A Case Study:

Benefits Associated with the Sharing of ATMS-Related Video Data in San Antonio, TX

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Introduction

This paper summarizes various findings relating to the integration of Advanced Traffic Management System (ATMS) components of video data in San Antonio, TX. Specifically, the paper examines the perceived benefits derived from the sharing of video data, based on on-site interviews with local stakeholders. The paper provides a general overview of the use and integration of video in Phase I of the TransGuide project. The motivating factors behind the sharing of video data, how video data are shared, and with whom the data are shared are also summarized in the paper. The paper also itemizes various issues relating to facility design, hardware, and software that the Texas Department of Transportation (TxDOT) faced during the design and implementation of TransGuide.

The evaluation is based primarily on expert opinion and observation. The benefits derived from the sharing of video data presented in this paper are mostly qualitative in nature. Since the reported benefits are based on interviews with various stakeholders, they do not necessarily include a complete and exhaustive list of potential benefits that may be derived from the sharing of TransGuide video data. A large portion of the study addresses issues associated with "why" and "how" video data are used as opposed to simply reporting the benefits associated with the sharing of these data.

The study focuses on traffic-related benefits and does not explicitly address safety benefits such as reduced fatalities and crashes. Furthermore, it is important to note that the study examines only ATMS issues relating to video data sharing. Potential benefits associated with video data uses in ATIS or APTS are not addressed in this paper.

Findings

Numerous benefits can be derived from integration in general and specifically from the sharing of video data. This study provides evidence indicating that significant benefits currently realized through the sharing of video in San Antonio would likely not have been realized at all if integration had not occurred. In most cases, the various integration benefits were achieved for a relatively small incremental cost. Benefit categories include:

- Integration of freeway management and incident management,
- Integration of freeway management and traveler information,
- Integration of freeway management and transit management, and
- Integration of incident management and freeway management (reverse flow).

The benefits presented in this study represent only a small portion of the potential total benefits of video data sharing. Stakeholders felt that additional benefits would become apparent over time. Since video data sharing is a relatively new practice, many stakeholders felt that the true potential for video data sharing was only beginning to be understood and realized.

According to TxDOT officials, the video component of TransGuide is possibly the most important feature of the ATMS in San Antonio. The current success of the system would not have been possible without the use of video. The TransGuide ATMS depends on voluntary public compliance to be effective, and therefore must provide both timely and accurate information 365 days a year. Video allows TxDOT to:

- Verify incidents,
- Accurately determine the severity of individual incidents,
- Quickly identify the location of individual incidents, and
- Select the most appropriate response to individual incidents.

Without video, these actions might not be possible.

Over the course of a week, the MMDI (Metropolitan Model Deployment Initiative) Integration Evaluation Team interviewed numerous local stakeholders who were asked open-ended questions regarding their opinions about the sharing of TransGuide video. The ten primary benefits attributed to the sharing of video data were:

1. Expedite EMS Response
2. Accurate EMS Response
3. Accurate Traffic Information
4. Reduce Congestion during Incidents
5. Improve Relationships between Stakeholders
6. Direct Cost Savings for VIA Metropolitan Transit Authority
7. Accurate Weather Conditions
8. Close Coverage of Incidents
9. 24-Hour Real Time Freeway Coverage
10. Direct Cost Savings for the San Antonio Police Department (SAPD)

An improved relationship between stakeholders was the most commonly mentioned benefit. Many stakeholders also considered improved relations to be the greatest long-term benefit. Real-time video was the catalyst for co-location of the various agencies in the Traffic Operations Center (TOC). In turn, co-location has facilitated improved cooperation and communication among the various stakeholders.

Improved communication and cooperation between public sector agencies has extended well beyond Phase I of the TransGuide project. Individual agencies now tend to be much more aware of what other agencies are doing, and voluntarily work together to achieve common goals. Improved cooperation and communication can result in operating cost savings and improved public service.

Several stakeholders indicated that the San Antonio Police Department (SAPD) is the biggest public sector beneficiary of video sharing. Video allows the SAPD to effectively perform its job on monitored freeway segments. Prior to TransGuide, operational procedures required the SAPD to investigate all reported incidents. Officers had to verify the incident, assess the situation, and then call for the appropriate backup. Details with regard to the location and severity of reported incidents were often vague or misleading. Using video, the SAPD dispatcher at the TransGuide Traffic Operations Center (TOC) can view the scene of a reported incident in order to verify the report without having to send a patrol unit. Once a report is verified, the dispatcher can view details of the incident using CCTV cameras and select the appropriate level of response. Incidents are responded to within two minutes of detection.

The use of video is explicitly designed to benefit the driving public. The sharing of video provides even greater benefits to the public. The public receives significant benefits in the form of:

- Quick EMS response
- Accurate EMS response
- Accurate traffic information
- Reduced congestion during incidents.

Participants were also asked how they felt the public, elected officials, traffic agencies, and non-traffic-related public agencies perceived the use of video. The various stakeholders had substantially different opinions on how the various groups view the use of video, particularly with regard to the public. Some survey participants felt that it was important that the public have a good understanding of the benefits associated with ATMS video data. Other participants did not seem to think public understanding of video was really that important to the overall success of the project.

Chapter 1. Introduction

The city of San Antonio is the third largest metropolitan area in the state of Texas, and is the ninth largest city in the United States (1, 2). Like many other large metropolitan areas in the country, San Antonio experiences heavy congestion on its freeway system during both peak and off-peak hours due to accidents, recurrent congestion, and highway maintenance and construction. San Antonio currently averages around 100 accidents per day (1, 2).

Before implementation of TransGuide, police response times following incident notification averaged about 18 minutes. Additional time was also spent determining the appropriate response to individual incidents and waiting for the arrival of emergency medical services, the fire department, tow trucks, and other support/emergency personnel once the police arrived at the scene.

In order to respond to these traffic conditions, the Texas Department of Transportation (TxDOT) – San Antonio District, with support from the Federal Highway Administration (FHWA), developed an ATMS program for San Antonio. Phase I of the project, entitled Transportation Guidance System (TransGuide), became operational on July 26, 1995 (3). Phase I of the project provided for construction of the initial 26 miles of the 191 miles of the ATMS program. Phase I also included construction of the Traffic Operations Center (TOC), mainframe computer system, application software, communication switching equipment, and all supporting hardware (1, 2, 4).

The TOC was designed to operate with full functionality upon its completion. Consequently, although the full 191 miles of the ATMS roadway are not yet deployed, the TransGuide system is fully operational for the 26 miles of roadway currently deployed. The additional lane miles will have only a minor impact on the operations of the center.

1.1. Overview of the MMDI

On January 10, 1996, Secretary of Transportation Federico Peña announced a major ITS deployment goal called Operation TimeSaver. The goal of Operation TimeSaver is to reduce travel time by at least 15 percent by deploying an integrated Intelligent Transportation Infrastructure (ITI) in the 75 most congested metropolitan areas in the United States[1]. To support this goal, the US DOT initiated the Metropolitan Model Deployment Initiative (MMDI) program. The MMDI sites provide a setting for evaluating the benefits associated with deployment and implementation of the ITI in four metropolitan sites in the Unites States[2]. The deployments are expected to improve transportation management and increase the level of service to the traveling public. The goals for the MMDI mirror the National ITS Program Plan goals and objectives:

[1] The ITI is the core ITS infrastructure described in Operation TimeSaver. The nine ITI components are described in the *San Antonio Metropolitan Model Deployment Initiative Evaluation Plan*.

[2] The four MMDI sites are San Antonio, TX, Phoenix, AZ, Seattle, WA, and New York, NY.

- Improve the safety of the Nation's surface transportation system.
- Increase operational efficiency of the surface transportation system.
- Increase the capacity of the transportation system.
- Reduce energy and environmental costs associated with traffic congestion.
- Enhance present and future productivity.
- Enhance personal mobility and convenience/comfort of the surface transportation system.
- Create an environment in which the development and deployment of ITS can flourish.

1.2. Background of the San Antonio MMDI

San Antonio is one of the four deployment sites selected to participate in the MMDI. The other three sites include Phoenix, AZ, Seattle, WA, and New York, NY. The San Antonio MMDI consists of ten evaluation projects. These projects are listed in Table 1[3].

Table 1. The Ten MMDI Evaluation Projects in San Antonio

SA-1 City-wide Traffic Signal Coordination	SA-6 Kiosks
SA-2 Freeway Management Expansion	SA-7 In Vehicle Navigation (IVN)
SA-3 LifeLink	SA-8 Web Page
SA-4 Bus Incident Management System (BIMS)	SA-9 Paratransit Vehicles with IVN
SA-5 Advanced Warning for Railroad Delays (AWARD)	SA-10 Area Wide Database

Source: San Antonio MMDI Evaluation Plan, 1998

The video data sharing case study is part of the MMDI Integration Evaluation. It is currently one of three Integration case studies being performed in San Antonio. The three studies are:

1. The Benefits Associated with the Sharing of ATMS-Related Video Data
2. Effectiveness of Vehicle Probe and Loop Detector Data for Advanced Traveler Information System (ATIS)
3. Performance of Vehicle Probes at Higher Levels of Market Penetration

TxDOT has established specific ITS-related goals that are consistent with the goals outlined in the National ITS Program Plan. The specific goals of TransGuide, TxDOT's ATMS for San Antonio, are:

- Improve traveler safety on San Antonio's freeway system.

[3] A detailed description of each of the projects is provided in the *San Antonio Metropolitan Model Deployment Initiative Evaluation Plan*.

- Improve response by police and emergency service personnel and equipment in treating and transporting injured persons to hospitals and in assessing and clearing traffic incidents.
- Reduce traffic congestion and transit delays experienced by freeway travelers.
- Increase effectiveness of user services and other related initiatives through integration with TransGuide.

In addition to the specific goals mentioned above, TransGuide has identified several priorities. Gaining public support and acceptance for the deployment and use of ITS technologies are regarded as extremely important to the success of ITS deployment in the San Antonio area – both present and future. In order to gain public support and acceptance, TransGuide must be highly accurate and dependable. Like other traffic management systems, TransGuide relies on driver acceptance and compliance to be effective. TransGuide is therefore designed to provide transportation and enforcement officials with the opportunity to react to freeway incidents within two minutes of their occurrence and to affect changes to all traffic signal devices in the system within 15 seconds (1, 4).

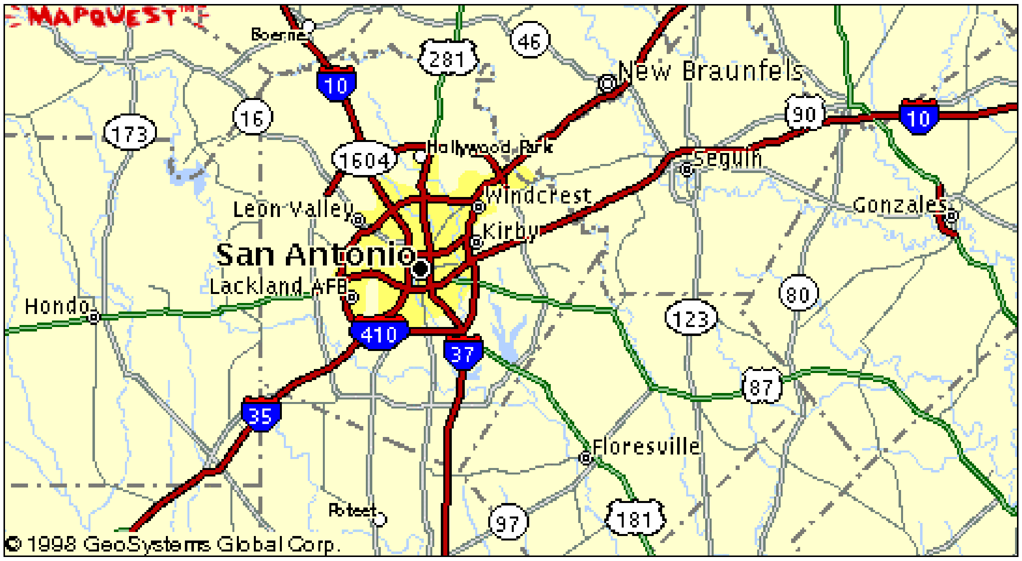
1.3. Geography and Demographics

The city of San Antonio is located in the central portion of southern Texas, and is the third largest city in the state. San Antonio encompasses approximately 389 square miles and has a population of about 1,115,600 (5). Major highways in the metropolitan area include I-35, I-10, and I-37. San Antonio has two freeway loops running around the city. The inner loop is Loop 410, which is primarily located within the San Antonio metropolitan area. The outer loop is Loop 1604, which is located outside the metropolitan area. The northern portion of Loop 410 and I-10 are the most congested segments of the freeway system according to TxDOT officials. San Antonio has a public transit system that includes buses, paratransit vehicles, and streetcars which are operated by the VIA Metropolitan Transit Authority.

According to the 1995 Highway Statistics (6), the city of San Antonio contains 5,139 total roadway miles, with about 211 of those miles being interstate or freeway miles. Approximately 44 percent of Daily Vehicle Miles Traveled (DVMT) are on freeways. The total DVMT in San Antonio are 29,157,000. Of those, 9,737,000 are interstate miles, 3,175,000 are other freeway and expressway miles, and 4,629,000 are other principal arterial miles

A road map of San Antonio is shown in Figure 1. The major highways and loops described above are clearly illustrated.

Figure 1. Highway Map of San Antonio



Source: Excite Travel, San Antonio, TX

This paper is organized in the following manner. The scope and purpose of the study are discussed in Chapter 2. An overview of the TransGuide ATMS and the use of video data for traffic management are presented in Chapter 3. The study methodology is discussed in Chapter 4. Chapter 5 provides a detailed description of video data sharing, summarizes the origins of video data sharing, and examines the various obstacles faced by local stakeholders in implementing the sharing agreement. Chapter 6 describes the perceived benefits associated with video data sharing, discusses the potential magnitude of those benefits, and maps the perceived benefits to the Few Good Measures (FGMs). The summary is provided in Chapter 7.

Chapter 2.   Scope and Purpose of the Study

The purpose of this paper is to report the perceived benefits resulting from sharing ATMS-related video data in San Antonio. The paper presents the motivating interests behind the sharing of video in San Antonio, how video is shared, the stakeholders involved in the sharing of video, and the benefits resulting from the sharing of video.

TransGuide is a dynamic ATMS, and therefore is constantly changing. New benefits will be realized, and the magnitude of certain benefits may even change over time. The MMDI evaluation, however, took place during a specified period. The TransGuide system and the benefits reported in this paper reflect conditions during the evaluation of San Antonio's ATMS during the summer of 1998. Figure 2 provides a timeline of developments for TransGuide, and clearly illustrates the point in time at which the MMDI evaluation took place relative to other activities.

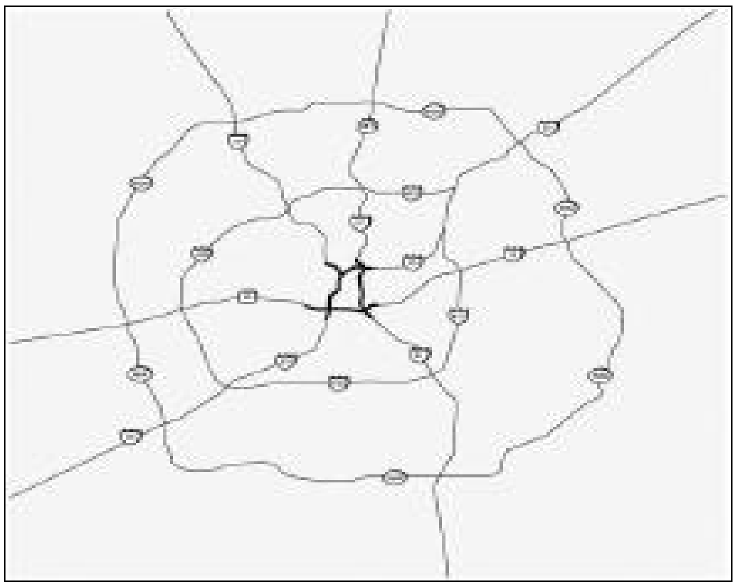
Figure 2. TransGuide Timeline

Waiting on input

Although the focus of this paper is on the video data component of TransGuide, the video component is not entirely separable from other components in the TransGuide system. TransGuide relies on real-time traffic information to initiate any one of, or a series of, responses based on pre-engineered solution scenarios. Video data is only a portion of the total information used by the system to effectively manage San Antonio's roadways. The system is also dependent on data collected from inductive loop detectors, probe vehicles, and simulation modeling. Given the interdependence between the various data used in TransGuide, this paper also addresses some issues relating to ATMS data in general.

The study focuses on the 26 miles of I-10, I-35, I-37, US-90, and US-281 included in Phase I of the TransGuide implementation. Fifty-nine video cameras, more than 800 inductive loop detectors, 359 lane control signals (LCS), 51 variable message signs (VMS), and approximately 70 miles of fiber optic cable were required to adequately instrument the first phase of the San Antonio ATMS program (1, 4). A map of TransGuide coverage is provided in Figure 3. The bolded roadways in the center of the map are included in Phase I of the project.

Figure 3. Map of TransGuide Functions in San Antonio



Source: TransGuide Advanced Traffic System Management Web Page

It is important to note that TxDOT is currently involved in numerous other projects relating to the TransGuide ATMS. The MMDI evaluation focuses on the specific issues, geographic areas, hardware, and software involved in the Phase I project of TransGuide. This paper does not examine specific benefits related to other phases of San Antonio's ATMS or to other TxDOT projects that may utilize video data.

An overview of the TransGuide system is presented in Chapter 3. The use of video data is also discussed in detail in Chapter 3.

Chapter 3. Overview of TransGuide

Understanding the basic goals and functionality of the TransGuide system is paramount to understanding the use of video data within the system. This section presents a brief but detailed overview of the layout and functionality of the TransGuide ATMS. System requirements, system design, and the role of video in TransGuide are also discussed.

TransGuide is an ATMS that utilizes innovative traffic management concepts and technologies to restore freeway capacity and improve safety (4). TransGuide refers to the ATMS as a whole, not just the Traffic Operations Center (TOC), software, or hardware. TransGuide was designed to allow for flexibility and expandability in order to incorporate future development and technologies into the system as the metropolitan area of San Antonio grows and as new technologies become available. TransGuide will also be integrated with other ITS systems such as Advanced Traveler Information Systems (ATIS), Advanced Public Transportation Systems (APTS), and Commercial Vehicle Operations (CVO) in the future.

TransGuide, like other traffic management systems, depends on driver compliance and acceptance to be effective. The first and highest priority of TxDOT was to establish baseline public confidence in the system (4). Once public confidence was won, it became imperative to maintain that confidence over time. Public confidence and acceptance of TransGuide depend on the ability of the system to provide accurate, real-time traffic information to drivers.

The goal of providing accurate responses to traffic conditions was addressed by the development and implementation of pre-engineered responses to detected traffic incidents (4). TransGuide incorporates a library of thousands of pre-engineered incident responses in its database. Operators can quickly select the most appropriate solution scenario with the confidence that each response has been individually developed, reviewed, and approved by traffic management experts for use in a particular situation. TransGuide designers felt that the use of pre-engineered and approved responses was the best way to ensure system consistency, achieve quality performance, and reduce potential legal liabilities within the ATMS. The goal of providing real-time detection and assessment of traffic conditions was specified to mean that incidents are detected, assessed, and responded to within two minutes of occurrence.

In addition to the operational goals presented in Chapter 1, TxDOT has several self-imposed operational priorities for TransGuide. The priorities were dictated by the importance of achieving public acceptance and long-term viability of the system. According to the TransGuide ITS Design Process (4), self-imposed operational priorities include:

- Accuracy and credibility,
- Real-time responses to incidents,

- Operations and maintenance cost considerations, and
- Positioning TransGuide for the future.

TransGuide designers also recognized the importance of certain time-sensitive activities in order for the system to achieve its goals of capturing and maintaining public confidence and trust. The nature of these time-sensitive activities can impact safety and traffic delay. According to the TransGuide ITS Design Process (4), the real-time functional goals include:

- Detect incidents,
- Verify presence and nature of incidents,
- Respond to incidents in an appropriate manner,
- Control traffic in order to reduce congestion, and
- Support other ITS user services.

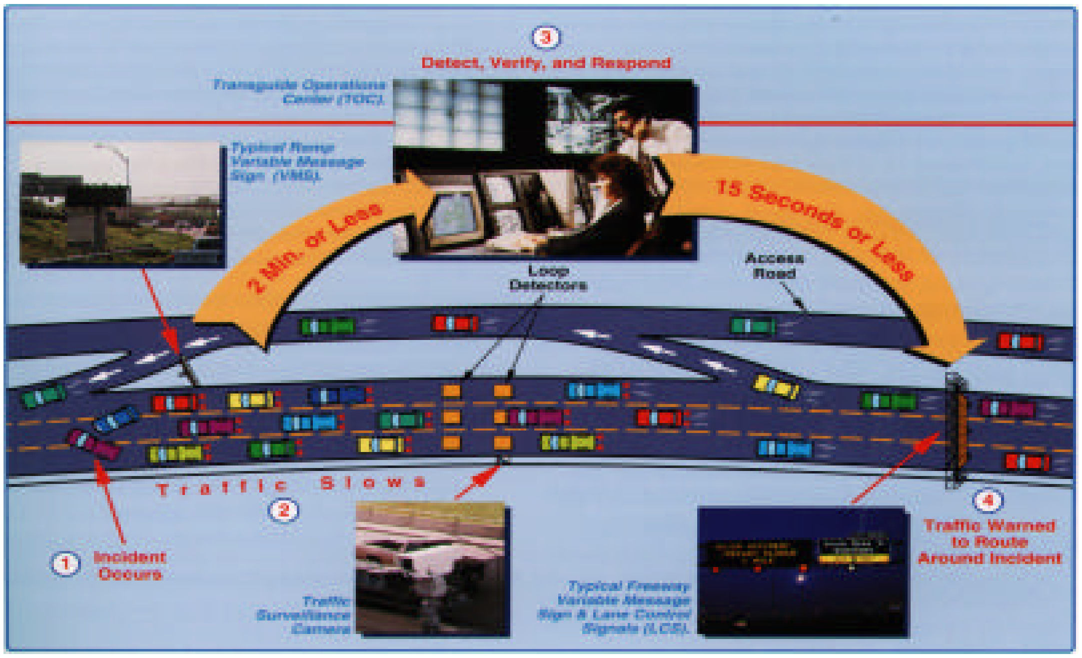
An overview of the TransGuide system requirements and design process is presented in Appendices A.1 and A.2. Details concerning the functionality and specifications of TransGuide video equipment are discussed in Appendix A.3. The future of TransGuide is discussed in Appendix A.4. The design and system requirements are not necessarily directly related to video use, but provide an important foundation for understanding the use of video in the TransGuide system. A brief review of the system requirements and design is useful in helping the reader understand how the TransGuide system functions. The use of video data in TransGuide is presented in Section 3.1. The startup and operational costs associated with TransGuide video hardware and software are briefly summarized in Section 3.2.

3.1. The Use of Video Data in TransGuide

The TransGuide ATMS is primarily concerned with incident detection and response. The system relies on full coverage, high-quality video to assess individual incidents and formulate the appropriate response. The TransGuide system uses loop detectors to collect traffic data in covered areas. The TransGuide system compares these data to baseline traffic conditions to detect congestion and incidents. For each detector, or group of detectors, there are up to four separate alarms that can be generated based on baseline conditions specified for that segment of roadway (4). Baseline conditions are adjusted at 15-minute intervals based on historical data. An alarm sounds if the average speed on the segment is less than the baseline, or if the occupancy is greater than the baseline.

Once an alarm has sounded, the TransGuide video system is used to verify and categorize the incident. The TransGuide operator can view a detailed map of the segment and select the appropriate camera icon on the map. Real-time video from the selected camera can then be viewed. Video is also used to assess the severity of the incident and to dispatch the appropriate response (fire/rescue, emergency services, police, tow trucks, etc.). Video data are collected through a user-controlled camera and lens system, which operators use to view any covered roadway segment. Figure 4 provides a graphical overview of the functionality of the TransGuide ATMS.

Figure 4. Overview of TransGuide Functionality



Source: TransGuide ITS Design Process

The TransGuide system utilizes high resolution one-half-inch Frame Interline Transfer CCD color video cameras that are installed on top of video surveillance poles (1, 2, 4). The cameras have pan/zoom/tilt capabilities, and incorporate 750 lines of horizontal resolution with a signal to noise ratio of 60 dB. The camera is controlled via an RS-232 interface, which is a standard serial digital interface used to communicate between devices (1, 2, 4). A standard 2/3-inch 16:1 high power lens equipped with a 1.5 tele-converter and built-in 2X-rear extender is mounted on top of the camera. The lens has a maximum focal length of 427mm and a minimum focal length of 16mm. Figure 5 provides a picture of a TransGuide Close Circuit Television (CCTV) camera.

The video signal generated by the camera is converted to a digital format and transmitted to the TransGuide TOC using DS-3 (44.736 Mbps) video coder decoders (codecs). The use of the DS-3 equipment allows the TOC to receive near broadcast-quality video that is not subject to significant amounts of motion artifacts (jumpiness, delay, or loss of clarity). The signal is received by the TOC, reconverted, and displayed on workstation Cathode Ray Tube (CRT) screens or on arrays of screens that make up the video display wall in the control room (4). The video system provides TransGuide operators with a detailed color view of covered roadway segments during the day and night. Each operator can view up to four separate road segments or map images from his or her individual workstation. Problem areas or incident scenes are displayed on the video wall at the front of the operations control center.

Figure 5. TransGuide Camera

Source: TransGuide ITS Design Process

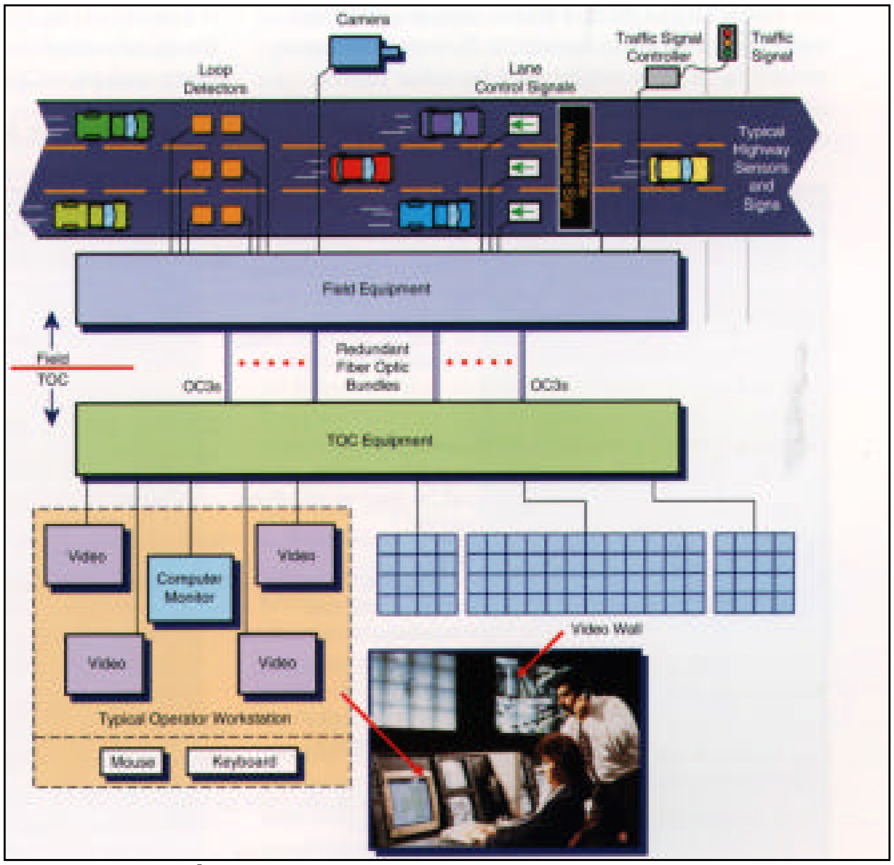
The video system is critical to the operation and success of TransGuide. The video system was selected only after considerable investigation, testing, and evaluation. Numerous issues concerning the cost and functionality of cameras, lenses, video codecs, monitors, and user control functions are discussed in detail in Appendix A.3.

A communications network ties the TransGuide system together. In order to be effective, the system must be able to collect data from vehicle probes, loop detectors, and cameras. The data must then be sent to the TOC where it is utilized in different ways to facilitate traffic management. TransGuide operator responses must then be distributed to the drivers on the road via radio broadcasts, traffic control signals, and variable message signs.

A schematic of the video component of the TransGuide communications network is presented in Figure 6.

The previous section briefly describes the TransGuide ATMS in its current operational condition. The system is designed to be flexible and easily modified should it become necessary to upgrade or replace certain equipment or components. TransGuide will continue to evolve and develop through a series of phases. The development team intends to use the phased approach to incorporate the lessons learned in the early phases into the latter phases of the project. Future plans for TransGuide are briefly discussed in Appendix A.4.

Figure 6. Video Component of the TransGuide Communications Network



Source: TransGuide ITS Design Process

3.2. Costs of TransGuide Video System

Startup, operation, and maintenance cost estimates associated with the TransGuide video system are briefly described in this section. The cost estimates presented in this section focus on the video component of TransGuide, and may not reflect the total costs of the TransGuide system as a whole.

Although the focus of this study is not explicitly on the costs associated with TransGuide video, general estimates of the costs of video and video sharing are provided to help readers better understand the value of integration. Cost estimates for TransGuide video are based on Phase II hardware and equipment costs. TransGuide video costs are presented in Table 2.

Table 2. Estimates of Video-Related Costs for TxDOT

	Number x Unit Cost	Total Cost	Cost per Mile[1]
TransGuide TOC			
Capital	Not yet available	Not yet available	Not yet available
Operational		$945,642 / year	$36,371 / mile
Maintenance		$30,000[2] / year	$1,154 / mile per year
Cameras			
Capital	59 cameras x $10,750	$634,250	$24,394 / mile
Maintenance	59 cameras x $2,586	$152,574 / year	$5,868 / mile per year
Field Equipment			
Poles[3]	26 poles x $4,100	$106,600	$4,100 / mile
Cabinets	2 cabinets x $1,200	$2,400	$92 / mile
Fiber Optic Cable			
Capital		$5,037,263	$193,741 / mile
Loop Detectors			
Capital	800 x $462	$369,600	$14,215 / mile
Maintenance	800 x $67.57	$54,056 / year	$2,079 / mile year
Total[4]			
Capital		**$6,150,113**	**$236,543 / mile**
Annual		**$1,182,272**	**$45,472 mile**

Source: All costs are estimates based on Phase II cost data.
1 - Cost per mile equals the total cost divided by 26 miles of Phase I. Figures are rounded.
2 - Based on video wall maintenance only.
3 - Costs are based on the assumption that 26 poles were included in Phase I (one for each mile).
4 - Total costs represent only the costs for which data exist.

The cost estimates provided in Table 2 represent estimated costs associated with deploying a "TransGuide-like" video system. Although the costs associated with the TransGuide TOC, fiber optic cable, communications cabinets, and loop detectors are not entirely for video alone, the components are an integral part of the TransGuide video system. No attempt has been made to specify or allocate a specific percentage or portion of these costs to video.

Some of the potential costs associated with the sharing of video data are presented in Table 3. Two examples are provided for video sharing costs. The first example includes costs associated with the Media Distribution Plan (MDP). MDP costs are based on published figures. The second example provides a general summary of the costs associated with co-location in the TransGuide TOC. Data are not currently available for these cost categories. These costs are likely to vary by agency. These costs do not necessarily represent all costs associated with the sharing of video data.

Table 3. Potential Costs Associated with Video Sharing

	Total Cost	**Cost per Mile**
EX#1: Cost Components of the MDP		
Low Power Television Station (LPTV)	$152,370	$5,860 / mile
Hardware Engineering	$27,000	$1,038 / mile
TransGuide Software	$88,000	$3,385 / mile
End User Hardware	$3,636	$140 / mile
End User Software	$51,000	$1,962 / mile
Total	**$322,006**	**$12,385 / mile**
EX#2: Potential Costs Associated with Co-location		
Office Space in TOC	Not yet available	Not yet available
Hardware or Equipment	Not yet available	Not yet available
Additional Communications Lines	Not yet available	Not yet available
Operations	Not yet available	Not yet available
Total	**Not yet available**	**Not yet available**

Source: Example #1 costs are based on reference (2). Potential costs in Example #2 are based on potential costs of co-location in the TransGuide TOC.

Table 4 provides a qualified overview of the costs and benefits associated with four alternative video scenarios. The purpose of this table is to simply illustrate, in a general manner, the potential costs and benefits associated with various alternative video scenarios. The four alternative scenarios are:

Scenario #1: No TxDOT video, No independent video (no ATMS video at all). This is equivalent to a "pre-TransGuide" scenario.

Scenario #2: TxDOT video, No independent video, No video sharing (TxDOT utilizes TransGuide video data, but does not share the video). This is a purely hypothetical scenario used to illustrate the benefits of integration.

Scenario #3: TxDOT video, No independent video, Video sharing (TxDOT utilizes TransGuide video data, and shares the video with other stakeholders). This is equivalent to the current situation in San Antonio.

Scenario #4: TxDOT video, Independent video, No sharing (TxDOT utilizes TransGuide video, other local stakeholders also utilize video through their own "TransGuide-like" video systems). This is a purely hypothetical scenario.

Table 4. Alternative Video Scenarios

Scenario #1: No TxDOT Video, No Independent Video (Before TransGuide)
· No video costs · No video benefits
Scenario #2: TxDOT Video, No Independent Video, No Video Sharing (Hypothetical)
· TxDOT video costs · Limited video benefits · No integration benefits
Scenario #3: TxDOT Video, No Independent Video, Sharing (Actual Case)
· TxDOT video costs · Sharing costs · Full video benefits · Full integration benefits
Scenario #4: TxDOT Video, Independent Video, No Sharing (Hypothetical)
· TxDOT video costs · Independent video costs · Full video benefits · No integration benefits

The methodology used in the study is described in Chapter 4.

Chapter 4. Methodology

The goal of the evaluation team was to use a methodology that allowed sufficient flexibility in considering all the issues associated with the integration of ATMS-related video data in San Antonio. The team was interested in collecting information pertaining to how and why certain integration activities were taking place, as well as attempting to identify the benefits resulting from integration. In the case of video data sharing, the team also faced time constraints and data limitations.

The team selected a case study approach to evaluate the potential benefits associated with video data sharing. This case study approach allowed the evaluation team to consider both quantitative and qualitative issues, and provided flexibility in terms of the types of benefits data used in the analysis.

The case study approach is discussed in detail in Section 4.1. Data collection is summarized in Section 4.2.

4.1. The Case Study Approach

A focus of the MMDI evaluation involves the measurement of specific Measures of Effectiveness (MOEs) or a Few Good Measures (FGMs) as key indicators. The MOE/FGM variables are measurable, quantifiable, and consistent across each project. MOE/FGM-driven studies enable the MMDI evaluation team to provide the data inputs that are necessary to subsequently conduct benefit/cost (B/C) analysis.

The case study methodology is an issue-driven approach that can be used to evaluate a wide range of issues or problems[4]. Furthermore, case study may be either quantitative or qualitative in nature. The case study approach allows the user to combine elements from several research methodologies that may utilize external observation, interpretation, and/or grounded theory (8).

Case study involves the study of individual, bounded systems with a specific problem definition. Although the study focuses on an individual system, the problem statement is generally not unique to that system[5]. In other words, case study allows readers to find similarities between the reported case and problems/questions of their own. The issues addressed in the case study can often be applied to problems or questions encountered elsewhere.

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[4] In this case, "issue-driven" refers to the type of research question asked. MOE/FGM-driven studies are implicitly limited by quantifiable variables. Issue-driven studies do not necessarily focus on using quantifiable MOE/FGM data, but allow flexibility in the types of data used for the analysis. For example, in the case of video data sharing, questions pertaining to "how" and "why" sharing is taking place may be as important as the benefits derived from the sharing of video data.

[5] The term "system" is used rather loosely to describe the boundary of the case study. A system may be a city, a defined corridor, a group of people, etc. In a case study, the system being examined must be bounded. That is, the system we are referring to is a well-defined and closed area or group.

For the purpose of evaluating the integration of ITS for the MMDI sites, the evaluation team focused on examining not only the potential benefits from integration, but also the institutional issues relating to how and why integration was occurring. Given the objectives of the study and the various constraints in performing the analysis, it was determined that the case study approach was an appropriate methodology to evaluate the sharing of video data at the time of the evaluation.[6]

It is important to note that the case study approach can be used in parallel with B/C analysis, or any other quantitative approach. One approach does not have to be used at the exclusion of the other. The use of case study does not imply that B/C should not be used to evaluate the sharing of video data in the future.

4.2. Data Collection

The data used in this study were collected from a variety of sources. The evaluation team relied on published research findings and reports, as well as interviews, to collect information. Several of the documents referenced in this study were in draft format at the time of the evaluation and may have changed to some degree since this paper was written.

The benefits relating to the sharing of video data within San Antonio presented in this paper are primarily qualitative in nature. The evaluation of video data sharing is based mostly on expert opinion and observation. The evaluation team considered cost savings as well as increased benefits resulting from the sharing of video. The study examines only user and public sector traffic-related benefits associated with video sharing[7]. Potential safety benefits associated with video data are discussed in the *LifeLink* study and are not explicitly addressed in this paper.

In terms of the few good measures (FGMs), this study excludes references to how sharing of video data may reduce fatalities or the severity of incidents. Furthermore, it is important to note that the study addresses only potential ATMS benefits relating to video data sharing. The study does not examine other potential benefits of video data such as ATIS or APTS[8].

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[6] B/C analysis was considered for the Integration Evaluation in San Antonio. A properly conducted B/C analysis can require a significant amount of time, money, and expertise. If a research question can be accurately answered using a less complex approach, that option should be considered, particularly if there are time constraints or data limitations.

[7] User benefits are benefits that accrue to an individual or individuals as a result of a particular action or investment. Examples include travel time savings, operating cost savings, and personal convenience. The term “public sector” refers to public agencies (in this case, state and municipal agencies that collect and/or utilize video data in San Antonio).

[8] The sharing of video data between the various stakeholders may involve the use of video for ATIS and APTS to some degree. The benefits associated with video data pertaining explicitly to any system other than ATMS will not be examined in this paper.

The evaluation team initially relied on papers and reports to gather background information about the use of video data in San Antonio. The MMDI Integration Evaluation Team then spent a week in San Antonio touring the TransGuide TOC and discussing the collection and use of video data with numerous stakeholders, including:

- Texas Department of Transportation (TxDOT),
- VIA Metropolitan Transit Authority,
- San Antonio Police Department (SAPD),
- Texas Transportation Institute (TTI), and
- The local media[9].

An informal questionnaire was created that focused on specific video data sharing issues. Personal interviews were conducted in order to gather information regarding the issues and benefits associated with the sharing of video data in San Antonio. Local stakeholders were asked to discuss the survey questions with an evaluator from the MMDI Integration Evaluation Team. Stakeholders were also encouraged to provide any additional insight or comments relating to video data sharing that they deemed appropriate.

The evaluator also spent several hours on the floor of the TransGuide operations control center with an SAPD dispatcher and a senior operator at TransGuide. The evaluator was shown how the SAPD and TransGuide operators work together to more effectively manage responses to traffic incidents, and how each party uses the video data on a daily basis. The evaluator witnessed numerous SAPD responses to calls from both monitored and unmonitored sections of the freeway system, and was able to observe the effectiveness of the responses to various incidents. The senior TransGuide operator provided a detailed "tutorial" on the system Graphical User Interface (GUI), the various maps and camera controls included in the system, and how scenario responses are initiated.

Interviews and stakeholder feedback took place in three stages. The first stage consisted of face-to-face interviews conducted during meetings between local stakeholders and the Integration evaluator in San Antonio. The second stage involved follow-up telephone interviews or emails with various stakeholders in order to clarify responses or to gain additional insight into specific issues. Finally, a draft version of the video data sharing case study was sent to the various stakeholders for review. Comments were incorporated into the final version of the paper. A copy of the questionnaire is presented in Appendix A.6.

The first four chapters (Chapters 1–4) of this paper primarily rely on information obtained from published papers and reports on various aspects of the TransGuide ATMS

[9] TransGuide video data were discussed with the KMOL-TV Chief Engineer. Other television and radio interests were not included in the meeting, although all three of the local major TV network affiliates have participated in the TransGuide stakeholder meetings and are members of the Media Distribution Partnership.

or MMDI Integration Evaluation. These chapters are based on published information and are supplemented by the on-site observations and experiences of the evaluation team. The last three chapters (Chapters 5–7) are based directly on personal conversations with various local stakeholders and TxDOT employees in San Antonio. Chapter 5 summarizes important issues relating to video data sharing, while Chapter 6 lists specific benefits reported by the survey participants. The conclusions of the study are presented in Chapter 7.

Chapter 5. Analysis of Video Data Sharing in San Antonio

A portion of San Antonio's ATMS involves the collection and use of video data as part of the TransGuide system. Specifically, video data are used to verify and classify incidents, and to aid operators in selecting the appropriate response to incidents. TxDOT currently operates the TransGuide TOC, is responsible for the collection of video data, is a primary user of the data, and maintains proprietary control over the data.

Video data "sharing" is not a specific project implemented under the MMDI. The sharing of video data is an ongoing and continuous process that originated when the system came on line in 1995. In the case of San Antonio, the sharing of video generally refers to the use of the ATMS video data currently collected by TransGuide cameras by public agencies and stakeholders in San Antonio other than TxDOT. Although TxDOT has proprietary control of the data, it allows other agencies free access to these data.

Cameras placed on poles along major freeway segments provide 24-hour real-time video coverage of traffic conditions. TransGuide video data are typically not recorded and archived. TxDOT does not record incident scenes or traffic patterns unless explicitly requested to do so. An example of an instance where video data were recorded and reviewed is described below. The SAPD was having problems with officers leaving burning flares at incident scenes after the incidents had been cleared. Police regulations stipulate that officers should extinguish the flares or kick them off to the side of the road after an incident is cleared. The SAPD requested that TxDOT videotape police response at incident scenes in order to record policy violations with respect to the clearance of road flares. TransGuide video cameras were used to record the police response to individual incidents along covered freeway segments. The recordings were then reviewed by the SAPD and sent to the police-training academy as instructional videos.

Video data sharing is facilitated by the physical presence of all public sector stakeholders in the TransGuide TOC. The TOC or TransGuide building is a combination office building and traffic operations control center. TxDOT personnel occupy the first two floors of the building. The operations center is also located on the first two floors. The operations center is similar to a small theater. The center is a large semi-circular room that is approximately two stories in height. The video wall is displayed at the front of the room, with rows of workstations facing the wall. The operations center is pictured in Figure 7.

Figure 7. TransGuide Operations Control Center

Source: TransGuide ITS Design Process

The TransGuide TOC currently contains 17 workstations or consoles. There is space currently available for up to ten additional consoles (4). TxDOT currently has 11 consoles allocated for TransGuide staff, research and development (R&D), and training. The San Antonio Police Department (SAPD) has one full-time dispatcher who staffs a workstation in the operations center. The SAPD has been allocated two workstations by TxDOT (4). VIA currently staffs two of the TransGuide workstations. The city and fire departments have one workstation each, but do not currently staff them on a daily basis.

Table 5 provides an overview of the stakeholders currently located in the TOC. It also describes the degree to which each of the stakeholders has access to TransGuide video cameras. Some of the stakeholders utilize video data on a daily basis, while others utilize video data only in special case situations. The data are available to all stakeholders, however, it is up to individual stakeholders and agencies to choose how they use the data.

Section 5.1 discusses how video data sharing originated in San Antonio. Section 5.2 describes the term “sharing” and discusses how these data are shared. Obstacles that needed to be overcome in order to implement the sharing arrangement are discussed in Section 5.3. Although the Low Power Television Station (LPTV) is actually an ATIS implementation of video data, it plays an integral part in illustrating how the video data are used. The LPTV station is described in Appendix A.5.

Table 5. Stakeholders Located in the TransGuide TOC

Agency/Stakeholder	Location in TransGuide Building
TxDOT	Offices on first and second floors. Allocated 11 workstations in the operations control center.
VIA	Paratransit operations are located in offices on the third floor. Fixed route operations are located in offices on the first floor. Allocated and currently staff two workstations in the operations control center.
SAPD	Officer staffs the front desk of the TransGuide Building for security purposes. Allocated two workstations in the operations control center. Currently staff one workstation with a full-time dispatcher. Emergency management center on third floor.
City	Has one workstation allocated in the operations control center. The workstation is not currently staffed on a full-time basis.
Fire / EMS	Emergency management center on third floor. Staffed during emergencies and used for training.
TTI	Office on third floor. Access to workstations through TxDOT
SRI	Office on third floor. Access to workstations through TxDOT

Source: Based on TransGuide ITS Design Process

5.1. How the Sharing of Video Data Originated

The concept of video data sharing originated during the early stages of the TransGuide project. During project planning, TxDOT officials met with local stakeholders to discuss the potential uses of and benefits associated with real-time traffic video data. According to TxDOT, initial interest in the project was limited. The less than enthusiastic reaction to TransGuide was due to several factors:

- Although some agencies recognized the potential benefits associated with video data, they had doubts that the project would proceed.
- Some agencies understood the potential benefits of real-time video data, but were hesitant to get directly involved in the project because they were not interested in sharing the costs of the project, or they felt the project was too risky.
- Some agencies could not really envision how the system would work, or how real-time video data would be useful to them.

TxDOT proceeded with the project despite limited interest from other agencies. By funding the project itself, TxDOT was able to establish system requirements and a system design that conformed exactly to its own goals. As the project progressed from the planning phase to the implementation phase, stakeholders gained a clearer picture of how video would be used. Once the potential benefits associated with video data became more apparent, interest in the project ballooned.

TxDOT's approach to TransGuide is somewhat atypical of most large-scale ATMS projects. Generally, projects proceed very slowly, and rely on some sort of consensus commitment or "buy-in" from local stakeholders. In the case of TransGuide, TxDOT proceeded with the project without receiving financial contributions or commitments from local stakeholders prior to the actual construction phase. There are four key reasons why this approach worked in San Antonio:

1. The Municipal Planning Organization (MPO) in San Antonio had no objections to the project and was not involved in funding the project.
2. The number of stakeholders in San Antonio is limited. There was no serious opposition to the project.
3. The political power base and the tax base are centralized within the municipality of San Antonio. Approximately 1.1 million of the 1.3 million residents of San Antonio live within the corporate limits of the city[10].
4. TxDOT had sufficient funding to implement TransGuide without financial contributions from additional parties[11].

As additional stakeholders became interested in TransGuide, TxDOT modified the original plans for the TOC to include a third floor for the building. TxDOT financed the shell of the building, while the stakeholders paid the total costs for their own office space and hardware.

Stakeholders indicated that they were very satisfied with the development of the project. Several stakeholders commented that they were glad that TxDOT did not wait to form a stakeholder committee before proceeding with TransGuide because the process would have taken too long and the committee would not have significantly improved current operations. By initiating the project by itself, TxDOT was able to proceed with the development and deployment of TransGuide in a quick and effective manner without negotiating through political red tape.

5.2. The Sharing of Video Data

The "sharing" component of TransGuide involves the distribution of ATMS-related data, free of charge, over the Internet, television, and FM subcarrier. Sharing also consists of an informal arrangement between TxDOT and:

- VIA Metropolitan Transit Authority (VIA),
- City of San Antonio Department of Public Works,
- City of San Antonio Traffic Management,
- San Antonio Police Department (SAPD),
- Texas Transportation Institute (TTI),
- Southwest Research Institute (SRI),
- San Antonio Fire Department/EMS,
- Local television stations (major network affiliates).

The agreement allows stakeholders access to the live video feeds and traffic data, and in some cases allows limited control over the camera equipment. TxDOT allows the SAPD and VIA to control cameras from their workstations in the operations center. Other stakeholders do not currently have (or do not fully utilize on a daily basis) direct access to the workstations in the TOC.

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[10] Based on a conversation with Brian Fariello and David Rodrigues of TxDOT, Tuesday, June 9, 1998.

[11] TransGuide was a Federal Aid Project. TxDOT did not require additional financial assistance from other state or local agencies to complete TransGuide.

The SAPD currently has one full-time officer working in the operations center. The SAPD workstation has been modified to allow the officer to receive fax printouts of traffic-related calls, and provides a direct communication link to the SAPD Traffic Division headquarters located downtown. VIA currently manages all paratransit and fixed route operations from the third floor of the TransGuide TOC. VIA occupies two workstations within the operations center in order to assist with routing and timing of transit operations.

Although both the SAPD and VIA operators can control CCTV cameras from their respective workstations, they do not have the authority to implement traffic scenarios or control the Variable Message Signs (VMS) or Lane Control Signals (LCS). All video equipment is under the direct control of TransGuide managers, who have the power to give or take away control of individual cameras, pass control of scenario responses to individual operators, or assign specific incidents to individual operators. In this way, TxDOT allows other agencies considerable control over the freeway segments they choose to view at any particular time, while maintaining strict control over scenario implementation.

Not all video data used in San Antonio are shared data. For example, the city is currently using video cameras to collect traffic volume data on Fredricksburg Road. The data are used exclusively for traffic signal control on that roadway segment. The cameras used on this segment are not compatible with the TransGuide system, and these data are not directly available to, or used by, TransGuide. TTI is currently using video data from TxDOT cameras along Phase II freeway segments along with mobile video stations to assess existing traffic conditions on these segments prior to official initialization of Phase II. These video data are not generally shared with the local stakeholders[12]. TTI is using this data for research purposes in order to establish a baseline scenario for traffic conditions before Phase II comes on line. Once Phase II is initialized, these data will be compared to data collected by the TransGuide TOC along Phase II segments.

5.3. Obstacles to Sharing Data

Despite the fact that the design and construction of the TransGuide TOC was completed in a relatively smooth and timely manner, there were several obstacles that had to be overcome before the video sharing arrangement was implemented. Two key obstacles were mentioned:

1. Bureaucratic process
2. Privacy issues

The most frequently mentioned obstacle was the long and tedious bureaucratic process associated with locating various public agency offices in a TxDOT building. It took considerable time to coordinate the various agreements between TxDOT and the individual agencies. All agreements had to be approved by TxDOT headquarters in

[12] These data may be shared with TxDOT to some degree, but they are not incorporated into the TransGuide system, and therefore are not used for incident response. The data are for research purposes only.

Austin, TX. Many of the survey participants indicated that the bureaucratic process was a distraction to the overall goal of video data sharing and became quite discouraging at times. Patience, perseverance, and a commitment to the project were all key factors involved in overcoming the bureaucratic obstacles.

Privacy issues centered on police access to video data and concerns over how the data would be used. Some citizens complained that the cameras were looking into residential neighborhoods near monitored freeway segments. The complaints stemmed from the practice of rotating cameras along the horizon when switching the camera view to another direction or angle. Operators did not necessarily return the camera to the original "default" position focusing down on the freeway. Cameras were sometimes left pointing along the horizon, or pointing in a direction that was not consistent with the freeway segment immediately below the camera.

SRI is currently developing a software application that returns each camera to a default position focusing down along the freeway segment immediately below the camera. Operators are instructed to keep cameras at a low tilt when panning to other views if possible. TxDOT views invasion of privacy as a serious issue, and will dismiss any operator who violates operational policy concerning the use of cameras.

The use of ATMS video has been a topic on local radio talk shows from time to time. Controversy generally stems from the potential use of video for law enforcement. The SAPD does not use TransGuide video for law enforcement, and has no plans to do so. The nature of the police presence in the TOC is to facilitate quick and effective incident response, not to use the video to search the roadways for potential traffic violations and issue tickets through the mail. Since video is not recorded, it is really not feasible for the SAPD to use it for law enforcement. Issues relating to the potential admissibility of ATMS video in court were not addressed in this study.

Survey participants were also asked questions about their perceptions on the relative importance of the following constraints in the development and operation of video data sharing through TransGuide:

- Technological constraints
- Organizational constraints
- Financial constraints
- Legal constraints

The participants all agreed that technological constraints were not a factor in the sharing of video data. Opinions differed as to how much of an issue organizational, financial, and legal constraints were. Most of the participants did not believe these constraints were serious impediments to video data sharing.

Participants agreed that initially, organizational constraints were an important issue. It was a slow process getting everyone together and moving forward with regard to the video sharing arrangement. A major organizational constraint was physically getting everyone together to begin discussing the sharing of video data. Although some stakeholders expressed the desire to have more control over the operation and use of video equipment, these points were not serious obstacles to the sharing agreement. From the beginning, TxDOT made it clear that control of the video equipment was not negotiable, and the other agencies respected that decision. Stakeholders do not see organizational issues as an important factor in the future development of TransGuide.

Financial constraints impacted the design of the system and the equipment used in the TransGuide system in some ways. Financial constraints, however, did not really impact the sharing arrangement according to most participants. Since stakeholders were not initially involved in the system requirements and design phase of the project, financial issues associated with the initial design and implementation of TransGuide were not a constraint to video sharing. None of the local stakeholders indicated that the costs associated with their physical location in the TransGuide TOC or costs associated with the Media Distribution Partnership[13] were serious constraints. Stakeholders, as a whole, felt that the costs associated with co-location in the TOC were not excessive, and that cost did not impact their involvement in the data sharing arrangement.

According to TxDOT, about 40 percent of the funds needed for planned system expansion are currently available[14]. They are confident, however, that the necessary funds will become available over time. Since the San Antonio ATMS is proceeding in well-defined phases, funding is not really an issue. Funds are generally available for specific projects as needed during the fiscal year.

Legal constraints depended on the individual organizations. Participants felt that legal issues did not severely impact the sharing arrangement. Video data sharing is not a legal issue. Since TxDOT has proprietary control over the data and operation of the video cameras, there are no legal agreements involving the use of TransGuide CCTV cameras. The degree to which stakeholders can use the video equipment is based on a verbal agreement with TxDOT. According to survey participants, there were minor legal issues associated with the co-location of the various agencies in a TxDOT building, but these were overcome without too much difficulty.

The benefits associated with the sharing of video data are discussed in Chapter 6.

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[13] For additional information on the Media Distribution Partnership and details concerning cost sharing agreements, please see McGowan and Dellenback and/or the TransGuide ITS Design Report.

[14] Based on a conversation with Brian Fariello and David Rodrigues from TxDOT. June 9, 1998.

Chapter 6. Benefits of Video Data

The benefits associated with the use of video data for traffic management can be summarized with the following statement: "A picture is worth a thousand words." The underlying meaning of this statement is simple: verbal descriptions of incidents or prevailing traffic conditions do not accurately describe the actual situation. Ascertaining what is actually happening on the freeway network requires the use of real-time video.

The video data component of TransGuide is an integral part of the system. The use of real-time video data is the best way in which TransGuide can:

- Verify an incident,
- Accurately determine the severity of an incident,
- Quickly identify the location of the incident, and
- Select the most appropriate response to the incident.

Public confidence and acceptance of TransGuide depend on the ability of the system to provide accurate, real-time traffic information to drivers. Real-time video ensures the system's accuracy because operators can actually see what is happening. There is no guesswork associated with incident response on monitored sections of the freeway. The use of video eliminates potential problems due to incomplete or contradicting information.

Benefits are presented in four sections. Section 6.1 discusses benefits associated with integration in general. Section 6.2 summarizes the results of the Transportation Research Board publication, *Before and After Analysis of the San Antonio TransGuide System Phase I*. This information is important because it provides quantified results from early benefits assessments of TransGuide. However, the benefits of video data are not separated from the TransGuide system as a whole in the analysis. There is not necessarily a direct one-to-one correspondence between the benefits reported in the *Before and After Analysis* and the benefits presented in the video data sharing case study.

Benefits information collected by the Integration evaluation team is presented in Section 6.3. These benefits are based on interviews with individual stakeholders in San Antonio. Section 6.4 provides some insight into how the stakeholders believe various groups in San Antonio perceive TransGuide video data.

6.1. Video Integration

Integration involves the sharing of infrastructure or data, and/or the coordination of control (7). Sharing or coordination can take place between different modes of transportation, or between different ITS systems, technologies, or components. Due to the potentially large number of systems and equipment, evaluation of the integration of various ITS technologies and systems can be somewhat complicated.

The primary objectives behind integration are to reduce user or operator/agency costs, and/or to increase user or operator/agency benefits. Within the context of the Integration Evaluation, the following two hypotheses are considered:

1. The benefits of the whole are greater than the benefits of the individual parts, and
2. The costs of the whole are less than the costs of the individual parts.

In the case of San Antonio, the benefits realized from the integration of video do not explicitly focus on reducing operator/agency costs–TransGuide was under construction before the sharing agreement was implemented. TxDOT deployed a video-based ATMS despite the initial lack of interest from other local stakeholders. The other stakeholders involved in the sharing agreement had no intention of implementing a video system on their own, and admitted that if TransGuide had not been built, they would have probably never considered the use of video. As mentioned in Chapter 5, the TransGuide ATMS was not a cost-sharing project[15].

Figure 8 provides a diagram of integration linkages between the components of a metropolitan ITS infrastructure (10). The linkages illustrate data flows between components. The shaded circles indicate the integration linkages identified in the San Antonio video data sharing study.

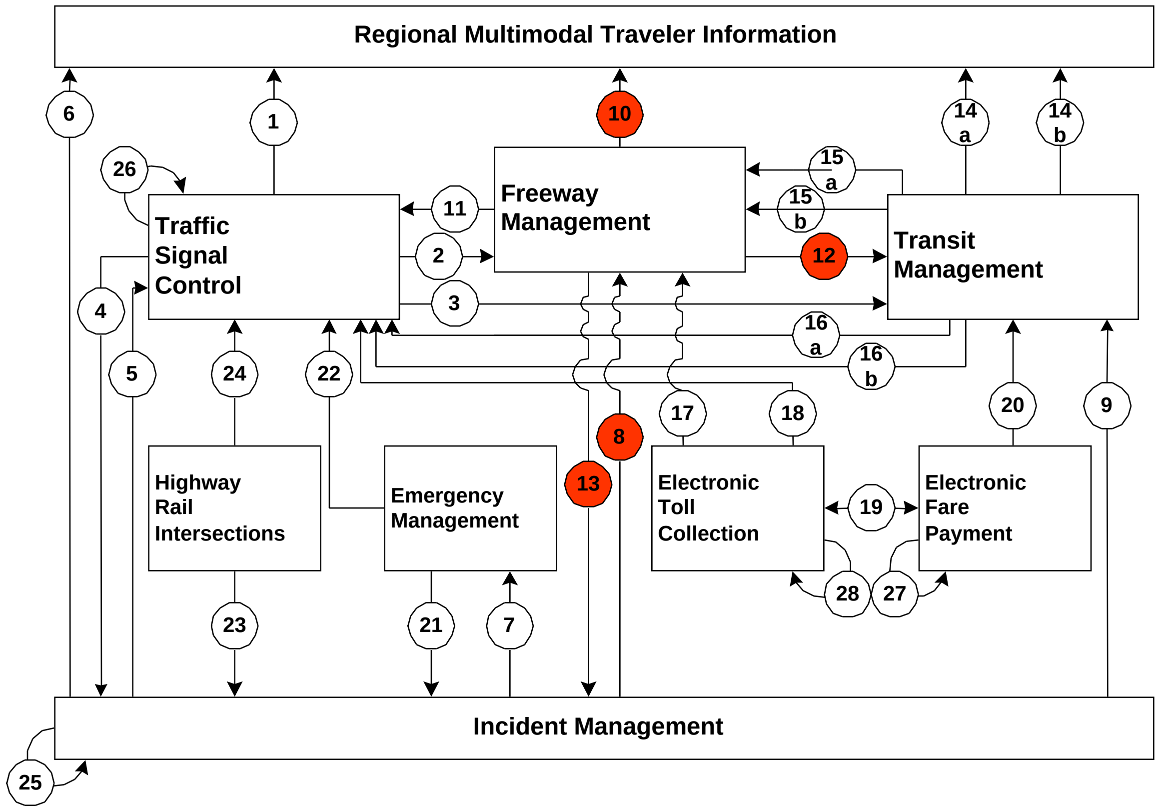
In the case of San Antonio, increased operator/agency benefits resulting from integration are more readily observed than the reduction of costs. The majority of benefits identified in this study would likely not have been realized at all if integration had not occurred. In most cases, the benefits were achieved for a relatively small incremental cost. There are four separate integration linkages described in this study:

- Freeway Management and Incident Management (13),
- Freeway Management and Traveler Information (10),
- Freeway Management and Transit Management (12), and
- Incident Management and Freeway Management (8).

The integration linkages are discussed in detail below.

[15] Although TransGuide is a federal aid project, TxDOT received no financial contributions from local stakeholders. There is a cost sharing agreement that relates to Advanced Traveler Information Systems (ATIS). Specifically, the Media Distribution Partnership involved the shared development of user software for access to TransGuide data provided over the Low Power Television Station (LPTV).

Figure 8. MMDI Integration Relationships



Source: Integrating the Metropolitan ITS Infrastructure

Freeway Management and Incident Management

This linkage is described as the sharing of information relating to freeway travel time, speeds, and conditions. The information is used to detect incidents and manage incident response. In the case of TransGuide, the benefits derived from the integration of traffic management and incident management are somewhat difficult to separate from the TransGuide system as a whole.

In many cases, it is relatively easy to distinguish between freeway management and incident management because the functions of each component are easily separable. Separating the functionality of freeway management and incident management in San Antonio is difficult because the TransGuide system was designed for incident response. The underlying objective of TransGuide is to facilitate traffic management through accurate and timely incident response.

The benefits associated with the integration of freeway management and incident management involve the degree to which the TransGuide system is effective. The benefit of integration is not the EMS response itself, but improved response times and improved accuracy of the response. EMS response would occur, even if TransGuide did not exist, and even if the various agencies were not physically located in the TOC.

In San Antonio, the value of the integration of freeway management and incident management is most directly realized by co-location of the various agencies in the TransGuide TOC because co-location improves the accuracy and timeliness of the response. It is also important to note that in the case of San Antonio, the sharing of video between TxDOT and the individual stakeholders (specifically, the public agencies) occurs within the TransGuide TOC.

The Traffic Division of the SAPD is the agency tasked with verifying and responding to freeway-related incidents in San Antonio. TxDOT is not the primary agency notified about freeway incidents and does not have the authority to respond to freeway incidents. For example, TxDOT is not responsible for requesting EMS units, tow trucks, or hazardous materials crews at incident scenes in San Antonio.

In order to illustrate the benefits of integration, hypothetical Scenario #2 is utilized[16]. Realistically, there is no alternative “no TransGuide” scenario, or an independent video scenario; neither of those scenarios is logical given what we know about the development and implementation of TransGuide. In this scenario, the TransGuide ATMS is fully functional; however, there is no SAPD dispatcher located at the TOC. TxDOT does not share video data with the SAPD–only information it obtains through video. A typical incident response identified by TransGuide video might proceed as follows:

1. TransGuide operators call SAPD Traffic headquarters in downtown San Antonio and notify them of an incident on a monitored freeway segment.
2. The SAPD receives as much information as possible from TransGuide and sends a unit to investigate the incident.
3. Upon arriving at the scene, the officer assesses the incident and calls for the appropriate EMS backup.
4. At the same time, TransGuide operators assess the incident from the TOC and implement a response scenario, without receiving direct input from the SAPD.

In the hypothetical scenario, response times would be relatively slow and inefficient. The SAPD would send a unit to investigate an incident scene that could probably be accurately described by the TransGuide operators. However, TxDOT does not have the authority to implement freeway response and is required to notify the SAPD. The police would be spending additional time verifying and assessing incidents that have already been categorized by TransGuide operators. The hypothetical scenario provides an illustration of an inefficient incident response in terms of both operator/agency time and response time. In this case, the agencies would neither be serving themselves or the best interests of the general public.

[16] Hypothetical Scenario #2 is described in Chapter 5.4, Costs Associated with Video.

TxDOT can confidently state that incidents are responded to within two minutes of detection because all the personnel needed to authorize whatever response may be necessary are located within the TOC. When an incident is called in or detected, TxDOT, the SAPD, and EMS can all immediately view the scene of the incident using real-time video. The exact location and severity of the incident are assessed, and the agencies coordinate their efforts and expertise to assure that the appropriate response is dispatched immediately. TransGuide operators can implement a freeway response scenario based on the type of response selected by the SAPD.

It is possible to share video and other traffic-related information without having the various stakeholders located within the same building. The effectiveness of such a situation depends on the communications system used, the responsibilities of the individual agencies, and the relationships between the operators/agencies. In the case of San Antonio, the stakeholders repeatedly indicated that the success of video sharing is largely contingent on co-location of the various stakeholders within the TransGuide TOC.

Freeway Management and Traveler Information

As indicated in Figure 5 (10), the information shared between freeway management and traveler information includes freeway travel times, speeds, and conditions. Information is displayed to travelers through the local media or via information kiosks. These benefits are easy to recognize because the functionality of the two components is separable.

TransGuide provides an excellent example of integrating freeway management and traveler information. Integration is primarily achieved through The Media Distribution Plan (MDP). The MDP was initiated to facilitate the transfer of information from the operations center to various media organizations (television, radio, and print) for dissemination to the traveling public (2). Other entities with access to traffic information will include trucking firms, hotels, businesses, taxi services, hospitals, information kiosks, tourist information centers, public transit services, the police department, the fire department, and more. The TransGuide system provides real-time data for the entire project, and it is not possible for these entities to acquire this information without using the TransGuide system (2).

Real-time traffic data are shared through the Low Power Television Station (LPTS), which is owned and operated by TxDOT. The LPTS was primarily developed in order to disseminate video data to the general public. Members of the Media Distribution Partnership are able to access real-time traffic video and utilize map-based software to view traffic flow and incidents. The general public can access the video images transmitted on the LPTV by purchasing a low-cost UHF antenna.

Integration of traffic management and traveler information provides real-time video and traffic data to a variety of sources. Various organizations or the general public can access these data in various forms through the use of information kiosks, the local media, or over the LPTS. Without integration, the dissemination of real-time traffic information would not be possible.

Traffic Management and Transit Management

The information shared between freeway management and traveler information includes freeway travel times, speeds, and conditions. This information is used by transit (in this case, VIA) to adjust transit routes and schedules. Benefits associated with the integration of freeway management and transit are also easily identifiable. In the case of TransGuide, the benefits of integration between freeway management and public transit are recognized in the form of:

- Real-time traffic information distributed through information kiosks, the media, and the LPTS, and
- Direct benefits using TransGuide video cameras.

VIA utilizes real-time traffic information distributed through the MDP to help with routing. For example, VIA uses the video feeds broadcast over the LPTS to assess current traffic conditions. Operators are aware of any major accidents that may affect transit operations and can route vehicles around potential delays.

VIA also benefits from the video sharing agreement by having direct access to TransGuide video cameras. VIA uses the cameras to assist with paratransit operations and special events. Using video, VIA can provide a demand-based service approach. Operators can view pickup locations using live video to determine when vehicles need to be dispatched to pick up passengers. Real time video not only allows operators to determine when vehicles need to be dispatched, but it also allows operators to determine how many vehicles need to be dispatched for special event services such as concerts or sporting events.

Video also helps VIA locate disabled vehicles. Because VIA operators are located within the TOC, they have access to information regarding current traffic conditions and incidents on monitored freeway segments. VIA uses video to advise operators of existing traffic conditions and relies on the TransGuide ATMS for all real-time traffic information.

Without integration between freeway management and public transit, VIA would have no information about current traffic conditions. Operators would not have access to real-time traffic reports over the radio, nor could VIA rely on TransGuide video for special events and paratransit operations.

Incident Management and Freeway Management

According to Figure 5 (6), the information shared between incident management and freeway management includes incident severity, location, and type. This information is used to adjust VMS and LCS. Again, the benefits attributed to this integration linkage are difficult to separate from the TransGuide system as a whole because TransGuide is an incident response and management-based ATMS. TransGuide was essentially designed around the principle of integrating freeway management and incident management.

The primary benefit realized through integration is improved travel times due to reduced congestion on the freeway system. Through video, TxDOT is able to implement incident response scenarios that provide the general public with real-time information about the location and severity of freeway incidents using VMS and radio. Responses include closing specific lanes and re-routing traffic through LCS.

6.2. Summary of Before and After Analysis

The analysis summarized in this section provides quantified results from early operational field tests of TransGuide. As the title implies, the analysis compares specific traffic conditions before TransGuide was implemented to conditions after the TransGuide system became operational. There are three major focus areas of the analysis:

1. Safety,
2. Incident Management, and
3. Diver Understanding and Utilization.

Although safety issues are not the focus of this case study (they are addressed in detail in the *LifeLink* study), the safety results from the *Before and After Analysis* are included in this section. Table 6 provides a brief summary of the study results. Since the focus of this paper is on the benefits associated with video data sharing and not on the TransGuide system as a whole, details from the *Before and After Analysis* are not included.

Table 6. Summary Results of the TransGuide Before and After Analysis

Focus Area	Reported Benefits
Safety	· Overall accident frequency rate dropped by 15 percent · Projected accident frequency rate dropped by 21 percent · Translates into estimated annual injury cost savings of $3.3 million
Incident Management	· Response time for minor incidents dropped by 19 percent · Response time for major incidents dropped by 21 percent · Simulation results estimated annual delay savings at 700 vehicle hours and annual fuel consumption savings at 2,600 gallons · Translates into estimated annual savings of $1.65 million
Driver Understanding and Utilization	· Motorist confidence in the traffic management system improved from 40 percent to 86 percent · 45 percent of people surveyed changed their route during incidents before TransGuide, while 71 percent of people changed their route during incidents after TransGuide · Driver compliance with VMS and LCS has improved from 33 percent to around 80 percent · 88 percent of the people surveyed feel VMSs are easy to understand

Source: Based on Henk, Molina, and Irwin, 1997

6.3. Benefits from Video Data Sharing

The benefits described in this paper are based on the individual perceptions of local stakeholders. Stakeholders were asked open-ended questions regarding the benefits associated with the sharing of video data. Responses were then discussed in detail in order to gain additional insight into individual perceptions and opinions. Questionnaires were administered on a one-to-one basis using a discussion-based format[17]. Although it may be possible to quantify the majority of benefits described in this section, no attempt has been made to do so. The benefits information collected from the interviews is summarized in Table 7. Benefits are described in general terms, and examples are given where appropriate.

Ten separate benefits are discussed:

1. Expedite EMS Response
2. Accurate EMS Response
3. Accurate Traffic Information
4. Reduce Congestion during Incidents
5. Improve Relations between Stakeholders
6. Cost Savings for VIA
7. Accurate Weather Conditions
8. Close Coverage of Incidents
9. 24-Hour Real Time Freeway Coverage
10. Cost Savings for SAPD

<u>Expedite EMS Response</u>

Identifying incidents and responding with the appropriate level of service is an essential objective of TransGuide. Incidents are typically reported by drivers or the police, or are identified using video. Once an incident has been reported, cameras are used to verify the incident. After the incident is verified, the TransGuide system can pinpoint the exact location of the incident using both real-time video and detailed mapping software.

The SAPD use video to verify incidents and dispatch the appropriate response to an incident scene within two minutes of detection. Before TransGuide, the SAPD would send a unit to investigate all incident reports in order to verify the incident and determine the appropriate response. Officers generally did not know exactly where an incident occurred or the degree of its severity. Available information depended on the detail and accuracy of the report. With video, the SAPD can immediately view an incident scene and relay the details of the incident directly to EMS units. Quick and accurate EMS response reduces fatalities and improves emergency medical treatment to the public.

[17] Stakeholders were not asked to fill out the questionnaire. The evaluator used the questionnaire as a catalyst to facilitate discussion about video data sharing. If requested, stakeholders were given a copy of the questionnaire to follow during the course of the discussion.

Based on the TRB report summarized in Section 6.2, the TransGuide system is directly responsible for improving incident response times by 19 percent for minor incidents and 21 percent for major incidents (3).

Table 7. Perceived Benefits Associated with Video Data Sharing

Stakeholder	Perceived Benefits Associated with Video Data Sharing
TxDOT	· Expedites EMS response · Improves accuracy of EMS response · Provides accurate traffic information · Reduces congestion during incidents · Improved relationship between stakeholders, particularly between public agencies
VIA	· Accurate incident response · Accurate traffic data. · Cost savings for VIA. Demand-based response for special events pick-ups · Improved relationship between stakeholders, particularly between public agencies
Local Media	· Accurate weather conditions on freeway · Close coverage of incidents · Exact location of incident · 24-hour real-time freeway video · Improved relationship between stakeholders
TTI	· Accurate response to incidents · Accurate assessment of prevailing freeway conditions · Cost savings to SAPD · Improved relationship between stakeholders, particularly between public agencies
SAPD	· Cost savings to SAPD · Accurate incident response · Exact location of incident · 24-hour coverage · Improved relationship between stakeholders, particularly between public agencies

Source: Based on interviews with individuals from each of the five stakeholder groups listed above

<u>Accurate EMS Response</u>

Video allows the SAPD to determine what type of response is needed at a particular incident scene, thereby insuring an accurate response. In the case of a minor fender bender, a single patrol unit can be dispatched. In the case of a more severe incident, the appropriate EMS support can be dispatched. Accurate response reduces incident response times and improves emergency response.

<u>Provide Accurate Traffic Information</u>

In order for the ATMS to function properly, the information provided to motorists must be accurate. Video allows TxDOT to collect real-time traffic information and to actually "see" what is happening on monitored freeway segments. Since an ATMS depends on public compliance, the accuracy of the information provided is a critical component of the overall success of the system. Accurate, real-time traffic information is greatly facilitated by the use of video cameras. TxDOT feels that the use of video is imperative to providing the public with accurate traffic information. Accuracy improves public compliance with the system, which improves the overall effectiveness of the ATMS.

According to the TRB report (3), driver confidence in the methods used to report freeway conditions rose from 40 percent before TransGuide to 86 percent after TransGuide. Eighty (80) percent of survey respondents in San Antonio indicated that they followed instructions provided by the VMS and LCS. This indicates a high level of driver confidence and compliance with the system (3).

Reduce Congestion during Incidents

Video sharing allows quick and accurate response to incidents. Video also allows operators to assess individual situations and provide the appropriate response to incidents. The quicker and more accurate the response, the quicker the incident can be cleared. Providing accurate traffic information improves compliance with VMSs and LCSs, and facilitates more effective traffic management, which in turn reduces congestion.

FREFLO simulation results estimate average delay savings of 700 vehicle-hours per year for major freeway incidents on Phase I of the freeway network (3). The reductions in delay are based on the improved incident response times observed after the implementation of the TransGuide system. These time savings are expected to be even greater on segments of the freeway network that experience significant recurrent congestion.

Improved Relationships between Stakeholders

Survey participants pointed out that relations between the various stakeholders had improved considerably since TransGuide became operational. The sharing of video data provided a catalyst for co-location of stakeholders in the TransGuide building. The fact that the individual agencies are located in the same building is the major factor driving cooperation between the agencies, according to the stakeholders.

According to one stakeholder, political infighting and lack of communication and cooperation between various agencies was common before TransGuide. Individual agencies generally followed their own agendas and paid little attention to what other agencies were doing. In some cases, agencies were forced to cooperate, but typically did not do so voluntarily. Although the sharing of video data has not eliminated these problems, it has greatly improved interagency cooperation and communication. Individual agencies now tend to be much more aware of what other agencies are doing, and voluntarily work together to achieve common goals, rather than working alone to achieve individual goals. Improved cooperation and communication can result in operating cost savings and improved public service.

Direct Cost Savings for VIA

VIA experiences direct cost savings from the sharing of video data. The cost savings are realized by using a demand-based approach for special events rather than using a fixed schedule approach. Since video cameras are installed at key special events locations (the AlamoDome and nearby park-and-rides), VIA dispatchers can actually see how many people need to be picked up at a particular location at any point in time rather than simply running routes based on a fixed schedule. The demand-based approach eliminates excess trips and allows VIA to optimize individual pickups.

Accurate Weather Conditions on Freeway

Video data provide detailed and accurate weather conditions for the entire monitored freeway network. There is no speculation about prevailing conditions on any one segment. The TransGuide cameras allow operators to verify heavy rain, flooding, and high winds. The local television networks provide viewers with a real-time picture of weather conditions using video images provided by TransGuide. Live traffic video provides a much more accurate account of how weather conditions may be impacting travel than a verbal description.

Close Coverage of Incidents

TransGuide video allows the media to supplement mobile unit video coverage of incidents and current traffic conditions with close-up footage, or with footage from a different viewpoint. The purpose of close coverage is to provide the public with as much detailed information as possible.

24-Hour Real-Time Freeway Coverage

TransGuide video provides coverage of freeway segments 24 hours a day. TransGuide video provides up-to-date, comprehensive coverage of the monitored freeway system all day, every day.

Cost Savings to SAPD

Before TransGuide became operational, the SAPD received incident reports from local motorists or patrol cars. Calls from civilians were often inaccurate and vague. Up to one-half of all freeway-related calls to the SAPD were false alarms or minor incidents where the motorists left the scene before the police arrived[18]. Furthermore, callers could not always identify the exact location of an incident. Operational procedures require the SAPD to dispatch units to investigate each report. Due to the vague nature of many of the calls, police officers could not always locate reported incidents in a timely manner. Once an incident report was verified, officers had to assess the scene and call for the appropriate backup.

Using video, the SAPD dispatcher at the TOC can view the scene of a reported incident to verify an incident report. Once a report is verified, the dispatcher can select the appropriate level of response. The dispatcher coordinates his efforts

[18] Based on a conversation with Russell Henk from TTI on Thursday, June 11, 1998.

with the TransGuide operators to ensure that the appropriate traffic management response is selected.

Video sharing allows the SAPD to effectively use their limited resources by eliminating unnecessary trips to investigate false calls, providing the exact location of incidents, and providing prompt and accurate response to incidents.

Based on the information collected during the interviews, a matrix was constructed that summarizes the possible magnitude of each of the benefits described above. The matrix is presented in Table 8. The benefits categories described by the survey participants are listed along the vertical margin, while the various stakeholders are listed along the horizontal margin.

The matrix is not a comprehensive benefits matrix. The matrix includes only those stakeholders interviewed (along with the general public), and only the benefits described during the interviews. No attempt has been made to determine the potential magnitude of indirect benefits.

Table 8. Relative Magnitude of Perceived Stakeholder Benefits

	General Public (estimated)	**San Antonio Police Dept.**	**Texas Department of Trans**	**Local Media**	**VIA Metropolitan Transit**
Expedite EMS Response	Large	Small			
Accurate EMS Response	Large	Small			
Accurate Traffic Information	Large	Large	Large	Large	Large
Reduce Congestion	Large	Large	Large		Large
Improved Relations	Small	Large	Large	Moderate	Large
Cost Savings to VIA					Large
Accurate Weather	Moderate	Small		Large	Small
Close Coverage	Small	Large		Large	
24-Hour Coverage	Small	Moderate		Large	
Cost Savings to SAPD		Large			

A goal of the MMDI is to demonstrate the measurable benefits resulting from specific applications of ITS. In order to consistently measure benefits resulting from the deployment of different ITS systems and equipment across the individual MMDI sites, the ITS JPO developed a set of measures of effectiveness called the Few Good Measures (FGMs). The FGMs are (9):

- Crashes
- Fatalities
- Throughput
- Time Savings
- Cost
- Customer Satisfaction

For the purpose of this study, the FGMs were not explicitly used. Since interviews were open-ended, survey participants discussed perceived benefits associated with TransGuide video data based on their personal feelings and insights. The benefits described may or may not correspond directly with the FGMs. Table 9 shows how the benefits described in this study may be mapped to the FGMs. The table also provides an indication as to how difficult or easy it may be to quantify the various benefits. The first column of the table contains the perceived benefit. The second column contains the FGM that may best capture the perceived benefit. There may be more than one FGM that maps directly to any one perceived benefit. The third column (far right) provides three potential levels of quantification: 1) Difficult, 2) Moderate, and 3) Easy.

Table 9. Mapping of Perceived Benefits to a Few Good Measures

Perceived Benefit	FGMs	Relative Ease of Quantification
Expedite EMS Response	· Time Savings · Fatalities	Easy
Accurate EMS Response	· Time Savings · Fatalities	Easy
Accurate Traffic Information	· Customer Satisfaction	Easy / Moderate
Reduce Congestion	· Time Savings · Throughput	Moderate
Improved Relations	· Cost · Customer Satisfaction	Difficult
Cost Savings to VIA	· Cost	Easy
Accurate Weather	· Customer Satisfaction	Difficult
Close Coverage	· Customer Satisfaction	Difficult
24-Hour Coverage	· Customer Satisfaction	Difficult
Cost Savings to SAPD	· Cost	Easy

The relative ease of quantification is based not only on how difficult it may be to monetize these benefits, but also on the expected degree of difficulty in obtaining the data needed to quantify the perceived benefits. For example, although customer satisfaction can be quantified using a variety of well-established economic valuation techniques, collecting the data needed for the analysis is not a trivial process. Collecting the data needed to conduct a customer satisfaction benefit assessment typically involves the use of surveys or focus groups. On the other hand, the data needed to measure time savings and throughput benefits are traffic data that may already be available in some form.

Furthermore, it may be difficult to establish a baseline scenario in order to assess the incremental benefits attributed to the sharing of video data. For example, three years have passed since TransGuide became operational. It may be unrealistic to assume that unbiased and accurate information can currently be collected from the general public regarding a baseline scenario that examines the quality of traffic information before TransGuide.

In some cases, the effort needed to accurately measure and quantify a particular benefit may not be worth the time. For example, the total magnitude of benefits associated with close coverage of incidents and 24-hour coverage of roadways may be rather insignificant compared to improved stakeholder relations. It may therefore not be cost effective to attempt to quantify the benefits associated with close coverage of incidents or 24-hour coverage.

Since benefits have not been quantified at this point, it is difficult to draw any definitive conclusions regarding the net value of the benefits described in this paper. Additional research is required to quantify and monetize these benefits.

6.4. Perceptions of Video Data

Participants were also asked how they felt the general public, elected officials, traffic agencies, and non-traffic-related public agencies perceived the use of video. The various stakeholders had substantially different opinions on how the various groups view the use of video, particularly with regard to the general public. Some survey participants felt that it was important that the public have a good understanding of the benefits associated with ATMS video data. Other participants did not seem to think public understanding of video was really that important to the overall success of the project. The results are summarized in Table 10.

Although several news stories about TransGuide were aired during the first several months of operation, there has been a significant decline in media coverage over the past several years. Promotion of the system was discussed with several stakeholders. Currently, there are no concrete plans for a public awareness campaign regarding the use of video data. Several stakeholders felt that public perception of the system would be greatly improved if a promotional campaign were launched.

It is important to note that the perceptions of video data presented in this table are based on opinions of a small group of survey participants. The evaluator did not obtain a representative sample from any of the various groups listed in the first column of Table 10.

Table 10. Perceptions on How Various Groups Feel About the Use of Video

Group	Perception of Video Data
The General Public	· The general public is afraid of the video cameras. They believe the SAPD is using the video for law enforcement. · Other than direct access to the LPTV, the public does not understand how video data are used. So, the general public is not really aware of how video data impact the TransGuide system. · Public really has no perception of video data because they don't understand what is going on. · The public uses and appreciates the video data. They would definitely complain if video coverage were not available.
Elected Officials	· Fairly low appreciation for and understanding of video, but higher than the general public. Few elected officials understand what is going on at TransGuide. · Those that know about TransGuide favor the system. · The mayor, in particular, has seen the system in operation and was very impressed. He thinks the video is useful.
Traffic Agencies	· All traffic agencies are participating partners with financial contributions. They probably wouldn't be located in the TransGuide building if video were not available. · The traffic agencies understand what TransGuide is about and realize the importance of video to the success of the project and for accurate traffic management in general.
Non-Traffic Related Agencies	· Most agencies have some understanding of the use of video data and are supportive. · Many agencies do not understand TransGuide, and probably have no opinion, because they don't know how the video data are used. · There is a moderate level of appreciation and understanding of video. There are social equity issues that have surfaced with regard to what freeway segments are being monitored and where the Automated Vehicle Identification (AVI) readers are placed. Politics may tend to overshadow the real purpose of video.

The conclusions are presented in Chapter 7.

7. Conclusions

This paper provides a summary of the perceived benefits associated with the sharing of video data in San Antonio. Information was collected from local stakeholders using an open-ended interview process. The benefits described in this paper are based directly on those responses. The study focuses on the ATMS component of video data collection and use in San Antonio. Safety measures such as crashes and fatalities are not explicitly examined.

The video component of TransGuide is possibly the most important feature of the ATMS. The current success of TransGuide would not have been possible without the use of video. The TransGuide ATMS depends on voluntary public compliance to be effective, and therefore must provide both timely and accurate information 365 days a year. Video allows operators to:

- Verify incidents,
- Accurately determine the severity of individual incidents,
- Quickly identify the location of individual incidents, and
- Select the most appropriate response to individual incidents.

Without video, these actions might not be possible.

In this case, increased operator/agency benefits resulting from integration are more readily observed than the reduction of costs. The majority of benefits identified in this study would likely not have been realized at all if integration had not occurred. In most cases, the benefits were achieved for a relatively small incremental cost. Integration benefits discussed in this study include:

- Freeway Management and Incident Management,
- Freeway Management and Traveler Information,
- Freeway Management and Transit Management, and
- Incident Management and Freeway Management.

The ten perceived benefits mentioned during the interviews are:

1. Expedite EMS Response,
2. Accurate EMS Response,
3. Provide Accurate Traffic Information,
4. Reduces Congestion during Incidents,
5. Improved Relationships between Stakeholders,
6. Direct Cost Savings for VIA,
7. Accurate Weather Conditions,
8. Close Coverage of Incidents,
9. 24-Hour Real Time Freeway Coverage,
10. Direct Cost Savings for the SAPD.

Improved relations between stakeholders was the most commonly mentioned benefit. Many stakeholders also considered improved relations to be the greatest long-term benefits. Real-time video was the catalyst for co-location of the various agencies in the TOC. In turn, co-location has facilitated improved cooperation and communication among the various stakeholders.

Several stakeholders indicated that the SAPD is probably the biggest public sector beneficiary of video sharing. TransGuide video allows the SAPD to more effectively and efficiently perform its job. The use of video is explicitly designed to benefit the driving public. The general public receives significant benefits in the form of:

- Quick EMS response
- Accurate EMS response
- Accurate traffic information
- Reduced congestion during incidents.

Appendix

The MMDI Integration Evaluation team would like to thank all the Local MMDI Team members and stakeholders for their contributions to this study. Special thanks are extended to the following group of people who helped considerably with the successful completion of this study:

- Brian Fariello, Texas Department of Transportation, Deputy PM
- David Rodrigues, Texas Department of Transportation, Operations Manager
- Tony Cade, VIA Metropolitan Transit, Director of MIS
- Russell Henk, Texas Transportation Institute, Program Manager
- Harold Friesenhahn, KMOL-TV, Chief Engineer
- Steve Lamas, San Antonio Police Department, Officer/Dispatcher

A.1. TransGuide System Requirements

The TransGuide system was organized and developed based on a specific set of goals and requirements. Before individual components and subsystems were considered, the design team carefully developed a comprehensive set of minimum system requirements and goals that needed to be met. These goals and requirements are discussed in this section.

The functional elements of the TransGuide system operation include several core capabilities that are required to meet the specified goals. These capabilities are designed to:

- Alert TransGuide operators when incidents are detected,
- Provide the means to assess the nature and severity of the incident,
- Provide the ability to implement traffic control measures, and
- Provide the means to effectively communicate traffic information to drivers, public transportation systems, and service providers (4).

There are six core capabilities discussed in the TransGuide ITS Design Process:

1. Alert TransGuide operators to abnormal freeway conditions
2. Provide surveillance of suspected incidents
3. Control traffic lane occupancy
4. Control access to freeways
5. Communicate traffic information to motorists
6. Communicate traffic information to public safety, public transit, and other ITS

In addition to the core capabilities described above, there are specific system level performance requirements for TransGuide. Performance requirements for TransGuide are based on perceptions of the driving public and are centered around timely and accurate operation of the system, and the credibility and utility of the system. As mentioned in the

Introduction, traffic management depends on voluntary public compliance to be effective. A top priority of TransGuide is to provide the driving public with a high quality, accurate, timely, and useful ATMS. Performance measures are therefore based on public perception and reaction to the TransGuide system.

The physical configuration and implementation of the various system functions are designed to be compatible with the goals for real-time operation of the TransGuide core functions (4). Additional requirements include attributes such as design life, cost priorities, manageability, expandability, adaptability, availability, re-usability, and environmental capability.

The system attribute requirements were considered during the planning stages of the project, and influenced the design and procurement process. There is some interaction and overlap between the various system attribute characterizations. For example, component flexibility, durability, and reliability affect cost. The complexity of the system also affects cost, re-usability, and availability. The goal of TransGuide was not simply to meet the minimal systems requirements at the lowest cost, but to also consider other attributes such as expandability and manageability.

The most significant attributes considered in the design of TransGuide are discussed below:

- Design life
- Initial cost
- Maintainability and maintenance costs
- Operational quality and operational costs
- Manageability
- Expandability
- Adaptability
- Availability
- Reusability
- Environmental Capability

Design Life

The design life requirement for TransGuide is 20 years. The design life requirement provided rationale for equipment and architecture design decisions, as well as criteria for decisions regarding the balance of the system requirements (4). Future growth estimates and the scope of TransGuide were additional considerations in the design life.

Initial Cost

TransGuide was designed to meet aggressive traffic management and operational goals for a practical initial cost (4). The cost approach used in the TransGuide project was not explicitly a least-cost approach. The initial deployment goals of TransGuide could have been obtained using individual components that cost less than those chosen. The design team concluded, however, that once the system goals and requirements were integrated, and attributes such as maintainability, expandability, and durability were considered, selecting the least expensive components might not be the best approach in the long run.

The design team selected individual components while considering a variety of attributes, including cost. Cost was not necessarily the most important attribute considered. This approach allowed the team some flexibility in determining the best bundle of components that would enable the team to consider all attributes. For example, the video camera/lens system used in TransGuide is relatively expensive (4).

When the team considered that a high level of video quality and performance were imperative to the success and functionality of video surveillance in an ATMS, cost was not considered to be the most important factor in the camera selection decision. Ensuring that the video equipment selected provided TransGuide operators with sufficient detail and image quality to allow them to make fast and accurate decisions regarding incident assessment and response was determined to be the top priority.

Maintainability and Maintenance Costs

Maintainability was also a critical factor considered by the design team. The ability to respond to failures in a quick and effective manner as well as issues pertaining to routine system maintenance were important features considered by the design team (4). In some cases, funding policies dictated that the minimization of routine operational and maintenance costs be a higher priority than the incremental minimization of initial costs. The tradeoff between incurring higher initial costs while minimizing operations and maintenance costs was justified in some cases.

Operational Quality and Operational Costs

Day-to-day variability in the decision-making process pertaining to incident responses was perceived by the design team to be one of the most prevalent threats to maintaining a high level of quality in system operation (4). In order to minimize the variability of incident responses between operators, and over time, TransGuide limits the operator input needed for any particular response. In order to reduce long-term operational costs, TxDOT hires and trains TOC operators rather than using traffic engineers to operate the TransGuide system.

Manageability

The TransGuide system currently handles vast amounts of data on a daily basis, with the potential for much more data to be introduced into the system as the scope of operations expands (4). In order to reduce the complexity and cost of management, a manageability requirement was established for the components and subsystems used in the system. The requirement mandated that all components and subsystems easily integrate into a system with sufficient self-diagnostics, reporting, and system management functions. This requirement was achieved with a single network management system that simplified management, standardized reporting, and eliminated operational and functional redundancy where it was not needed.

Expandability

Expandability of the TransGuide system was an important consideration in the design process, given that the scope of TransGuide is expected to expand within San Antonio in the near future, and possibly expand throughout the South Texas region in the more distant future. The ability of the system to accommodate more miles of freeway was an important attribute.

Adaptability

TransGuide was also designed to allow for the adoption of new technologies and methodologies. Since ITS is an evolving system, TransGuide established a standardized format for information interchange that includes the excess capacity and bandwidth needed to allow for significant added functionality over time (4).

Availability

TransGuide is required to be online and functioning 24 hours a day, 365 days a year (4). Poor system reliability influences performance and subsequently the public perception of the system. TransGuide system designers therefore established a baseline requirement that the system be fully operational at least 99.99 percent of the time.

Reusability

TransGuide designers required that the components, subsystems, configuration, and software design alternatives utilized in the system be reusable where possible (4). This requirement was adapted based on the likelihood that designers may want to use all or part of the TransGuide implementation design for other ITS facilities in the future. Designers chose to use proven commercial hardware with broad applications and a well-established maintenance and support base to enhance potential reusability. Components that were likely to become obsolete or scarce were avoided. The software system was designed to be modular, portable, and well documented to allow system designers as much independence as possible.

Environmental Capability

Since traffic management systems are required to operate in all types of weather conditions and atmospheric extremes, TxDOT established tough environmental capability standards for TransGuide field equipment (4). The requirements specified that system operational integrity would be maintained under worst-case environmental extremes to ensure that the operational life of the system would not be degraded by extended exposure to a wide range of environmental conditions.

TxDOT focused on the creation of detailed plans and specifications when designing TransGuide and selecting the major subsystems. The minimum requirements were established to ensure that the integrated system would have the functionality and performance specified. After a comprehensive specification document was prepared, it became an important issue in the contract between TxDOT and the contractor. Specifications for the TOC, roadway, signs and structures, communications and computing equipment, video equipment, software, and electrical components were included in the technical requirements.

The designers used a holistic approach to develop TransGuide that considered the integration of all components. Flexibility was a major concern of the development team (4). It was less important to develop a system that included predetermined functional or physical partitions than it was to develop an integrated system that met all the goals and requirements with as much excess capacity as possible. Components were continually updated as new technological developments and specifications were achieved. The system, therefore, is easy to upgrade and modify. The design team developed the system requirements before they began designing the individual pieces of the integrated system.

TxDOT decided to perform most of the design and development in-house since they would be responsible for operating and managing the system. The rationale behind this decision was that the people who use the system the most are uniquely qualified to determine the operational and functional requirements of the system. The design and implementation of the system was approached in a phased manner. This approach allowed the design team to gain insight into the operation and functionality of the system during early phases of the project, and to apply what they learned in later phases.

A.2. TransGuide System Design

Once the system requirements for TransGuide were finalized, a formal specification for the system was generated. The specification was used as a basis for all system design and procurement. System design issues are presented in this section.

TransGuide incorporates several major subsystems in a well-defined process. Several considerations affected the subsystems and components used in the TransGuide system. These considerations are divided into four categories:

- Operational Processes
- Organization
- Software Issues
- Redundancy and Fault Tolerance

Each consideration is discussed in detail below:

<u>TransGuide Operational Process</u>

There are alternative processes for the operation of a TOC. Many TOCs focus on detecting congestion by comparing traffic parameters such as occupancy, volume, or average speed (4). Other TOCs focus on controlling freeway volume using ramp metering. An alternative approach is to focus on incident detection and response. Since incidents are one of the primary causes of congestion in San

Antonio, TransGuide focuses on incident detection and response. TransGuide compares traffic volumes and speeds to dynamically varying baselines rather than to a single baseline (4). Loop detectors are used only for detection of incidents, and not for the classification of incidents.

TransGuide is able to select and execute scenarios involving multiple road signs and traffic signals in a real-time manner. In addition to supporting TxDOT operations, the TransGuide TOC also supports police, emergency, and transit operations (4). TransGuide uses a real-time full-coverage video system to classify incidents and to determine the appropriate response to these incidents. Full-coverage video provides TransGuide with the ability to actually see what is happening on any particular segment of the instrumented portion of the freeway. The use of video is discussed in more detail in the following section.

TransGuide Organization

TOCs can be organized in a variety of ways. Table A.1 illustrates several different organizational structures, along with some of the characteristics of those organizations (4). One type of organization is a distributed system that has no central TOC, but relies on several local TOCs. Another type of organization is hierarchical, which utilizes the distributed concept of local TOCs, but has a centralized TOC that coordinates all responses. A third type of organization is centralized, where all traffic management is controlled from a single location. Each structure has advantages and disadvantages.

TransGuide relies on a centralized organizational structure. All traffic management functions are controlled from the TransGuide TOC. All video signals are transmitted to the TOC. All signs and signals are controlled from the TOC. All TransGuide managers and personnel are located at the TOC. The mainframe computer and management equipment is located at the TOC (4). The design team felt that the goals and objectives of an ATMS for San Antonio could best be met using a centralized structure given specific time and budget constraints. In the case of San Antonio, the team determined that the initial cost savings associated with using the centralized approach were at least $4.5 million.

A centralized organizational structure worked especially well in San Antonio because the political power and tax base of the city is fairly centralized. Approximately 1.1 million of the 1.3 million residents of San Antonio live within the San Antonio metropolitan area. A centralized tax base went a long way in eliminating potential problems regarding the location of the TransGuide TOC, jurisdictional issues relating to police and EMS response, and what agencies would be located within the building.

Table A.1. Comparison of TOC Organizational Structures

Type of TOC	Centralized	Distributed	Hierarchical
Pros	Centralized control and management Ability to share equipment and personnel among all traffic management tasks Single location for all equipment Allows operators to easily communicate about interrelated problems Potential cost savings	High probability that at least part of the system will always be operational Allows operators to concentrate on local or familiar parts of the ATMS	Provides both local control and control of overall system High probability that at least part of the system will always be operational Allows operators to concentrate on local or familiar parts of the ATMS May allow better sharing of resources than a distributed system
Cons	Potential for entire system to fail Does not allow operators to concentrate on the detail of local areas	More expensive due to larger number of TOCs Does not allow for resource sharing May encounter control problems relating to incidents that span boundaries of local areas	Complex management More expensive Is subject to some of the resource sharing and communication problems in a distributed system, but probably to a lesser extent

Source: Based on information contained in TransGuide ITS Design Plan

Software Issues

System software development was critical to the success of the TransGuide project (4). The software was designed to interact in a successful and reliable manner with all of the equipment and devices specified for the various subsystems of TransGuide. The software used in TransGuide provides a variety of functions:

- Provides a user interface to the system,
- Collects, organizes, and analyzes data,
- Alerts the operators to potential incidents,
- Allows operators to control the cameras and view data in a graphical environment,
- Facilitates incident evaluation,
- Allows the operator to select and modify scenarios controlling VMSs and LCSs, and
- Provides the tools needed to maintain and expand the TransGuide system.

TransGuide software was developed as several independent, cooperative software processes (4). Many of the software-based functions are required to integrate and manage the various parts of the TransGuide system. The software development process had four major areas of focus:

1. Data acquisition
2. Database design
3. Graphical User Interface (GUI)
4. Software development and standards

The focus areas specify:

- How information is collected,
- How that information is stored and retrieved,
- How the operators and managers interact with the computer system,
- How information is viewed (graphical versus numerical),
- Input and Output (I/O),
- The operating system requirements and standards,
- The system programming language, and
- The communication protocol (4) [19].

Redundancy and Fault Tolerance

In order to maintain the high levels of reliability and availability described in the system requirements, the system must be operational and protected against equipment failure and power outages. TransGuide therefore incorporates significant redundancy and fault tolerance features into the system. Redundancy and fault tolerance does not only apply to the computer hardware, but to field equipment as well.

In the field, loop detectors are deployed in a trap configuration, which consists of two loop detectors (4). If one detector fails, the system can still retrieve volume and occupancy data from the other loop detector. The video surveillance system provides for overlapping coverage by video cameras in many cases. If one camera fails, the roadway can still be viewed by another camera. LCS and VMS messages are still displayed if bulbs fail. Furthermore, the signs are designed to detect failed lamps and “map around” the failure by using operational lamps. The lamps also contain redundant fibers to replace fibers that fail.

The TransGuide computer system consists of two independent computers that execute the same instructions at the same time (4). There is a separate backplane for each of the computers to the I/O. The redundancy feature allows the system to

[19] Loop detectors are used to collect traffic data throughout Phase I of the TransGuide project. Probe vehicles are currently being used to collect traffic data outside of the road segments included in Phase I. Probe data are being used by TransGuide. It is unclear at this point in time whether the city will use both loop detectors and probes to collect data in the future, or whether the city will decide on one approach.

stay fully operational in the event that one of the computers fails or is being repaired. The Local Area Network (LAN) used to communicate between the mainframe and the individual workstations consists of dual segments that will allow at least half of the workstations to remain operational if one of the LANs fails.

A.3. Details Associated with TransGuide Video System

The video surveillance system is a key component to the operation and success of TransGuide. The video system was selected only after considerable investigation, testing, and evaluation. Details concerning the cost and functionality of cameras, lenses, video codecs, monitors, and user control functions are discussed in this section.

Cameras

The selection of the camera, lens, and the spacing between cameras involved consideration of several interrelated factors. There are tradeoffs between the initial expense of high quality cameras and the initial expense of additional communication equipment required utilizing a less expensive, lower quality camera. There are also tradeoffs between less expensive cameras that may have high installation and maintenance costs versus more expensive cameras that have very low installation and maintenance costs.

Several different cameras were compared by the design team, including one-chip low-resolution cameras; one-chip high-resolution cameras, three-chip high-resolution cameras; and digital cameras (4). The three-chip, high-resolution camera was selected based on the quality of color and picture resolution it provided. The one-chip cameras did not provide useful enough video quality to the operator. The team felt that the additional cost of the digital camera did not justify the incremental improvement in picture quality and resolution.

Lens

The selection of the lens system had a direct impact on the spacing of video cameras. A tradeoff exists between lens magnification and camera spacing (4). Various camera/lens combinations were tested at spacing intervals of 1/2 mile, 3/4 mile, and 1 mile. The designers chose a 1-mile nominal spacing for the cameras. A prime factor in determining the spacing was the availability of a lens stack and camera consisting of primarily off-the-shelf components that could provide useful video at 1/2 mile.

The lens system was selected after camera spacing was determined. The lens system selected was required to meet minimum TransGuide requirements of image quality and clarity. The lens system is comprised of several components, including a standard 2/3-inch lens capable of being remotely zoomed from 9.5 to 15 (4). An adapter that allows the lens to interface with the 1/2-inch camera lens mount provides effective magnification of 1.48. The system also includes a teleconverter and an additional extender lens that provides additional magnification of 1.5 and 2.0, respectively. The extender can be remotely added to or taken out of the lens configuration. Overall, the system is capable of providing magnification of between 21 and 33.3 without the extender, and between 42 and 66.6 with the extender.

Video Codecs

Video codecs provide the interface between the video subsystem and the communications subsystem at both the camera end and the video display end (4). The codec must be compatible with the video signal and capable of converting the signal between analog and digital format without significant attenuation.

Several methods of interconnecting the field and TOC portions of the video surveillance system were considered. Cameras could be hardwired to specific monitors in the TOC using direct analog communications (4). The camera signals could have been multiplexed onto single coaxial lines by frequency. The camera video signals could also be converted to digital format and transmitted to the TOC over digital communications lines.

The design team chose to convert the analog video signals to digital format through the use of a video codec, and send the signal to the TOC over digital lines. The signal is then reconverted back to analog format to be viewed on monitors. DS3 codecs were selected which operate at a speed of 44.736 Mbps. After testing the various signal speeds, it was determined that the quality of video transmitted at speeds below 44.736 was not good enough to meet the standards set by TxDOT. The team also determined that the improvement in the quality of video transmitted at 135 Mbps did not warrant the extra cost of using high-speed codecs needed to transmit at 135 Mbps.

Monitors

Each operator workstation at the TOC has four color CRT monitors used for viewing the video data collected from the cameras in the field (4). Each of the monitors has a 13-inch screen that is required to be Red, Green, Blue (RGB)- and National Television System Committee (NTSC)-compatible. The design team also considered 9- and 15-inch monitors. The 13-inch screen was selected after a series of experiments were performed that considered operator head movement, viewing comfort, and the ability of the operator to clearly view images.

User Control Functions

The TransGuide system allows operators to control the video equipment needed to view and respond to incidents. Each operator can select up to four cameras to view at a time. The operator can control only one camera at a time (4s). The operator can control the direction the camera is pointing, in addition to zoom, focus, iris, and gain. Camera functions are controlled using a mouse-based interface.

A.4. The Future of TransGuide

Phase II of the San Antonio ATMS includes an additional 27 miles of roadway. Phase II focuses on:

- Extension of the ATMS on I-10 north across Loop 1604,
- Extension of the ATMS along I-37 north toward Loop 410, and
- Expansion of the ATMS to include the northern portion of Loop 410 near the San Antonio national airport (9).

Phase II will involve the installation of 626 additional loop detectors, 63 sonic detector stations (covering 15 freeway centerline miles), and 37 additional CCTV cameras. The city of San Antonio will have 137 VMSs operational by the end of Phase II.

The operational and functional goals for TransGuide include providing ATMS and ATIS functions over the entire South Texas region. The South Texas region covers approximately 44,000 square miles and includes 39 counties (4). The expansion will also include 16 international bridge crossings along approximately 300 miles of the border between Mexico and the United States. This area supports international commerce that accounts for approximately 60 percent of all the trade between the two countries. TransGuide is also in a position to support either or both of the proposed 150-mile ITS corridors being considered for the region.

A.5. The Low Power Television Station

Video data are also shared through the LPTS, which is owned and operated by TransGuide. The LPTS was primarily developed in order to disseminate video data to the general public. Although this component of video data sharing is utilized for distribution of traffic data (ATIS), traffic data are also sent to the members of the Media Distribution Partnership. These data allow members to utilize map-based software to view traffic flow and incidents. The members of the partnership all have partial ownership of the Media Site Software, but they purchase the computer hardware needed to access and use the data themselves. The Media Site Software resides on the user’s hardware.

Private sector organizations funded 50 percent of the Media Site Software, while TxDOT funding the remaining 50 percent (2). As other organizations enter into the partnership, they are required to purchase one software license per outlet based on a fee that is 25 percent higher than the original development partners. Members who purchase a software license will have voting rights with regard to future enhancement of the program and the distribution of funds. Each member organization is represented by one individual. The partnership was accomplished through a Cooperative Industry Project Agreement and is regulated by the Federal Trade Commission.

The Agreement allows for an unlimited number of participants, and it is expected that several hundred partners will eventually join the organization (2). Additional funds will be used to enhance the program and to solicit new members. Since the software rights belong to the Cooperative Industry Project Agreement and not to TxDOT, it is possible that these rights could be sold to a private sector company sometime in the future.

The general public can access the video images transmitted on the LPTV by purchasing a low-cost UHF antenna. The image is viewed on an ordinary television (San Antonio channel 54). TransGuide operators rotate through a variety of freeway segments about every 20 seconds. Typically, the more heavily traveled intersections are shown. TransGuide will also show video coverage of incidents in order to alert drivers. The partners do not have control over what freeway segments are broadcast over the LPTV. TransGuide maintains strict control over what segments are shown, and for how long. The image is not edited, and is based on the TxDOT view of priority within TransGuide.

A.6. ATMS Video Questionnaire

Background Information

1. Which agencies/organizations are currently involved in the collection of video data in San Antonio?

2. Who (agencies/organizations) uses the data?

3. Exactly how are the data used, or what are the data used for? For example, in the case of the TransGuide Traffic Operations Center (TOC), the data are used primarily for verifying an incident and evaluating severity of incidents. Once an incident is detected, the operator zooms in to evaluate the severity of the incident and to assist in identifying the appropriate response measures. Are there other uses for the data? For example, are data used to identify traffic violations, etc? (We assume there are legal issues relating to the use of video data for enforcement, True?)

4. TransGuide loop and probe data are currently stored. Is video data also stored? If yes,

    - How and where are the data stored?
    - How long are the data stored?
    - What are stored data used for?

Implementation of Video Sharing

5. What does “sharing” mean? Does it mean that the current agencies/groups that collect video data will simply “give” the data to other agencies/groups? Or does sharing mean that additional agencies/groups will become involved in the collection and use of video data?

6. How will this information be shared? For example, will sharing only happen at the TOC? Does data sharing imply that the collection procedure will not change, but additional agencies will “have stations” at the TOC and use the data? Or will the data be transmitted off-site for use by other parties?

7. How did video data sharing get started?

8. Who were/are the main proponents for sharing video data (who were/are the main opponents)?

9. What were the major obstacles to sharing data? How were these obstacles addressed/overcome?

10. What are the three things that were most critical to the success of video data sharing?

11. Does sharing require legal agreements between parties? Please describe the arrangement in general terms.

12. If you could change the way you implemented the video system, how would you change it? And why?

13. Please describe any future plans for video data sharing.

The Use of Shared Video Data

14. Will the sharing of video data impact, in any way, how other data are used? If yes, how?

15. Will the sharing of video data impact, in any way, how or where the data are stored? For example, will a video archive need to be created and maintained?

16. Does sharing imply shared control of the video equipment and data, or will TxDOT maintain proprietary ownership of the equipment and data through the TransGuide program?

17. Will the sharing of video data impact TxDOT's relationship with other public agencies in San Antonio or the state? In what way?

18. Please describe the relationship between the low power television station and the ATMS video data collected by TransGuide.

    - Is the low power television station considered part of the ATMS data-sharing program, or is it considered an ATIS that is separate from video data sharing? Or does it cut across the boundaries defining ATMS and ATIS?

    - Are live video data feeds currently available to the public? If so, for how long have they been available? Were they available before video data sharing?

    - Are live video feeds sent directly from the cameras to the low power television station for broadcast? Or are video feeds first sent to the TOC, and

then sent to the television station? Is this data any different from the video data received in the TOC (i.e. is it altered or edited)?
- Does data sharing impact the current operation of the television station in any way? For example, will data become more widely available to the general public or will the operation of the station change in any way?

19. Under the video-sharing scenario, will new video data collection technologies be employed? For example, does sharing imply that different technologies will be used for certain types of video data? Or will all data be collected using the TransGuide CCTV cameras?

20. Will all video data be shared or just specific data?

21. Will shared video data be distributed statewide?

22. Will live video data be available over the Internet?

Cost Reduction and Benefits

23. Will sharing reduce TxDOT operating costs? In what way? For example, will the cost of data collection and camera maintenance also be shared? If so, please describe the arrangement.

24. Will sharing improve data availability, quality, or introduce potential new uses of the data? In what way?

25. Will video data be sold to the private sector (or others)? Why or why not? If yes, please describe the approach.

26. In your opinion, what are the benefits of ATMS-related video data?

27. How do you believe the value of video data is perceived by:

    - The general public
    - Elected officials
    - Traffic agencies
    - Non-traffic related public agencies

28. How do you think sharing video data will impact these perceptions or increase the benefits of video data? Please describe.

29. In your opinion, what were the primary reasons motivating video data sharing (maximize benefits, minimize cost, other)?

30. Who will benefit the most from video data sharing? How will they benefit?

31. What is the relative importance of the following constraints in building, operating, and/or expanding this type of video data sharing system?

- Technological constraints
- Organizational constraints
- Financial constraints
- Legal constraints

32. Where are / what are three (3) different things one could look at / look for in San Antonio to see clear evidence of the impacts of video data sharing?

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