8" character display); includes trailer, solar or diesel powered.
Highway Advisory Radio	20	15 - 30	0.6 - 1	Capital cost is for a 10-watt HAR. Includes processor, antenna, transmitters, battery back-up, cabinet, rack mounting, lighting, mounts, connectors, cable, and license fee. Super HAR costs an additional $9-10K (larger antenna). Primary use of the super HAR is to gain a stronger signal.
Highway Advisory Radio Sign	10	5 - 9	0	Cost is for a HAR sign with flashing beacons. Includes cost of the controller.
Roadside Probe Beacon	5	5 - 8	0.5 - 0.8	Two-way device (per location).
LED Count-down Signal	10	0.307 - 0.426		Costs range from low (two 12 x 12-inch dual housing unit) to high (16 x 18-inch single housed unit). Signal indicates time remaining for pedestrian to cross, and a walk or don't walk icon. Count-down signals use low 8-watt LED bulbs, which require replacement approximately every 5-7 years.
Pedestrian Crossing Illumination System	5	26.9 - 41	2.6 - 4	The capital cost range includes cost of equipment and installation. Equipment includes fixtures - 4 lamps per lane - for a three lane crosswalk, controller, pole, and push button activator. Installation is estimated at 150 - 200 % of the total equipment cost. Capital cost would be greater if the system included automated activation of the in-pavement lighting system. O&M is approximately 10% of the equipment cost.
Variable Speed Display Sign		3.5 - 4.7		Low range is for a variable speed limit display system. High range includes static speed sign, speed detector (radar), and display system.

(Source: US Department of Transportation, ITS Joint Program Office, 2006)

Table 2.2: Equipment Costs for In-Vehicle Information System

Unit Cost Element	**Life** Years	**Capital Cost** $K, 2004 Dollars	**O&M Cost** $K, 2004 Dollars	**Description**
Communication Equipment	7	0.2 - 0.4	0.004 - 0.007	Wireless data transceiver.
In-Vehicle Display	7	0.04 - 0.1	0.001 - 0.002	In-vehicle display/warning interface. Software is COTS.
In-Vehicle Signing System	7	0.13 - 0.31	0.002 - 0.006	Interface to active tag reader, processor for active tag decode, and display device for messages.
GPS/DGPS	7	0.2 - 0.4	0.004 - 0.01	Global Positioning System/Differential Global Positioning Systems.
GIS Software	7	0.2 - 0.3		Geographical Information System (GIS) software for performing route planning.
Route Guidance Processor	7	0.08 - 0.12	0.002	Limited processor for route guidance functionality.
Electronic Toll Equipment	7	0.03 - 0.1		Active tag interface and debit/credit card interface.
Software, Processor for Probe Vehicle	7	0.05 - 0.14	0.001 - 0.003	Software and processor for communication to roadside infrastructure, signal generator, message generator. Software is COTS.
Toll Tag/Transponder	5	0.025		Most toll tags/transponders cost approx. $25. Some toll agencies require users to pay a refundable deposit in lieu of purchasing a tag. The user is charged the cost of the tag if the tag is lost.
In-Vehicle Navigation System	7	2.5		COTS product that includes in-vehicle display and supporting software.

(Source: US Department of Transportation, ITS Joint Program Office, 2006)

Table 2.3: Equipment Costs for Information Kiosks and Personal Devices

Unit Cost Element	Life Years	Capital Cost $K, 2004 Dollars	O&M Cost $K, 2004 Dollars	Description
Informational Kiosk	7	11 - 24	1.1 - 4.4	Includes hardware, enclosure, installation, modem server, and map software.
Integration of Kiosk with Existing Systems	7	2.1 - 26.3		Software costs are for COTS (low) and developed/outdoor (high).
Kiosk Upgrade for Interactive Usage	5	5 - 8	0.5 - 0.8	Interactive information display interface (upgrade from existing interface).
Kiosk Software Upgrade for Interactive Usage	5	10 - 12		Software is COTS.
Basic PDA	7	0.1 - 0.3		Personal digital assistant. Personal digital assistant. O&M estimated at 2% of capital.
Advanced PDA for Route Guidance, Interactive Information	7	0.4 - 0.6		Personal digital assistant with advanced capabilities (route guidance, interactive).
Modem Interface, Antenna for PDA	7	0.14 - 0.2	0.003 - 0.004	Modem interface and separate antenna for wireless capability.
PDA with Wireless Modem	2	0.2 - 0.6	0.11 - 0.3	Personal digital assistant with wireless modem. O&M based on monthly subscriber rate plans of 50 KB (low) and 150 KB (high).

(Source: US Department of Transportation, ITS Joint Program Office, 2006)

Table 2.4: Equipment Costs for Information Service Provider

Unit Cost Element	**Life** Years	**Capital Cost** $K, 2004 Dollars	**O&M Cost** $K, 2004 Dollars	**Description**
Information Service Provider Hardware	5	27 - 40	0.54 – 0.8	Includes 2 servers and 5 workstations. O&M is estimated at 2%; could be higher for responsive and preventative maintenance.
Systems Integration	20	85 - 104		Integration with other systems.
Information Service Provider Software	20	264 - 528	13.2 - 26.4	Includes database software (COTS) and traffic analysis software.
Map Database Software	2	14 - 29		Software is COTS.
Information Service Provider Labor			239 - 341	Description is based on 1995 data: 2 Staff @ 50K to 75K and 1 staff @ 75K to 100K. Salary cost are fully loaded prices and include base salary, overtime, overhead, benefits, etc.
FM Subcarrier Lease			111 - 221	Cost is per year.
Hardware Upgrade for Interactive Information	5	12 - 18	0.24 - 0.36	Includes 1 server and 2 workstations. O&M is estimated at 2%; could be higher for responsive and preventative maintenance.
Software Upgrade for Interactive Information	20	240 - 480	24-Dec	Trip planning software (includes some development costs).
Added Labor for Interactive Information			136 - 205	Description is based on 1995 data: 1 Staff @ 50K to 75K for 2 shifts. Salary costs are fully loaded prices including base salary, overtime, overhead, benefits, etc.
Software Upgrade for Route Guidance	20	240 - 480	24-Dec	Route selection software. Software is COTS.
Map Database Upgrade for Route Guidance	2	96 - 192		Map database software upgrade.

(Source: US Department of Transportation, ITS Joint Program Office, 2006)

2.2 Benefits of ATIS Technologies

Benefits to Travelers: Incident locations, travel time, alternative route information, weather information, and amber alert are made available to travelers via ATIS infrastructure, road signs, on-board units, radios, and personal devices. The commuter survey in the Austin area has shown that commuters strongly desire better traffic information and more reliable travel time information that can be provided by various types of ATIS equipment.

It has been widely recognized that providing traveler information to drivers has the potential to mitigate congestion in the road network by influencing travelers' pre-trip and en-route decisions. Providing real-time information, as documented in Product 0-5079-P1 and Product 0-5079-P2, can enhance traffic distribution and benefit a system of tolled and non-tolled roads by increasing the use of toll roads and relieving congestion on non-tolled routes. The resulting benefits of ATIS to travelers and transportation agencies include:

- Increase customer satisfaction
- Reduce travel time
- Reduce delay
- Increase travel time reliability
- Improve commuters' confidence in arriving trip destinations on time
- Reduce number of stops
- Increase vehicle throughput in the transportation network
- Reduce fuel and environmental cost

Benefits to Transportation Agencies: In this study the DYNASMART-P simulation experiments have shown that providing congestion information to traveler information could increase toll road usage and alleviate congestion on alternative freeways. These findings imply that transportation agencies can use ATIS as an effective method to enhance traffic operations on both toll roads and non tolled roads. Increased throughput on toll roads and alternative freeways will enhance the effectiveness of transportation infrastructure. Better utilization of existing capacity may reduce the need for adding new capacities. Previous studies have reported 8—22 percent increases in throughput by making more efficient use of existing capacity. This study found that ATIS could benefit the 2007 Austin network with a 2% travel time reduction and a 11% stop time reduction. Therefore ATIS is a promising ITS deployment that can make such improvements for transportation agencies.

In addition, ATIS deployments enable traffic managers to monitor and control traffic operations remotely. Traffic information, hazard warnings, roadway safety, and recommendations on alternative routes can be disseminated to travelers in ways never before possible. Better traffic management can bring substantial benefits to transportation agency operations.

2.3 A Cost-Benefit Analysis of ATIS Technologies

Cost-benefit analysis is often used to determine cost effectiveness of an ITS deployment at the stage of planning. Zavergiu (1996) presents an ITS cost-benefit analysis framework that can be used to predict benefits for three categories of beneficiaries: the first order beneficiary consists of travelers, the second order beneficiary consists of transportation agencies, and the third order beneficiary is comprised of external economy and environment. The classification of the beneficiaries provides a better understanding of the true benefits of ITS. Lee (2000) presents a cost-benefit study on a traveler information system deployed in Washington State in which all internal benefits to travelers and external benefits to the environment and congestion were converted into dollar values. The value of time, dollar value of pollution cost, and the marginal cost of congestions were used in this cost-benefit analysis. Using a similar method, in this section, a case study of cost-benefit analysis for the Austin, TX region is presented, using available tools, and collected or simulated traffic data.

ITS Deployment Analysis System (IDAS): In order to assist decision makers in such cost-benefit analysis, some computer programs were developed at the federal level. The most often used programs include IDAS (Cambridge Systematics, 2001) and SCRITS (SAIC, 1999), which were discussed and compared by Peng et al. (2000) along with other ITS evaluation programs. The application of these computer programs has remarkably enhanced the ITS benefits evaluation process (Sadek and Baah, 2003).

IDAS is a sketch-planning tool designed to assist transportation planners and ITS specialists in completing a comparative cost-benefit analysis for potential ITS projects. It can be used to estimate impacts, benefits, and costs attributed to deploying ITS components. IDAS is a post-planning tool that requires travel demand models to be processed before being imported. IDAS is also capable of implementing mode split and traffic assignment steps associated with the traditional model. Working with the output of existing transportation planning models, IDAS is capable of predicting costs and benefits for more than 60 types of ITS options. Within IDAS, the users can:

- Compare and screen ITS deployment alternatives
- Estimate the impacts and traveler responses to ITS
- Develop inventories of ITS equipment needed for proposed deployments and identify cost sharing opportunities
- Estimate life-cycle costs including capital and O&M costs for the public and private sectors
- Provide documentation for transition into design and implementation.

The performance measures used by IDAS include:

- Changes in user mobility
- Changes in travel time/speed,
- Changes in travel time reliability (non-recurring congestion duration),
- Changes in fuel costs,
- Changes in operating costs,
- Changes in accident costs,
- Changes in emissions and noise.

Figure 2.1 shows a snapshot of IDAS analysis interface.

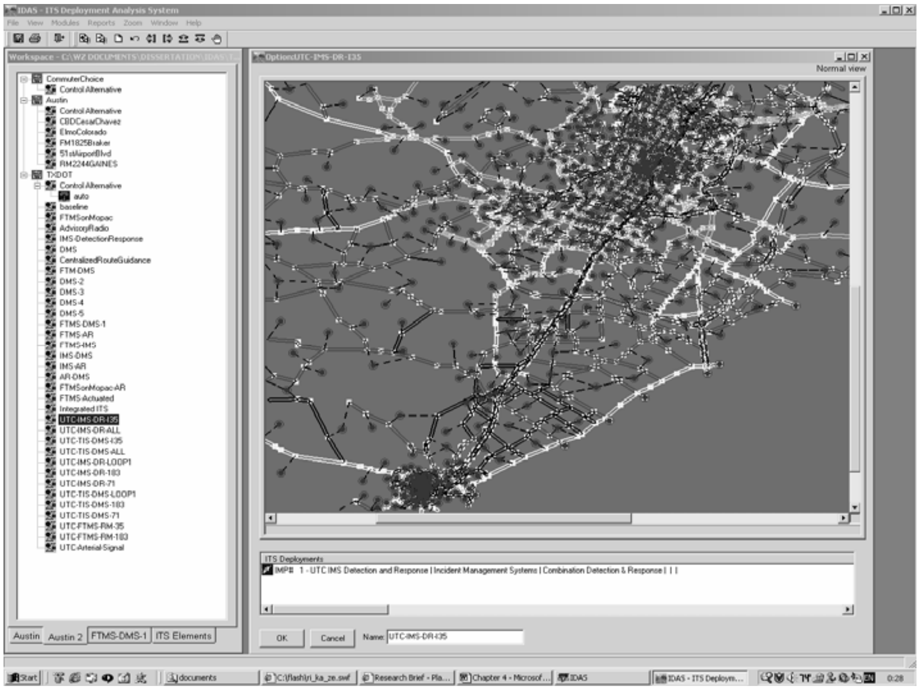

Figure 2.1: Evaluate ITS Options with IDAS

Compared to other ITS evaluation programs such as SCRITS, IDAS is a complicated program to evaluate ITS options. Basically, IDAS can estimate the costs as well as the benefits of an ITS option. The outputs of IDAS are the costs and benefits of the ITS options in dollars. A benefit-cost ratio is calculated for each ITS option. All of the ITS options benefits are measured in dollars. For example, IDAS use the average value of time to measure the benefits of time savings, travel time reliabilities, etc. In order to apply IDAS to a certain area, some parameters in the program need to be customized such as the average fuel price, the average value of time, etc. If the parameters are difficult to measure, then the default values in IDAS programs can be used. An example is the emission costs ($/ton). IDAS program gives the basic values for the costs of hydrocarbons, carbon monoxides, nitrous oxides, etc. If users are not able to customize these values, the default values can be applied.

Numerical Analysis: A simulation study has already been completed using the DYNASMART-P model to assess the impact of traveler information on both tolled and non-tolled roads. As described before in Product One and Product Two, two scenarios have been designed to perform the simulation experiment:

Scenario 1: SH 130 tolled, no traveler information provided. This scenario is considered the baseline scenario. In this scenario, SH 130 and SH 45 South are toll roads. There are no other toll roads in the Austin network. In addition, no traveler information is provided. In this no-ATIS scenario, DYNASMART-P simulation results show that the average trip distance is 8.4 miles and the total trip distance during the 100-minute period is 4,492,723 vehicle miles. The average travel time for all the trips made during the 100-minute morning peak period is 29 minutes, in which 12.8 minutes are stop time. The overall travel time is 259,229 vehicle-hours and the total stop time is 114,641 hours.

Scenario 2: **SH 130 tolled, traveler information provided via dynamic message signs (DMS)**. In this scenario, SH 130 is tolled. Traveler information is provided along Interstate Highway 35 (I-35) via DMS deployments. A total of 19 DMSs are deployed along IH-35 at major diversion points, which include the junctions of I-35 and major freeways in the Austin area, for example, the junction of I-35 and SH 130 in the north, the junction of I-35 and SH 45 North, and the junction of I-35 and US 183.

According to the DYNASMART-P simulation outputs, the average trip distance is 8.9 miles, which is 0.5 miles longer than the baseline scenario. The total trip distance during the 100-minute period is 4,777,624 vehicle miles. The average travel time for all the trips made during the 100-minute morning peak period is 28.45 minutes, in which 11.45 minutes are stop time. The system average travel time is about 0.5 minute less than the baseline scenario and the average stop time is about 1.4 minute less than the baseline scenario. The overall travel time in this scenario is 254,549 vehicle-hours and the total stop time is 102,425 hours.

IDAS program was used to perform cost-benefit analysis for the DMS deployments in the simulation study. The simulation outputs (i.e., the operational impact of DMS deployments described above) are used to determine the parameters and user inputs in IDAS. Table 2.5 presents the improvements of traveler information deployment.

Table 2.5: Network Performance with and without Traveler Information

	No-Information	**Information Provided**	**Change**
Average Trip Distance (miles)	8.4	8.9	+6%
Total VMT	4,500,000	4,800,000	+6.3%
Total Travel Time (hrs)	260,000	255,000	-2%
Average Travel Time (min.)	29	28.5	-2%
Total Stop Time (hrs)	115,000	102,000	-11%
Average Stop Time (min.)	12.8	11. 5	-11%

After running analysis in IDAS, the results are obtained on the proposed DMS deployments. Table 2.6 presents a summary of the costs of DMS deployments and video surveillance for incident detection and response.

Table 2.6: Cost Estimations for IH35 DMS Deployment

Cost	**Amount ($)**
DMS at IH35 N./SH130 (19 units)	
Public Capital	$489,975.18
Private Capital	$0.00
Public O&M	$234,600.00
Private O&M	$0.00
SUBTOTAL	**$724,575.18**
I-35 Incident Detection & Response (Video)	
Public Capital	$116,888.58
Private Capital	$0.00
Public O&M	$929,175.00
Private O&M	$0.00
SUBTOTAL	**$1,046,063.58**
TOTAL:	
Public Capital	$606,863.75
Private Capital	$0.00
Public O&M	$1,163,775.00
Private O&M	$0.00
GRAND TOTAL:	**$1,770,638.76**

Table 2.7 presents a summary of the cost-benefit analysis results. All benefits and costs are converted into dollar values.

Table 2.7: Cost-Benefit Analysis Output from IDAS

Benefit/Cost Summary			
Benefits are reported in 2003 dollars			
Annual Benefits	**Weight**		**DMS on IH35**
Change in User Mobility	1.00	$	2,498,203
Change in Costs Paid by Users			
Fuel Costs	1.00	$	3,921,847
Non-fuel Operating Costs	1.00	$	
Accident Costs (Internal Only)	1.00	$	979,001
Change in External Costs			
Accident Costs (External Only)	1.00	$	172,765
Emissions			
HC/ROG	1.00	$	60,220
Nox	1.00	$	240,007
CO	1.00	$	705,219
Noise	1.00	$	0
Total Annual Benefits		**$**	**8,577,335**
Annual Costs			
Average Annual Private Sector Cost		**$**	0
Average Annual Public Sector Cost		**$**	1,770,639
Total Annual Cost		**$**	**1,770,639**
Benefit/Cost Comparison			
Net Benefit (Annual Benefit - Annual Cost)		**$**	**6,806,696**
B/C Ratio (Annual Benefit/Annual Cost)			**4.84**

According to the benefit-cost analysis results, it can be seen that the proposed DMS deployments yield positive net benefits, with a benefit-cost ratio of 4.84. Providing traveler information, in this case, yields benefits in improving user mobility, reducing fuel costs, enhancing traffic safety, and reducing air pollution. The costs include equipment capital costs and O&M costs. A benefit/cost ratio greater than 1 indicates that the proposed ATIS deployment is cost-effective. It provides decision makers a good measure on the ATIS investment. The toll revenue, however, is not considered a benefit or a cost in IDAS because toll road users have to pay for that.

In addition to DMS, IDAS is capable of analyzing the costs and benefits of some other information provision strategies such as:

- Highway Advisory Radio
- Telephone-Based Multimodal Traveler Information System
- Kiosk Traveler Information
- Handheld Personal Device
- In-Vehicle Navigation System.

Analysts can customize the equipment costs and O&M costs according to local market. In general, IDAS provides analysts a practical tool to perform cost-benefit analysis for various ATIS deployments.

3. IMPLEMENTATION STRATEGY FOR ATIS IN TOLL ROAD CONTEXT

This section presents the potential implementation strategy of automated traveler information systems (ATIS) to improve both the operations of non-toll routes and the revenue potential of toll roads. Technologies and a framework for implementing ATIS in the toll road context are presented.

3.1 A Framework for Information Acquiring, Processing, and Delivering

3.1.1 Message Design and Format

The primary goal of ATIS is to provide useful traffic and travel-related information to travelers based on existing data and new supplemental data by using a variety of information dissemination technologies. This includes information for traveling in normal and poor weather, congested, and emergency conditions, etc. Table 3.1 shows the types of traveler information sought and the percentage of the 706 respondents likely to seek that information, as found in the Austin commuter survey conducted for this research project,. The table also shows the desirable frequency of updates to the content.

Table 3.1: Traveler Information Content and Update Frequency

Type of Information Sought	% Likely to Seek	Desirable Frequency of Updates
Accident locations	80%	Dynamic
Congestion locations	70%	Dynamic
Lane closures	57%	Dynamic
Estimated trip time	32%	Dynamic
Alternate routes	NA	Dynamic
Weather conditions	59%	Semi-dynamic
Road hazards	44%	Semi-dynamic
Road work	48%	Semi-static

Accidents, congestion, lane closures, trip time, and alternate routes are the most dynamic content, i.e., frequent updates are necessary. Weather and road hazards change less frequently, while road work is likely to be scheduled far in advance and is therefore virtually static information with regard to trip and route planning. Lane closures can result from static (road work), semi-dynamic (weather or hazards), or dynamic conditions (accidents/incidents), and therefore should be treated as dynamic information. These parameters serve as guidance on priorities for information to be collected and disseminated.

In the commuter survey for this project, it was found that the information content likely to affect route switching is as shown in Table 3.2.

Table 3.2: Information Content Likely to Affect Route Switching

Traveler Information Content	Likelihood of Switching Route (%)		
	Likely/ Very Likely	Neutral	Unlikely /Very Unlikely
Accident Locations	88	6	7
Road Work	77	12	11
Lane Closure	74	15	12
Recommended Alternate Route	66	24	12
Road Hazard Warnings	62	23	14
Estimated Travel Time	55	28	15
Weather Conditions	55	26	19

These findings indicate a priority for information content and relevance. Accident locations are by far the most likely information to encourage route switching, followed by road work, then lane closures. Clearly all of these are likely to result in congestion and delays, confirming that drivers want to avoid delays and/or save time. Recommended alternate routes are also highly valuable information, followed by road hazards. Surprisingly, estimated travel time ranks somewhat low as an incentive to switch. It is possible that drivers are now used to getting this information (as with weather information), and are deliberately ranking the less accessible information more highly.

In addition to content and relevance/timeliness, message design is also important. It will be critical that systems meet human factors objectives to ensure safety, efficiency, and usability. Dingus and Hulse (1993) specify human factors-related objectives for such systems. Desirable features include:

- *Navigate More Effectively*. The primary purpose of automatic navigation assistance is to allow the driver to locate unknown destinations and assist in error-free planning and route following. In addition, systems will have the capability to provide detailed, relevant information about traffic, obstacles, and roadways. The system must provide the information necessary in an accurate and timely manner.
- *Navigate More Easily*. A number of studies have found that memorizing a route, either through lists or from maps, is difficult and not done well. Remembering spatial map configurations or mentally reorienting a map is also difficult for people and it conflicts with the spatial task of driving. Other navigation tasks are difficult because the information is not always available or is obscured (e.g., street signs).
- *Navigate and Drive Safely*. Drivers should be able to navigate without jeopardizing driving performance. ATIS systems should be designed to minimize the demands imposed by the system and leave sufficient driver attention, information processing, and response resources for driving in all situations. In addition, information regarding upcoming obstacles or traffic congestion could warn drivers of potentially dangerous conditions. This feature could reduce risk, particularly in low visibility circumstances.

- *Optimize Roadway Use Efficiency*. Since traffic congestion is a problem encountered by many drivers and is expected to worsen, some systems try to distribute traffic more evenly throughout a system. If drivers are advised of congestion while planning their route, it is expected that they will avoid congested roadways. Thus, they would be able to avoid delays and not contribute further to congestion. Also, if drivers are informed of obstacles or congestion that occur while they are en route, they may be willing to detour to avoid the congestion. The feasibility of this objective depends partly on the amount and detail of information provided to the driver en route.

3.1.2 Information Sources and the Processing Requirements

As part of this research, the capabilities of Texas traffic management centers (TMC) regarding traffic information collection and processing were reviewed. The reviews were supplemented by visits to the TMCs in San Antonio (TransGuide), Houston (TranStar), and Austin (CTECC). In addition, capabilities of traffic centers in other major metropolitan areas were reviewed.

Incident Data collection: Generally, incidents that impact traffic flow are identified by observing changes in normal flows. A variety of sources provide information on traffic flow, from in-road loop detectors that count axles over time, to roadside radar detectors, to overhead video cameras that can pan and zoom in on a desired stretch of roadway. Fiber optic cable provides connectivity to the TMC, although some centers are now exploring wireless links. Detectors typically provide coverage at ramps and frontage road intersections, and the data is processed through algorithms that 'detect' unusual flows. The algorithms are adjusted for special events and holiday periods. Cameras provide coverage of freeway sections, and images are monitored visually at the TMC on a bank of screens. Most TMCs monitor only freeways, but Houston is considering adding arterial coverage. There are now some software for scanning images and detecting unusual flow conditions. Most TMCs have agreements with local TV stations to share video feeds, and in some cases even control the cameras.

There are some other sources for incident data. Many radio and TV stations provide a toll-free number for commuters to call in observed incidents, and some TMCs have started doing the same. With the ubiquitous use of cell phones, every commuter can now be a traffic monitor. Some media outlets also have ‘an eye in the sky’ during rush hours; a helicopter or light plane that circles the region and reports conditions. In some areas probe vehicles are used to monitor traffic flow and report incidents. It would be useful to have a shared database for pooling incident data.

Incident Data Processing: Since local police and the Department of Public Safety are responsible for handling incidents, they usually have a presence at the TMC. When an incident is detected, messages are exchanged via police radio to dispatch officers and emergency vehicles as appropriate. In San Antonio an “Accident Ahead” message is displayed on the upstream DMS if necessary. Incidents are logged in a TMC database/Web site which is now being made available to news outlets and the general public. However, an incident is not ‘closed’ until officers on the scene give the ‘all clear,’ which, due to liability concerns, can reportedly be as much as an hour after flow is restored. Therefore, information in the database may not be up-to-date with regard to its effect on traffic flow. It would be desirable to add a field to the database indicating that normal flow has resumed, with that field being managed at the TMC.

Congestion Data Collection: Often, there are predictable areas of congestion in a region, varying with time of day, day of week, and time of year (e.g., when school is in session). Frequent commuters are familiar with these recurrent congestion zones. Unusual congestion is of more concern. At the TMC, data on congestion comes from the same sources as incidents, i.e., flow data. In fact, congestion is usually the signal that an incident has occurred. Some newer technologies have been touted for capturing flow data and therefore monitoring congestion. For example, in Houston toll-tagged vehicles are interrogated as they pass specific locations, to provide estimates of the average speed on highway segments. In some jurisdictions public vehicles have been fitted with GPS units that report their location with a time stamp. Software converts flow data to plots of average speeds.

Congestion Data Processing: In Houston, a GIS interface is used to display color-coded average speeds. The map is updated every time a change is detected and confirmed, and is now available on the Internet. In San Antonio, a 'Congestion Ahead' message is displayed on DMS when relevant, according to a hierarchy of message urgency. Elsewhere in Texas, little is done to report the presence of, or changes in, congestion other than green/amber/red arrows on lane controllers. In Melbourne, Australia, 'Drive Time' signs provide estimated travel times as well as a color-coded indicator advising where traffic volume is light (green), medium (yellow), or heavy (red). In Japan, commuters see overhead visual displays similar to maps well in advance of congested locations.

Lane Closures Data Collection: Lanes may be closed for a number of different reasons. For emergencies, many jurisdictions have plans in place for road closures, contraflow evacuations, and similar drastic measures. For accidents, the police follow internal guidelines with regard to which lanes are closed and for how long, regardless of the effects on traffic flow. Even for relatively minor incidents, it is not unusual to have lanes closed. TxDOT has espoused a 'Move It' campaign to get motorists to move disabled vehicles off the traveled lanes to reduce congestion. Lane closures can also result from weather and other hazards. Some of these closures are predictable. The most predictable lane closures are those due to scheduled construction.

Since lane closures can result from a variety of events, data sources are also various. Obviously, closures for scheduled road work can be communicated by the contractor or maintenance crew to the TMC in advance. Similarly, weather hazards can be communicated by maintenance crews. Other types of lane closures (and re-openings) ought to be communicated by the party making the decision (e.g., police) as soon as practical. Clearly, the safety of the immediate victims of an incident is paramount, but the safety of approaching motorists and emergency workers makes it essential that lane closures are properly communicated to the TMC, and then effectively disseminated.

Lane Closure Data Processing: Lane closure locations ought to be recorded both as absolute coordinates and as relative positions. GPS coordinates would be ideal, obtained, possibly, from the portable arrow signs used to signal closures. A GIS interface that allows the GPS data to be graphically portrayed as a red line on a map, and 'translated' to a location description, would be useful. Many Internet map services, such as Mapquest, have software that ties specific locations such as intersections to maps and text descriptions of relative locations (e.g., 'southbound, half-mile from Exit 259').

Estimated Trip Time Data Collection and Processing: Trip times are derived from average travel speed on each segment of the system. As described earlier, sources of travel speed data include detectors, video, probe vehicles, toll tags, and GPS units. Point-to-point travel speed is chosen as the lower of upstream and downstream sensor speed. Algorithms convert average speeds into estimated point-to-point travel times in minutes. Segment travel time is the sum of point-to-point travel times. Times are typically given in ranges (e.g., 'travel time to IH 10 4-6 minutes'). TransGuide (San Antonio) provides travel times on DMS on all the major routes in the city, updated instantly as data is processed from the central control system. Generally, motorists express satisfaction with this information. One limitation is that it only applies to the next one or two segments. The TransGuide Web site now has a 'Dynamic Route Builder' that allows you to chain segments into a trip, and the estimated travel time is given. The Web site also has links to allow the user to see what message is currently displayed on each DMS.

Alternate Routes Data Collection and Processing: While it is possible to provide data to motorists on alternate routes, most TMCs do not, partly because of liability concerns. Route chains can be derived from digitized maps or GIS files, as is the case for TransGuide's 'Dynamic Route Builder.' The requirements for providing alternate routes are: algorithms for generating a hierarchy of paths for a given trip, lane closures, current travel times for each segment of each path, and estimated total trip time for each path.

Some private sector parties are entering the market to provide information on alternate routes. One such provider is TranSmart Technologies Inc., which is developing a 'routing' service. When the start and end points of a trip are input, the program will output the shortest-time route and driving directions. Dynamic routing is also proposed: as the driver proceeds the service would alert him if conditions on the current route change, and provide a new route from current position, using GPS and cell-phone.

Weather Data Collection and Processing: Sources of weather data include the National Weather Service (NWS) and local news outlets. The NWS provides radar images of recent, approaching and future weather patterns, and alerts, watches, and warnings of dangerous conditions. TV outlets often have their own radar services and meteorologists who provide information to radio and print media as well. Weather data is therefore sufficient in most locations for semi-dynamic updates. For example, many radio stations provide weather updates every ten minutes. Cell-phones now have the capability to provide a visual display of weather radar images.

Road Hazards and Road Work Data Collection and Processing: The sources of data on road hazards and road work have already been discussed under ‘Lane closures.’ In the U.S., commuters using cell phones are a growing source of data on road conditions. Mechanisms are needed to allow such information to be captured, verified, and in turn fed back to oncoming traffic. For example, on the toll roads in France, there is a dedicated FM channel that provides motorists with such information in addition to music and news. The station continually urges drivers to call a toll-free number to report useful information.

3.1.3 Information Delivery Technologies

According to the National ITS Architecture for the U.S., several systems are potentially capable of disseminating traveler information. Commuters currently obtain information from several sources but would prefer alternatives. Table 3.3 shows the responses of 706 commuters in the Austin area regarding technology preferences for traffic information (they could select more than one). Some commuters also added ‘cell phone’ as a category for receiving information. The differences between current sources and preferred sources, with increasing preference for ‘high-tech’ in-vehicle systems, suggest that there is a growing potential market for in-vehicle information delivery.

Table 3.3: Commuters' Technology Preferences for Traveler Information

Question	Radio	TV	Newspaper	DMS	Internet
How do you *currently* receive traveler information on the local roadway system?	89%	36%	4%	12%	15%
Which of the following would you *prefer* to use to receive traveler information on the local roadway system?	78%	19%	2%	37%	18%

Broadcast Systems: Broadcast technologies are those that broadly disseminate information through existing infrastructure and low cost user equipment. These applications are already in wide use, and the public expects not to have to pay extra for the information. Alternatives include:

- Highway advisory radio (HAR)
- Commercial radio
- Satellite radio traffic channel
- Commercial and cable TV
- Roadside dynamic message signs (DMS).

<u>Highway advisory radio</u>: For these systems traffic information is processed only to the extent necessary to conform to the medium, and is generic, i.e., not tailored to a specific user. HAR is usually a loop of pre-recorded messages notifying motorists of 'static' conditions such as construction and lane closures, and perhaps regional weather forecasts. Typically, it is a low power signal available in a limited area, and the messages are refreshed once a day. Due to the 'staleness' of the information, HAR has a very limited audience compared to commercial radio.

<u>Commercial and satellite radio</u>: Commercial radio is currently heavily favored by in-vehicle users as a source of traffic information. Radio stations obtain data from the TMC database/ Web site, from police, fire, and EMS radio transmissions, from flyover services, and/or from

commuter phone calls. Typically, traffic updates are provided every ten minutes during rush hour. Satellite radio is starting to penetrate the radio market, but is just beginning to tap into user desire for traffic information. Satellite radio is geared to users who want to listen to a favorite station 'coast-to-coast,' and is still to design a traffic information service that is specific to the user's location.

Commercial and cable TV: Commercial and cable TV play to a different market from radio: pre-trip users who are interested in unusual conditions on their usual routes. Most TMC provide video feed from their cameras to local TV stations. For example, the Austin CTECC provides local cable channel 8 with feeds from 22 of its cameras. The stations can choose which feed to show. Many stations also display map graphics of the locations of incidents. Most TV traffic reports are delivered in the morning, at about ten minute intervals, to commuters who will be traveling in rush-hour traffic.

Dynamic message signs: DMS is classified as a broadcast medium for traffic information, since the message is not targeted to a specific user's needs. The main advantage of DMS over radio and TV is that the message can be tailored to the location. TMC operators are able to access each DMS individually, select from a set of message designs, customize if needed, and sent directly to the DMS. Messages can be set to display for a fixed period then be replaced by automatically generated travel times or other default message. Disadvantages of DMS are that the signs are costly to install (over $30,000) and maintain, the message is very brief, and in most cases the information is not provided early enough for the driver to switch routes.

Driver Assistance Systems: This category of technologies relates to providing assistance to drivers based on location devices. The two main types are:

- In-vehicle driver assistance system
- On-board GPS navigation device.

For these systems, the driver purchases a device that uses his location or destination information as input to an in-vehicle or external database, and outputs guidance on routing, navigation, attractions, etc. Most current systems have static data, although some are now becoming interactive, providing ‘live’ data.

In-vehicle assistance: The private sector is active in promoting driver assistance systems. One provider is OnStar, a General Motors subsidiary. Equipment consists of a sensor system, a GPS unit, and a built-in cell phone link to the OnStar call center. If the sensor system detects an unusual event such as an accident, a voice link is established between the car and an OnStar center operator, who tries to talk to the driver. If the driver responds, information is exchanged to determine the appropriate action. If there is no response, OnStar determines the vehicle location via GPS and notifies local 911 services. The link is active until emergency services arrive. This ‘Safe and Sound’ plan costs $17 per month. OnStar is now offering additional services, including email of vehicle diagnostics, voice navigation, stolen vehicle location, etc., for $35 per month.

GPS navigation: High-end new vehicles now have in-vehicle navigation systems as standard equipment, but there are also a number of manufacturers providing portable units (e.g., Garmin, Magellan, Sony, Pioneer, etc.). Prices are in the $250- $500 range. The unit requires a power source. A GPS unit determines the vehicle location, accesses the built-in database, and displays a map of the area to an adjustable level of detail. Some units provide 3-D and perspective views, and some provide voice driving directions when a destination is selected (e.g., ‘Turn right at Maple Street’, or ‘You have passed your exit. Please execute a U-turn at the next safe location.’). Additional services include area attractions such as hotels and restaurants. Some units have a satellite receiver that, instead of using a static database, downloads data relevant to the location, even local traffic and weather reports.

These driver assistance technologies are establishing a market for themselves. They are especially marketable to women and drivers making trips to unfamiliar regions. Because they are creating their own market and adding services as customers request them, these technologies have viable prospects.

Interactive Systems: These are systems that provide tailored information in response to a traveler request. There are two types: real-time interactive systems that respond to requests, and systems that "push" a tailored stream of information to the traveler based on a submitted profile. The technologies in this category include:

- Traffic information kiosk
- Internet-based system accessible by personal computer
- 511 system
- Personal Digital Assistant

Interactive systems require that traffic data, such as collected by a TMC, be massaged and 're-packaged.'

Kiosks: Traffic information kiosks typically provide a limited menu of options and generate a fixed set of outputs. They are of use especially to tourists and low-income citizens who do not have ready access to more sophisticated systems. One shortcoming is that sometimes the information provided assumes some knowledge of the region's transport links, which is not always the case for tourists. Another drawback is that the information may be stale by the time the user makes the trip.

Web sites: Internet-based systems are gaining popularity. Many of the TMCs now have their own Web site, with displays of traffic conditions and interactive query-response options. Private providers are also entering this arena. One example is Traffic.com, a service now available in several large metropolitan areas. As their Web site states: "Traffic.com has a network of advanced roadside sensors deployed along the highways in many areas. These sensors allow us to accurately measure and update the actual speed of traffic flow–around the clock, regardless of the weather. We also gather data from many state and local Departments of Transportation and combine this with our own sensor information. And, we have our own Traffic Operations Center staff covering each of the markets we serve–listening to police and fire department activity on scanners, monitoring video cameras, talking to transportation and other government agencies, and even driving our own cars and flying our own aircraft–to get the latest updates." One disadvantage of Internet-based systems is that they are rarely accessible en-route, so are of use mainly for pre-trip planning.

<u>511</u>: Since July 2000, the FHWA and state DOTs have been deploying 511, a nationwide road conditions phone number analogous to 911. As of April 2006, about 50% of the U.S. population has access; 511 however, is still in the planning process in Texas. Messages on incidents, congestion, road construction, etc., are recorded into the 511 system by designated local agencies. Calls are routed to a local center as for 911 calls, and users can access a voice-command menu. The system is still in its infancy, and usage is expected to grow over time. A significant shortcoming is the difficulty local agencies have experienced in providing the data, usually a ‘double entry’ exercise for them. The voice recognition system is still limited, with as much as 37% of user inputs not recognized. A premium service for paying customers has been suggested, but private providers have not evinced interest.

<u>Personal Digital Assistant</u>: PDAs are a hybrid of the phone and the computer, being able to access phone services such as 511 as well as Internet services such as Traffic.com. They are currently the most versatile interactive traveler information device, useful for both pre-trip and en-route information. They can also submit queries based on the user profile and download updates without user handling, making them safer during driving than cell phones and similar interactive devices. With a text-to-voice converter, they are like a co-pilot. For example, ALK Technologies is offering ‘Co-pilot Live,’ an interactive system feeding audio and video to PDAs. As data sources, push technologies, and in-vehicle devices improve, en-route traveler information is likely to gain in popularity.

Vehicle-Vehicle-Infrastructure Communication: The next generation of ATIS is expected to include direct communications between vehicles and infrastructure. On-the-go communication between vehicles could significantly increase highway safety. In addition, traffic delays could also be significantly reduced. Potential technologies include:

- Dedicated short range communication (DSRC)

- Wireless networks
- Cell phone tracking.

Vehicle Infrastructure Initiative (VII): This initiative undertaken by the U.S. Department of Transportation will deploy advanced vehicle-vehicle and vehicle-infrastructure communications (US DOT, ITS: Vehicle Infrastructure Initiative, 2005). This wireless communication is supported by DSRC. The VII aims for the coordinated deployments of communication technologies:

- In all vehicles by the automotive industry, and
- On all major U.S. roadways by the transportation public sector.

A VII consortium has been established to determine the feasibility of widespread deployment and establish an implementation strategy. The consortium consists of the vehicle manufacturers already involved in the VII, AASHTO, ten State Departments of Transportation, and the USDOT. Vehicles could serve as data collectors and anonymously transmit traffic and road condition information from every major road within the transportation network. Such information would provide transportation agencies with the information needed to implement active strategies to relieve traffic congestion. The VII vision is that every car manufactured in the U.S. would be equipped with a communications device and a GPS unit so that data could be exchanged with a nationwide, instrumented roadway system. According to the USDOT, a well functioning vehicle-vehicle-infrastructure communications system could halve the 43,000 annual U.S. traffic deaths.

Dedicated Short Range Communication: An example of a DSRC device is ‘Otto,’ a 5.9 GHz RFID unit from Canadian technology integrator MARK IV, designed to provide warnings to drivers, allowing them to take evasive actions, as well as providing real time information such as weather conditions, congestion, and traffic accidents. Otto uses a digital radio technology to pass information over distances of up to 1 km between roadside communicators and the on-board imbedded DSRC device on the vehicle. The technology uses WAVE (wireless access in a vehicular environment).

Wireless systems: An example of a wireless system is DaimlerChrysler's experimental radio network system derived from the IEEE 802.11 standard, also known as Wireless LAN. As soon as two or more vehicles are in radio communication range, they connect automatically and establish an ad hoc network (Figure 3.1).

As the range of a single Wireless LAN link is limited to a few hundred meters, every vehicle acts as a router, sending messages over multi-hop to vehicles farther away. The routing algorithm is based on the position of the vehicles and is able to handle fast changes of the adhoc network topology. Motorola is also implementing wireless technologies, and is considering delivery of roadside camera images to PDAs.

Figure 3.1: Car-to-car Adhoc Networks

Cell phone tracking: Cell phones periodically send signals to their network in order to track their location and quickly route a call. The accuracy of location can be within in few yards in full-coverage urban areas to a few hundred yards in rural areas. This tracking feature makes it relatively easy to overlay cell phone locations on a highway network, determine on which roads the phones are moving, and how fast they are moving. Early in 2006, the Maryland DOT signed a contract with Delcan, a Canadian software company, to monitor Cingular cell phone signals and use the data to estimate traffic speeds in the Baltimore area. The project is now being expanded statewide. Similar projects are getting underway in Norfolk, Virginia, and a stretch of

Interstate 75 between Atlanta and Macon, Georgia, conducted by the Atlanta-based company AirSage in conjunction with Sprint Nextel.

The 'Sausage Diagram:' At present, US DOT and several state DOT's have attempted to incorporate vehicle needs, roadside requirement, travelers needs and different transportation centers into an all inclusive web connected by DSRC. The idea is that every user on every step of the transportation system will be interconnected, resulting in greater safety, efficiency and the maximization of utility for the traveler and transportation system alike. Figure 3.2 provides an overview of the interconnections between travelers, vehicles, roadside facilities, and traffic management centers. It also identifies the information flow and data exchange among different sub-systems.

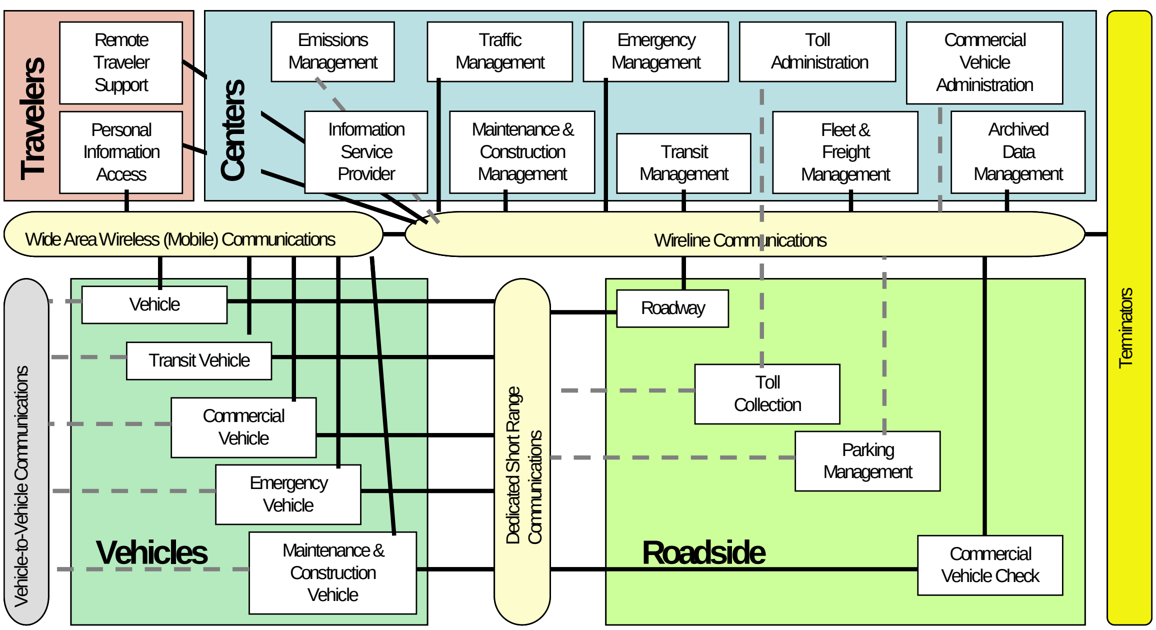

Figure 3.2: Partial "Sausage Diagram" for ITS Architecture
(from Kimley-Horn & Assoc., 2005)
http://www.dot.state.pa.us/ITS/architecture/definitions/def-subterm.htm

3.1.4 The Evolution of Traveler Information Technologies

As with most technological developments, pioneers are proving the technology, and 'settlers' are starting to adopt it. In the early stages, the emphasis has been primarily on providing travelers with information to improve their trip planning. The emphasis is now changing to supplementing static information with dynamic information that is collected and transmitted from other segments to optimize individual travel. The evolution of ATIS systems can be traced through three stages:

- 1990 to 2000: This stage focused on improving information access and timeliness. Most of these systems relied on existing technologies and drivers' knowledge of the network.
- 2000 to 2010: This stage focuses on en-route information systems, with increasing interactive content. Drivers are becoming part of the feedback loop.
- 2010 to 2020: This stage will see the development of communication between the infrastructure and vehicles. Vehicles will be used to report conditions, and the infrastructure will process the data and use it to manage traffic and inform drivers. A variety of integrated in-vehicle devices will be available.

Figure 3.2 presents an overview of the evolution of ATIS technologies and trends.

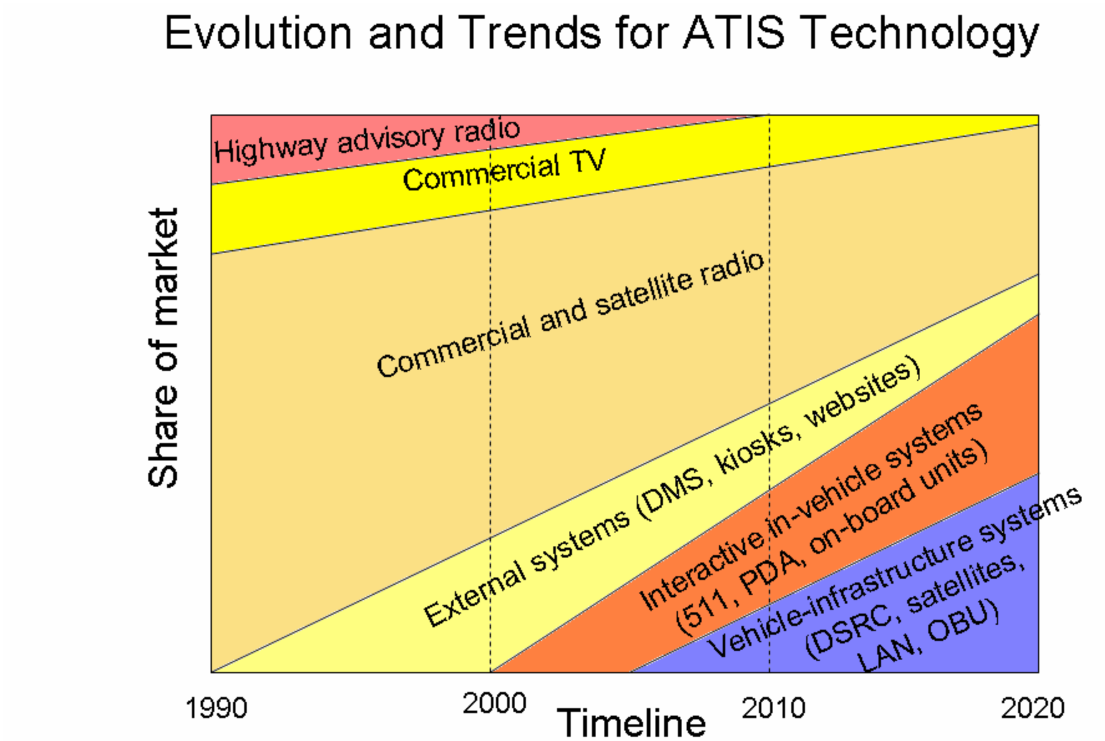

Figure 3.2: The Evolution of ATIS Technology and Trends

3.1.5 A Practical Framework for ATIS Deployment

ATIS uses advanced technologies that collect and process travel-related data and disseminate useful information to travelers. These technologies include sensors for monitoring travel conditions, communications for sending and receiving information, data processing, geo-location technologies, microprocessors, and other technological advances.

An ATIS system may cover a single metropolitan area, an entire state, or an even larger area such as a multi-state corridor. The types of information and the modes covered can also vary widely. A system might use data from a single transportation entity, such as a state department of transportation (DOT), or it may cover multiple modes of travel with data from several agencies and even private entities. Although ATIS systems may vary in coverage, technologies, and information handling capabilities, they share some common features. Namely, all ATIS systems must provide accurate, timely, and reliable information desired by travelers in a form that is convenient to use. Based on the working mechanism of ATIS, a practical framework, as shown in Figure 3.3, was developed to meet the commuter needs in Texas. Users' requirements on information and their preferences in receiving information are integrated into the framework.

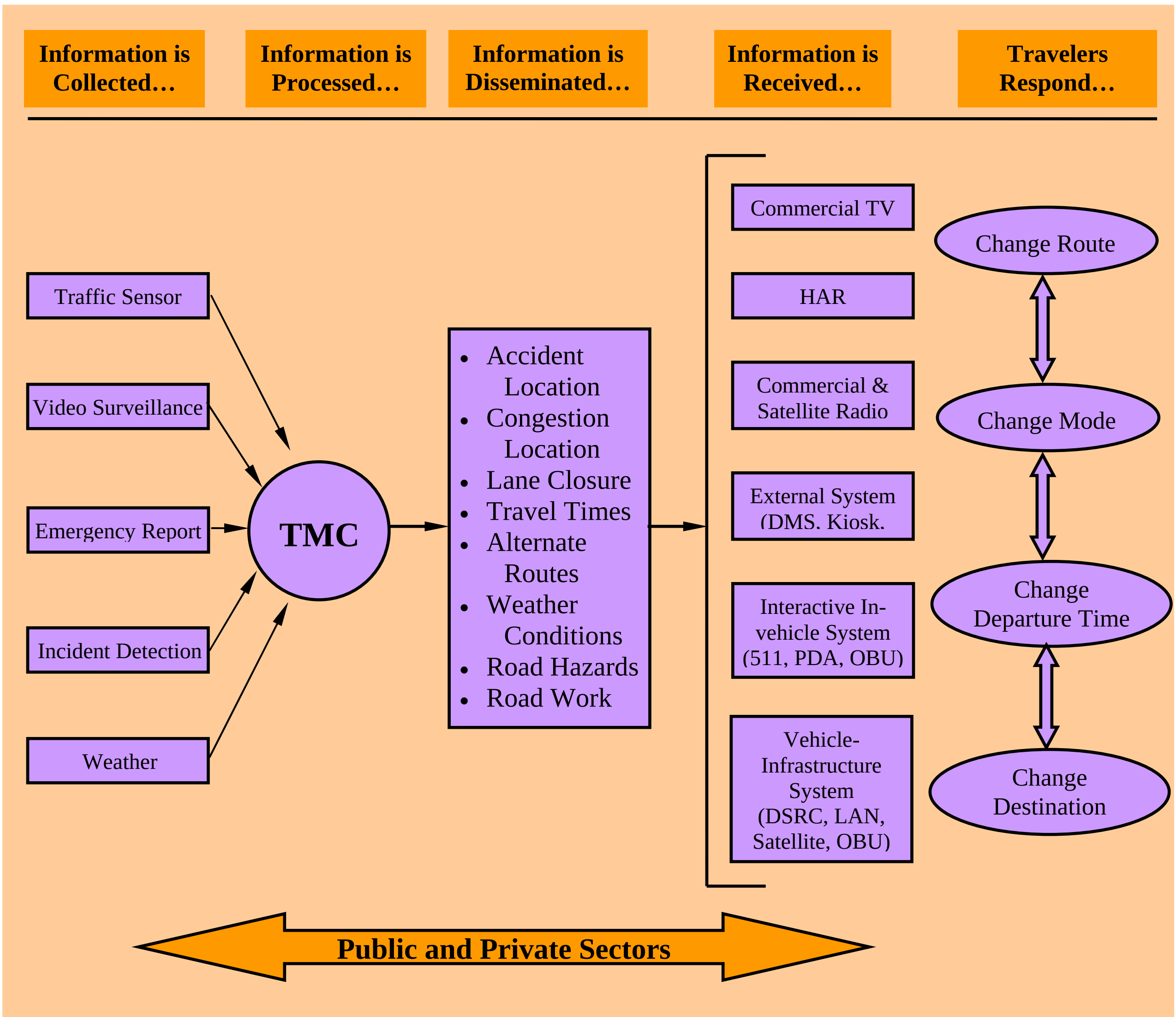

Figure 3.3: A Practical Framework for ATIS Deployment in Texas

3.2 Potential Implementation Issues

ATIS can be a promising method to enhance both tolled and non-tolled road operations. However, there are a number of specific issues associated with ATIS that need to be addressed in ATIS implementation. These issues are listed below with a brief description.

Measurement of Benefits: A significant amount of data is necessary to evaluate the benefits of an ATIS system. In most cases, information may not be available or enough for decision-making purposes. IDAS provides the analyst with a practical tool to measure the benefits and costs of an ITS alternative, including various ATIS deployments. However, it requires users to predict the potential impact of traveler information on traffic operations, which could be very difficult. In this study, the research team used the DYNASMART-P model, which is a good tool for that purpose. The data preparation and modeling process are still hard to go through. Improvements in these evaluation tools may help transportation agencies better assess various ATIS deployments and make wiser investments.

Integration with Existing ITS System: An important issue in planning for future deployment of ATIS is the constantly changing technology. The research has examined which technologies will still be in use and what new technologies need to be accommodated. Trends in ATIS clearly indicate that information dissemination is shifting to the private sector. A number of traffic information sources are available on the internet, and in-vehicle technologies such as General Motors' On-Star system, are rapidly providing additional opportunities for dissemination. It is also clear, however, that TxDOT will continue to play a key role in both data collection and dissemination. The integration of the information collection, processing, and dissemination may be a critical issue that requires strong private-public partnerships.

National ITS Standards: The National ITS Standards is one of the most researched area in ITS. Keeping ATIS deployments compliant with national ITS standards would ensure system integration, room for upgrade, interoperability, and the emergence of the wider information services.

Prospective Participants: It is important to involve all potential participants in ATIS to maximize the potential benefits. Both private and public sector groups can collect data, add value to it then disseminate information to customers. So deciding what groups to include in the ATIS is more an "inclusive" than "exclusive" process, with the selection process coming down to the question, 'Who adds net value?' (ITS-America, 1998).

Institutional Issues: Information exchange between existing TMCs and various agencies will be important in achieving maximum benefits of ATIS deployment. As ITS systems emerge in various metropolitan areas in Texas, strategies for coordination between TMCs need to be developed. Also, the coordination between state DOT and counties, state patrol, EMS, fire department, and police also need to be developed or improved. It is important to define each agency's roles and expectations, to identify the issues requiring the most coordination, and to create a management structure to resolve conflicts and carry out this coordination.

The Target Market and Revenue: Generally, there is a market for each type of information dissemination methods. For instance, the in-vehicle route guidance system is targeting at the vehicles that are equipped with in-vehicle devices and DMS is targeting frequent freeway users. The potential for revenue from the private sector is determined by the size of the ATIS market. Understanding the user market would help to improve ATIS implementations.

Funding Strategies: Development of a comprehensive funding plan for both new deployments and ongoing operations & maintenance usually remains a great challenge for any ITS deployment. The funding for operations and maintenance activities at the Texas TMCs are not likely to be available indefinitely. There is recognition that a more stable and diverse funding program is needed. Alternatives include allocation of funds from other federal and state sources, many of which are eligible for ITS.

Legal/Administrative Issues: State departments of transportation generally have broad expressed authority to contract for construction, perform maintenance and planning, or for developing and improving roads. Implied authority may exist to carry out these functions, but it is not always clear how far that implied authority extends. For example, the idea of using cell phones to collect traffic information has been proposed. It could be a very effective and economic method to achieve data collection goals. However, are transportation agencies allowed to do this? Legal issues are inevitably involved. In private-public partnerships, much of the legal concerns concentrate on who pays for what and how, who owns what and who has access to that knowledge, and who can access public information and how?

4. FUNDING OPPORTUNITIES FOR ATIS IMPLEMENTATIONS

4.1 Potential User Market for Traveler Information

The commuter survey done for this project showed that drivers are willing to pay to save time. The survey questions were couched to gauge route switching propensity for time savings, and value of those time savings. Figure 4.1 shows the threshold time savings likely to stimulate route switching.

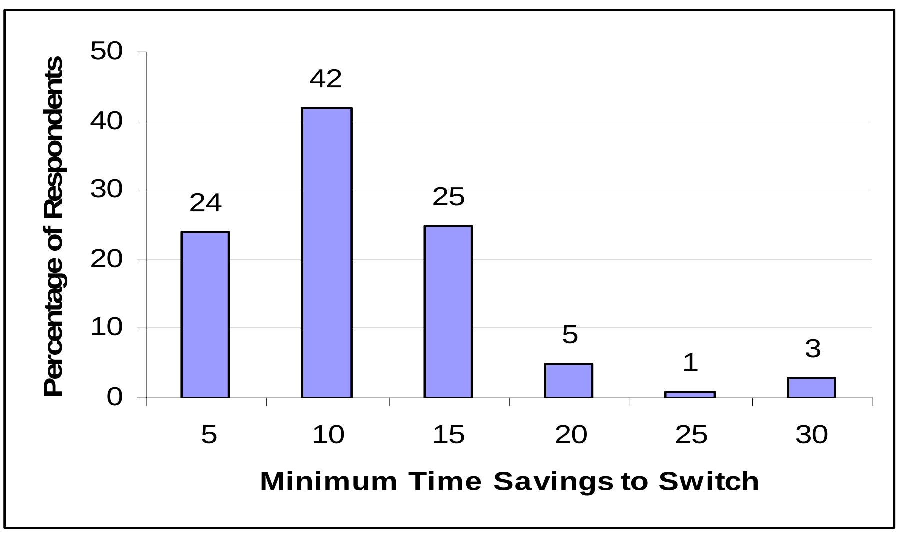

Figure 4.1: Threshold Time Savings to Stimulate Route Switching

The average desired time saving is 12.5 minutes, but the median is only about 8 minutes, i.e., 50% of commuters would switch routes for an 8-minute time saving. About 40% of respondents indicate they are willing to pay to save that time, ranging from $0.05 up to $275.50, with an average of $2.07 and a median of about $1.00 for each instance. These figures indicate that there is a potential market for systems that provide commuters with travel information that would save them time.

In the toll road context, there is an opportunity to combine tolling technology with on-board units (OBU). For example, Toll Collect in Germany uses a GPS unit on trucks to measure their mileage and apply tolls (in Germany trucks are tolled for the mileage they travel on the Autobahn system). Other European countries such as Switzerland and Poland are implementing similar tolling systems. Tolling in the U.S. is predicted to evolve from current corridor and cordon tolls, to area-wide or road user tolls as a replacement for the gas tax (Persad et al., 2006). Tolling technology is on the leading edge of ITS implementation, e.g., providing flow data for Houston TranStar. Ultimately, tolling is predicted to be a major component of integrated transportation system management, in which each vehicle carries an OBU that reports its location as well as road conditions to the vehicle-infrastructure network. As shown earlier, traveler information can enhance toll road revenues. Toll agencies can tap into this revenue by partnering with technology integrators to deploy toll collection systems that use multi-function on-board units.

4.2 Funding Opportunities from Public Sector

In this research, funding opportunities have been identified for ITS program in Texas. Funding opportunities include:

SAFETEA-LU: The bill contains a new real-time system management information program that directs the Secretary of Transportation to establish a program to provide, in all states, the capability to monitor, in real time, the traffic and travel conditions of the major highways in the United States. Appropriations in FY 2005 designated over 100 ITS deployment projects including ATIS. SAFETEA-LU has funds to cover these projects. After that, there are no dedicated ITS deployment funds. Although the ITS integration program is no longer available, ITS' are an eligible capital expense in FTA Federal funding programs.

New/Ongoing Federal Initiatives: USDOT recently announced nine new focal areas for ITS deployment that represent new sources of ITS funding. There also continues to be federal support and interest in ITS deployments related to safety and rural applications.

North American Free Trade Agreement (NAFTA) Transportation Corridors and Related ITS Strategies: As a state that facilitates a significant amount of the nation's trade— particularly in the form of providing safe and efficient routes for commercial trucks—Texas is well positioned to bring forward plans for ITS deployment that should receive significant federal support and be the source of innovative public-private partnering projects. ATIS deployments well suit that scope.

Homeland Security/Evacuations: As a state that is home to targets at high risk of terrorist attacks, contains several of the nation's largest metropolitan urban areas, and has the second-largest coastline in the nation that is prone to hurricanes, Texas is also well positioned to receive federal support for ITS deployment that addresses any/all of these issues. Regardless of federal support, ITS deployment projects that can offer multiple benefits by addressing many of these issues simultaneously should be considered. ATIS is no-doubt such type of deployment.

Cost-Sharing of ITS Deployment with New Toll Road Construction: In areas where new toll roads will interchange with existing roadways, there will be opportunities to co-deploy new ITS technologies and thereby accomplish increased ITS deployment at a reduced cost to TxDOT. ATIS should fall into this category.

4.3 Funding Opportunities from Private Sector

The funding opportunities from private sectors are very limited and generally require substantial marketing efforts. The funding opportunities from private sectors include:

Traveler Information Usage or Subscription: The commuter survey in Austin indicates that about 50 percent of respondents are willing to pay a fee if the information helps them save time. Therefore opportunities to create new sources of revenue for ITS funding appear to exist in several areas such as subscription services, data exchange, naming rights, sponsorships, and 511 information fees.

Multi-function, on-board units: In the toll road context, there is an opportunity to combine tolling technology with on-board units (OBU). As shown earlier, traveler information can enhance toll road revenues. Toll agencies can tap into this revenue by partnering with technology integrators to deploy toll collection systems that use multi-function, on-board units.

4.4 Potential Business Models for ATIS Implementations

The earliest commercial traveler information system appeared during morning commute radio shows in major U.S. cities, such as Los Angeles, New York City, and Chicago, in the mid-1950s. The traffic report programs at that time were produced by the commercial radio stations themselves and paid for by program advertisers (Lappin et al, 1994). Since the inception of the commercial traffic information business, traffic surveillance technology and information delivery technologies have improved. With rapid development in ITS technologies, ATIS becomes more powerful in collecting, processing, and disseminating information. Information provision, information processing, and information dissemination become more and more complicated and require stronger partnerships between different sectors. According to a statement of ITS-America, sorting out the roles, responsibilities and relationships of the public and private sectors is the key challenge to successfully launching ATIS (ITS-America, 1998).

In general, a business plan should address the following five issues: Define the target market, define the data to be collected, determine how to disseminate the consolidated information, show where the funding will come from and how it will be used, and estimate the costs of doing business. Based on the suggestion of ITS-America, there could be five types of business models that can be applied for ATIS implementations.

Public-Centered Operations: This business model gives the public sector the greatest measure of control over ATIS, helping direct its benefits toward meeting public policy goals, but generates the least amount of revenue while requiring the greatest amount of public expenditure. Figure 4.2 illustrates the concept of Public-Centered Operations model.

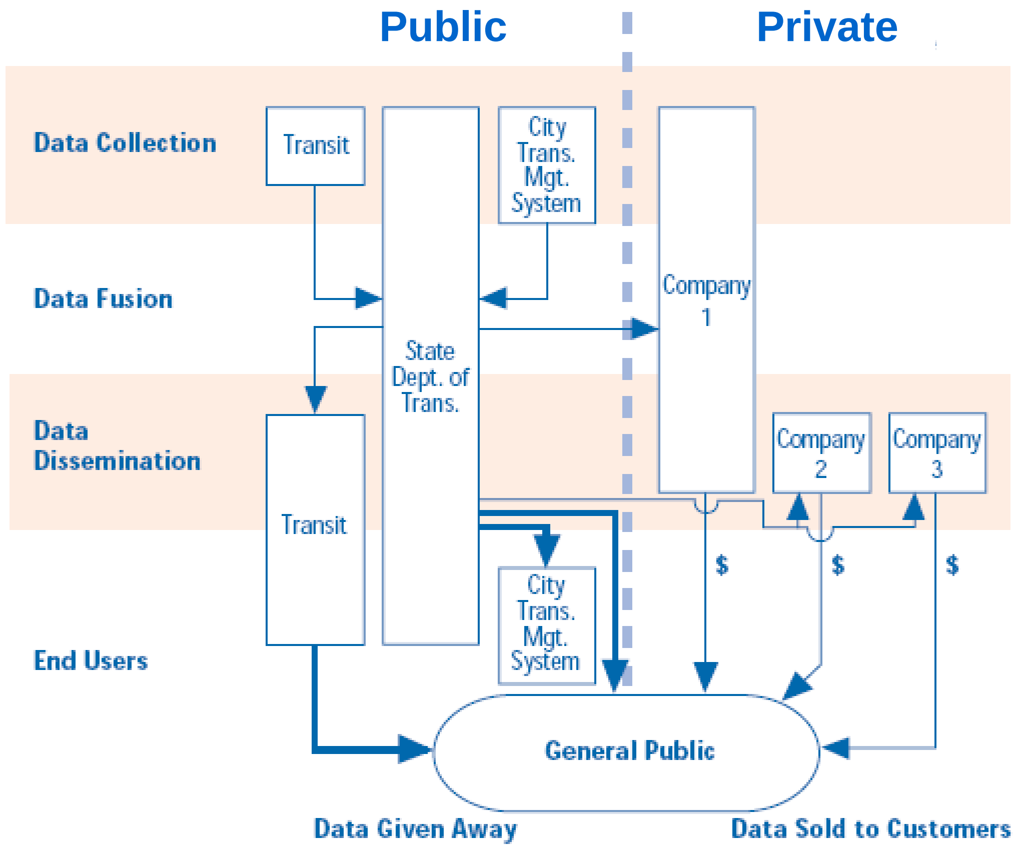

Figure 4.2: ATIS Business Model — Public-Centered Operations

This plan requires the state DOT has the expertise and interest to operate the data fusion process. Private companies have opted to obtain the data, repackage them and sell them to customers.

Contracted Operations: This business plan enables the public sector to maintain overall control of an ATIS system. It provides improved access to the private sector's technical expertise and staffing, but gives the DOT freedom to apply the constraints it believes are important for the system. Figure 4.3 illustrates the concept of Contracted Operations model.

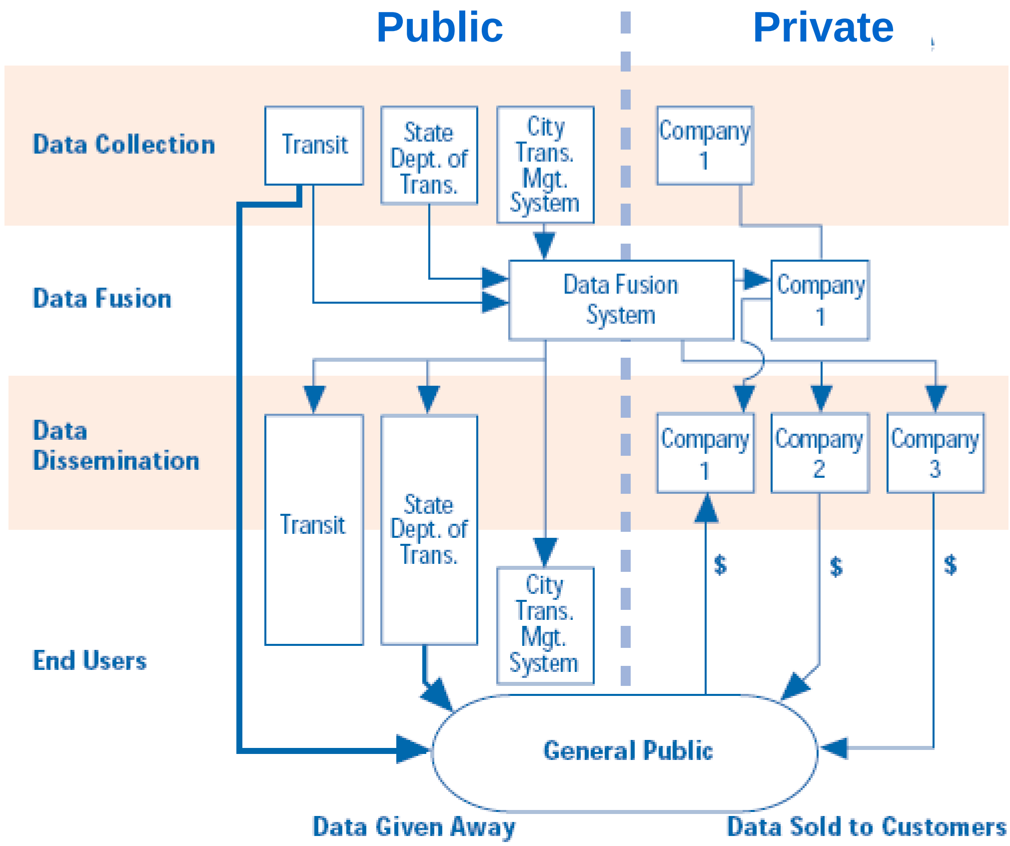

Figure 4.3: ATIS Business Model — Contracted Operations

With this business plan, the data collection and data fusion processes can be contracted to the private sector —possibly through some sort of agreements. The public sector, however, still collects, processes, and provides large amounts of traveler information to the general public. So aside from the data collection and data fusion service, the potential for revenue for the private sector might be limited.

Contracted Fusion with Asset Management: This business model adopts the same basic business structure as the Contracted Operations model, but has different emphases. First, there is a significant reduction in the amount of information provided to the public. Second, an “asset manager" function, which combines product development, marketing and sales functions, is added besides the data fusion function. Figure 4.4 illustrates the concept of Contracted Fusion with Asset Management model.

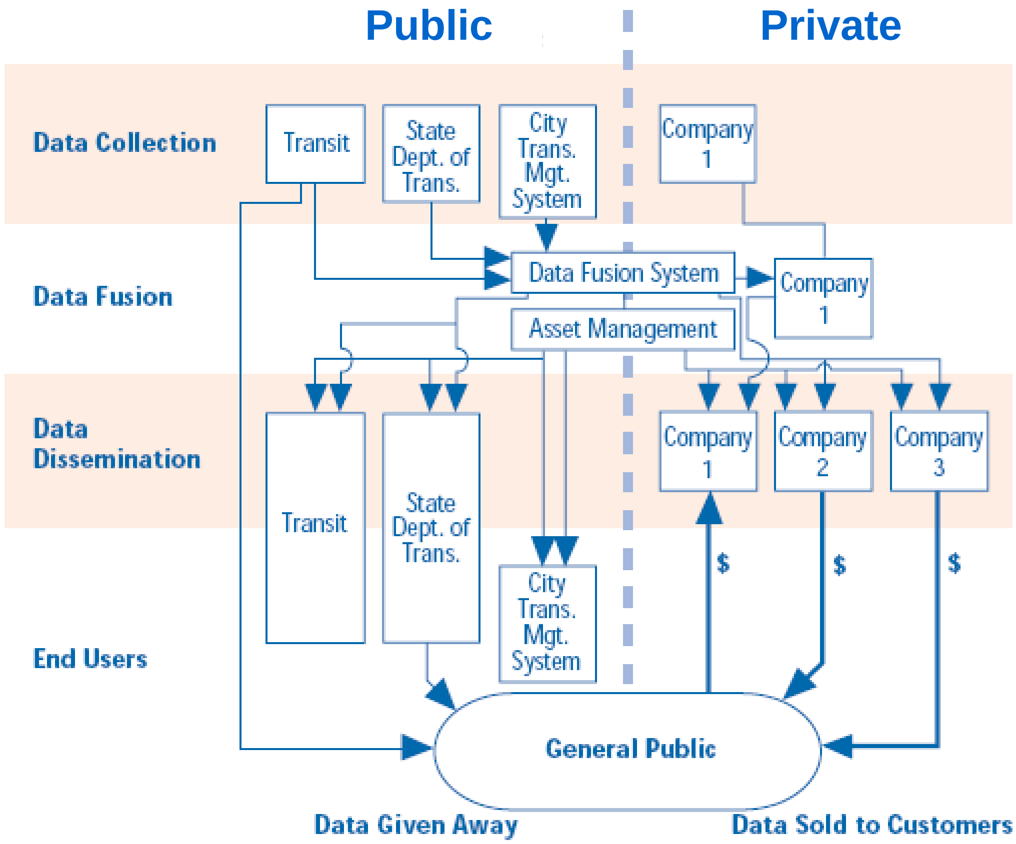

Figure 4.4: ATIS Business Model — Contracted Fusion with Asset Management

With this plan, the "asset manager" will undertake the task of finding and exploiting new uses and revenue sources of the available public sector data. It will work with the data fusion provider to create data products that meet user requirements, and sell those public sector data products to clients (private companies). The private companies will then create new services that can use these data products and maximize the revenue. The advantage of this model is that the revenue generated for public sector use can be increased.

Franchise Operation: In this business model, the public sector essentially removes itself from the data fusion process. The private sector takes over data fusion with their technical skills and marketing capabilities. Figure 4.5 illustrates the concept of the Franchise Operation model.

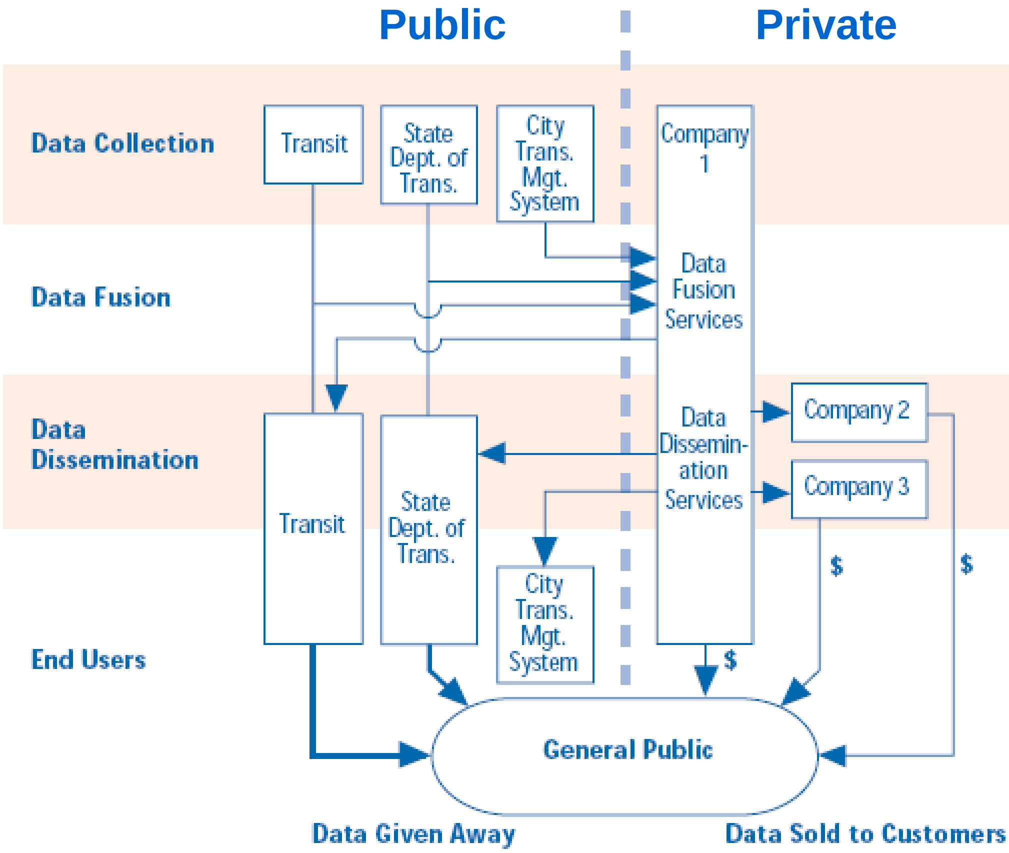

Figure 4.5: ATIS Business Model — Franchise Operation

A designated company may be granted exclusive data access to the public data. In return for the exclusive access, the private sector company that is fusing the data has to provide data back to the public sector free of charge. However, the company can sell the data to other private sector partners. With this approach, the public sector's cost can be significantly reduced and the private sector's revenue maximized. The public has to pay for most of the information. With this approach, the public sector agencies are totally reliant on the private sector for the fused data.

Private, Competitive Operations: This approach helps to maximize the competition within the ATIS market, and is aimed at lowering consumer costs and maximizing private sector innovation. Private companies have to compete in data fusions. Figure 4.6 illustrates the concept.

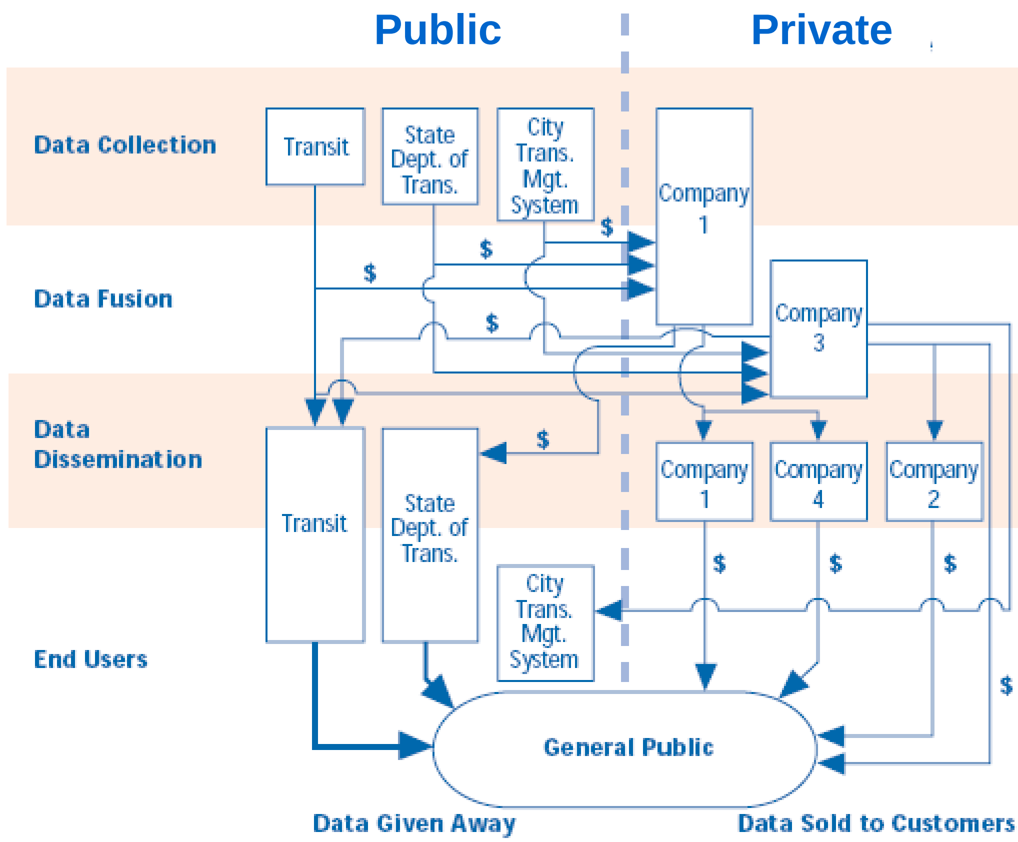

Figure 4.6: ATIS Business Model — Private, Competitive Operations

The advantage of this approach is that the competition should intensify the companies' incentives to provide better, lower-cost services. The disadvantage is that if the market is not large enough to sustain multiple companies, the revenue stream may be too small to achieve the growth needed to bring about better, lower-cost services.

A review of current Texas TMCs's data collection, processing, and disseminating shows that most TMCs are using the approach of Public-Centered Operations. In general, TMCs have overall control of the infrastructure and data. TMCs provide information to the public and other information providers such as TV stations and radio stations, mostly for free. It helps transportation agencies to meet public policy goals, but generate the least amount of revenue while requiring the greatest amount of public expenditure. In addition, all TMCs must maintain the expertise and technical staff to operate the data fusion process.

The five business models differ in the involvement of public sectors and private sectors in data collection, data access, data fusion, and information dissemination. It is recommended that Texas TMCs should adopt the business plan according to their primary objectives and policy. The decision of which business model to adopt, eventually becomes a policy issue.

5. CONCLUSIONS AND RECOMMENDATIONS

This document focuses on the following three issues with respect to ATIS:

- Benefits and costs of ATIS deployments
- A framework for ATIS implementation
- Funding opportunities and business models for ATIS

Major findings and recommendations are summarized as follow:

1) ATIS benefits both travelers and transportation agencies. When estimating the costs of ATIS deployments, the capital costs of ATIS equipments and the O&M costs are major concerns. The IDAS program is a good tool to evaluate the benefits and costs of ATIS deployments. It is capable of analyzing the benefit and cost of multiple types of ATIS. However, it may require users to provide the operational impact of ATIS on traffic flow.
2) Since traffic operations are dynamic, it is recommended to use a dynamic traffic assignment tool to estimate the impact of ATIS on traffic operations. The DYNASMART model represents the state-of-the-art of dynamic traffic assignment methodology. It is capable of evaluating several ATIS deployments such as DMS and in-vehicle navigation system. This model might well fit

TxDOT's needs in evaluating ITS deployments. Adopting the model and providing necessary training to TxDOT staff are recommended.

3) The IDAS evaluation results show that the DMS deployments in previous simulation study are cost-effective, with a benefit-cost ratio of 4.84. Deploying DMS' at major diversion points are recommended to enhance both toll road and non-tolled road operations.
4) The desired traveler information contents were identified through a commuter survey in Austin, TX. The information providing capabilities of Texas TMCs were reviewed. It was found that most TMCs in Texas are capable of providing the commuter-desired traffic information.
5) Various information delivery technologies were evaluated. These technologies include highway advisory radio (HAR), commercial radio, satellite radio traffic channel, commercial and cable TV, roadside dynamic message signs (DMS), in-vehicle driver assistance system, on-board GPS navigation device, Internet-based system accessible by personal computer, 511 system, personal digital assistant (PDA). Based on a review of evolution of ATIS technologies, it was found that the on-board unit was the most promising information receiving method for users. It is recommended that TxDOT explore funding opportunities and public-private partnerships in disseminating traveler information to users through on-board units.
6) A practical framework was developed for ATIS implementations. The elements and their relationships were identified for information collection, information processing, information disseminating, information receiving, and traveler response. The potential implementation issues such as system integration, national ITS standards, system evaluation, funding, institutional and legal issues were identified and reviewed.
7) Funding opportunities for ATIS deployments were explored in this study. It was found that ATIS deployments were generally reliant on funding from the public sector. There is a market for traveler information and it is found that about 50% of commuters are willing to pay. However, the market is still immature. Funding

opportunities in private sectors are limited and need substantial marketing effort. It requires public-private partnerships to create and promote the traveler information market.

8) Several business models for ATIS implementations were reviewed. It was found that most TMCs in Texas are using the Public-Centered Operations approach. There is significant scope for private sector involvements. Choosing which business model to apply eventually becomes a policy issue. It is recommended that TMCs choose the most effective approach according to their primary objectives and policies.

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