Houston TranStar

Annual Report 2005

The Houston TranStar consortium is a partnership of four government agencies that are responsible for providing Transportation Management and Emergency Management services to the Greater Houston Region.

Texas Department of Transportation

METRO

HARRIS COUNTY TEXAS

CITY OF HOUSTON TEXAS

INTRODUCTION

Houston, Texas is the fourth largest city in America. While constructing and maintaining roadways is part of the solution in keeping traffic moving safely and efficiently in the region, Houston TranStar has been a leader in designing and implementing transportation operations and management plans to reduce traffic congestion in the region. Whether the destination is work or play, Houston TranStar plays a pivotal role in the travel of people in the greater Houston region, saving motorists more than $1.3 billion in reduced travel time costs over the nine years of Center operation from 1997 to 2005.

Houston TranStar was established in 1993 to provide for multi-agency management of the region's transportation system as well as a primary resource from which to respond to incidents and emergencies in Harris County and beyond. Houston TranStar is a partnership among the four principal transportation and emergency management agencies in Harris County: the Texas Department of Transportation (TxDOT); Metropolitan Transit Authority of Harris County (METRO); Harris County; and City of Houston. Houston TranStar was the first transportation management center to include both transportation and emergency management functions in a single facility. Houston TranStar is recognized both nationally and internationally as a model for combining resources across modal and jurisdictional boundaries.

Houston TranStar's Mission

It is the mission of Houston TranStar and its partner agencies to provide highly effective transportation and emergency management services through the combined use of the partners' collective resources to maximize safety and mobility to the public.

This document is the ninth annual report for the Houston TranStar Transportation Management and Emergency Operations Center. This annual report provides a review of the performance of the center and summarizes the estimated return on investment as quantified by the estimated benefit/cost ratio.

The estimated cost of congestion in the Houston TranStar service area was calculated to be over $720 million in 2005. The estimated annual reduction of travel time attributable to the center operation was estimated to be 11.8 million vehicle-hours, with an estimated value of $216.8 million savings. These travel time savings are estimated to have reduced fuel consumption by 22.2 million gallons, resulting in an additional savings of $49.3 million. The reduction in fuel consumption also results in a net reduction of exhaust emissions estimated to be equivalent to a reduction of 480 tons of hydrocarbons; 3,105 tons of carbon monoxide; and 699 tons of nitrogen oxides. The total 2005 motorists' savings due to travel time and fuel cost savings attributable to Houston TranStar was approximately $266 million. Comparing the annualized TranStar operating cost estimate of $26.6 million to the annual benefit of $266.1 million yields a benefit/cost ratio of 10.0.

TRANSTAR OPERATIONS FRAMEWORK

Houston TranStar uses a three-tiered management structure (see Figure 1) with representation of each of the four agencies on each committee. Functions of the three committees are:

- Executive Committee – comprised of agency- or division-level executive administrators; sets policy and manages fiscal and staffing matters;
- Leadership Team – comprised of administrators of the transportation and emergency management groups; administers implementation of various projects and activities and reviews funding commitments; and
- Agency Managers Committee – comprised of managers of the transportation and emergency management groups; the agency managers are responsible for daily operations.

Houston TranStar is staffed by employees from the member agencies which support the three levels of management in operating the systems and programs housed in the Center. Operation of the Center is coordinated by a small management staff that is responsible for operating and maintaining Houston TranStar facilities, coordinating multi-agency activities, coordinating budget preparation, workshops, meetings, and facility tours, and managing public information activities.

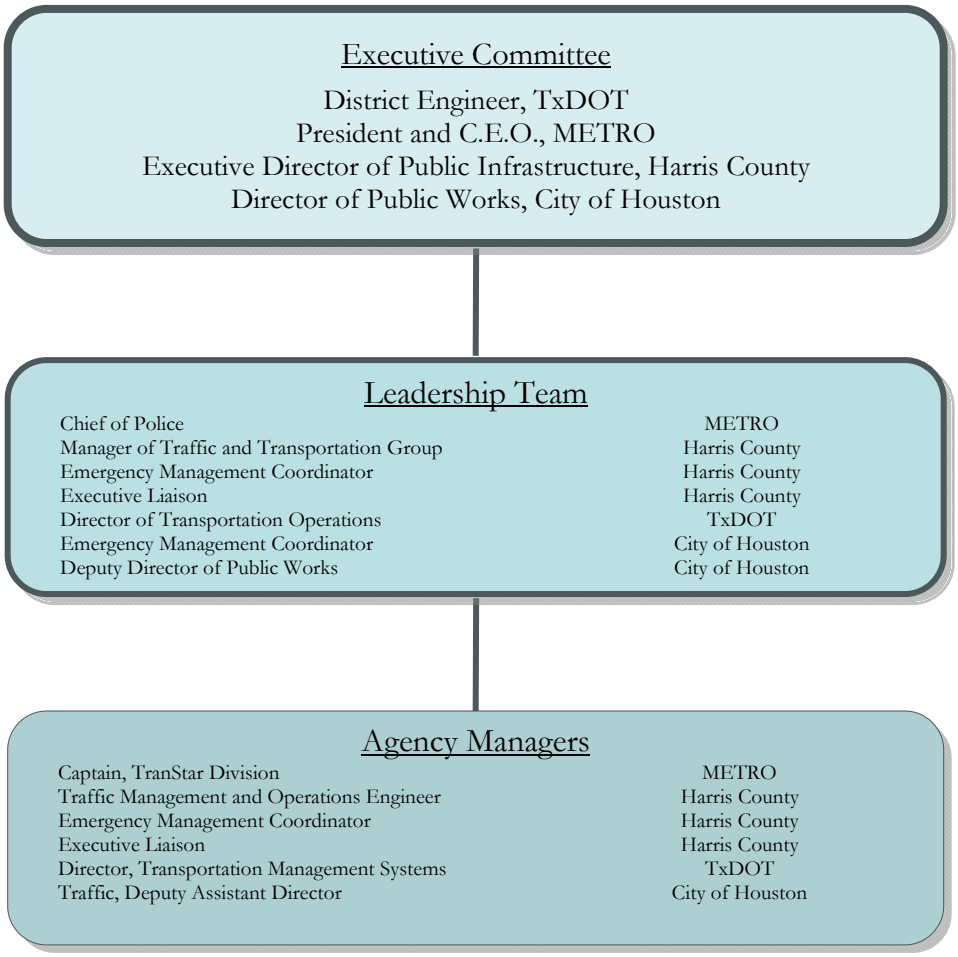


Figure 1. Houston TranStar Organization Chart

SUMMARY OF ACTIVITIES

The continued deployment of field devices and development of internal management information systems has allowed Houston TranStar to expand over the past year. In addition to the management of many aspects of the regional transportation system, the cooperative working relationships fostered by daily interaction of the various agency staff and training meetings are invaluable to the operations of Houston TranStar. Activities and accomplishments for the Year 2005 are highlighted in the following sections of this report.

Some of the highlights and significant accomplishments of TranStar during 2005 included:

- Added 20.8 directional miles of Automatic Vehicle Identification (AVI) system coverage on the Westpark Tollway and 73.6 directional miles of AVI system coverage on the Sam Houston Tollway South and East. This brings total covered directional miles to approximately 690 miles;
- Asynchronous Transfer Mode (ATM) network communications conversion – completed installation of the CCTV system ATM upgrades and integrated the system into control room consoles;
- City of Houston SafeClear Program (quick-response towing program) was implemented on most Houston-area freeways;
- Regional Incident Management System (RIMS) – addition of the SafeClear Operations Module initiated, allowing SafeClear reported incidents to be recorded in the RIMS databases;
- Harris County CCTV system was connected to the TranStar Computerized Traffic Management System (CTMS) - 63 cameras in 2005;
- Historical AVI data access was added to the TranStar website;
- 13 Rural DMS were added to the TranStar control room, and communication links made to these signs in three other TxDOT Districts;
- The Integrated DataBase Maintenance System (IDBMS) became operational;
- Temporary construction cameras were added to the Katy Freeway reconstruction project and added to the TranStar website;
- Instituted the After-Hours Maintenance/Signal Operations Personnel Call-Out System (POCET) to the TranStar website for internal agency maintenance use. This system is an Internet-based system allowing automated maintenance task entry and status reporting;
- "State and National Government Innovator" award winner from the 6th Annual Digital Government Awards at FOSE 2005, the largest government trade show in the world. Presented by MIT and Accenture;
- Winner of the 2005 "Best of ITS" Partnership Deployment (Public Sector) Award for its development and deployment of the Regional Incident Management System (RIMS);
- TranStar served as a nerve center for the direction of an influx of Hurricane Katrina evacuees from Louisiana in August. The center was the focal point of community response and provided messages on DMS signs to instruct evacuees on shelter locations and phone numbers for aid. TranStar coordinated the evacuee transportation staging area at Reliant Park as hundreds of buses from New Orleans arrived to the area; and

- TranStar was again at the center of a Hurricane event in September with the evacuation of the Houston area in anticipation of the landfall of Hurricane Rita. An estimated 2.5 to 3.0 million residents took to the roadway to escape the threat of the Category 5 hurricane. TranStar's website was accessed more than 9.8 million times by 475,000 unique visitors during the event. TranStar was the location where government officials convened to give media and the public the latest updates and information on the evacuation efforts.

TranStar Hurricane Katrina and Hurricane Rita Operations

For Hurricane Katrina, Louisiana DOT operated its plan which directed hundreds of thousands of evacuees into Texas and ultimately to Houston. TxDOT displayed shelter locations and phone numbers on DMS between Beaumont and Houston and in the Houston metro area. TxDOT staff provided Houston-area shelter information to the TxDOT Travel Information Center in Orange, Texas, as westbound evacuees entered Texas.

During the 2005 Hurricane Season, the Governor had enacted "mandatory" evacuation zones for the first time in Texas. In the short time that Katrina evacuees were barely being assimilated in the Houston area, Hurricane Rita set its sites on the Texas coastline. At least 500,000 permanent residents were at risk from storm surge if they did not evacuate. In addition, nearly 250,000 Louisiana residents had just been relocated to the Houston area. Based on the project storm path (see page 14) of this Category 5 hurricane, storm surge could have reach IH 610 East Loop and anything slightly south and east of IH 45 and Beltway 8.

Houston TranStar became the command, control, and information center for the region. Once Galveston made plans for their evacuation off the island, plans were set for evacuation of portions of Houston and Harris County that evening. In the end, between 2.5 to 3.0 million people evacuated. It was not always pleasant and there was some loss of life. The job was completed nearly a day before landfall, but it had impacted the whole state and even some adjoining states. The

impact of back-to-back Category 5 storms and the plight that the Louisiana area had just endured certainly brought a near "perfect-storm" evacuation scenario. Yet the media and the public were able to get real-time information to make their decision from TranStar. Had the storm not veered to the east and had the evacuation warning not been heeded, extreme loss of life, not unlike that experienced in Katrina, certainly would have been a possible outcome. TranStar played no small part in adverting that catastrophe. It is almost impossible to quantify that benefit.

Texas Department of Transportation (TxDOT)

TxDOT is responsible for traffic management of freeways and state-maintained arterial highways in the region. The Computerized Traffic Management System (CTMS) has been in continuous deployment on Houston area freeways since the late 1980s with 94 miles added in 2005. The total extent of the system now exceeds 335 miles. Components of the CTMS include closed circuit television (CCTV), dynamic message signs (DMS), highway advisory radio (HAR), freeway entrance ramp flow signals, travel time monitoring using the Automatic Vehicle Identification (AVI) system, and related fiber/communications systems and central facility computer systems. The extent of the freeway management system and other ITS components in 2005 is listed below:

- Closed Circuit Television: 353 cameras
- Dynamic Message Signs: 169 total DMS
  - 131 for freeway operations
  - 38 for HOV and P&R operations
- Highway Advisory Radio
  - twelve fixed transmitting locations
  - one portable transmitting station
- Flow Signals in Operation: 102 on five facilities (IH 45 North, IH 45 Gulf, US 59 Southwest, US 290 Northwest, and IH 610 North Loop)

The TranStar partner agencies, under the leadership of TxDOT, are participating in the Priority Corridor program, a federally sponsored ITS deployment program. This program, in addition to the ITS Deployment program, have added significantly to Houston TranStar's capabilities.

The Priority Corridor and ITS Deployment programs have resulted in deployment of DMS and HAR units in the region, development of database technology for regional incident management, development and expansion of environmental monitoring systems on roadways, and planning and initial deployment of the regional hurricane evacuation camera and radar system.

City of Houston

The City of Houston Signal Engineering and Operations Branch, located at Houston TranStar, directs the design and installation of new traffic signals, operates and manages the city's signal system, and oversees operations and development of the signal communications infrastructure.

Initiatives in 2005 included the continuation of the Traffic Signal Timing Optimization Program (TSTOP). TSTOP addresses traffic signal synchronization issues and began on January 7, 2004 (Phase 1) and concluded on December 31, 2005 (Phase 2). The central focus of TSTOP was to provide an optimized level of traffic signal operation on the city's most heavily traveled corridors and throughout some of its most heavily populated employment areas. TSTOP 2005 retimed 582 traffic signals distributed over 71 critical corridors throughout the City. TSTOP provided upgrades of controllers and detection at approximately 150 signalized intersections. Initial evaluations of TSTOP corridors indicate travel time savings of 10 to 25 percent. Through the City of Houston CMAQ project, timing on 138 additional traffic signals was optimized within the same model. The City also actively coordinates signal operations in work zones and at political boundaries with TxDOT and Harris County.

METRO

The Metropolitan Transit Authority of Harris County provides bus and light rail transit services as its core function but is also involved in other transportation and law enforcement functions. METRO is an active partner in the operation of Houston TranStar and using Houston TranStar's collection of ITS technologies; METRO is able to provide improved service to the Authority's patrons. METRO Programs operated from Houston TranStar include METRO bus and METRORail dispatch, traffic signalization systems, HOV management systems and incident management programs. METRO highlights for 2005 include:

RCTSS - Regional Computerized Traffic Signal System. In 2005, METRO completed deployment of the extensive RCTSS network for the benefit of Houston TranStar's traffic management agencies. The 1,351 signal RCTSS system is primarily located on bus routes inside Beltway 8 and is operated from Houston TranStar. The system is comprised of four primary elements: central control (Houston TranStar), intersections, communications, and transit vehicle interface (for transit signal priority). The following highlights RCTSS activities in 2005:

- All significant RCTSS contracts have been completed and closed out,
- RCTSS was operational in April 2005 with a final outlay of $120 million,
- The RCTSS communications SONET "backbone" is complete, saving METRO operating dollars,
- RCTSS in the Texas Medical Center and Spur 527 areas is operational,

- An adjunct to the RCTSS program provided the traffic/Light Rail Transit (LRT) signaling platform for METRORail at an additional 60 intersections,
- Construction was completed at an additional 156 intersections under Metro's CMAQ program with full integration expected by February 2007, and
- The City of Houston's TSTOP Program was based in large part on availability of RCTSS equipment and schedule.

The proposed transit signal priority treatments brought into balance the needs for general traffic operations and mobility and RCTSS provides a strong arterial signal system platform for future ITS systems and resulting benefits.

IVOMS - Integrated Vehicle Operational Management System. METRO continued work on the IVOMS system development and integration in 2005. IVOMS is an automatic Vehicle Location system that allows increased operator and passenger service by providing bus location and real time vehicle information directly to Bus Dispatch at TranStar. IVOMS can be used for automatic passenger counting and can be configured for traffic signal priority.

Hyperalert. Hyperalert provides METRO TranStar personnel Police, Bus and Rail staff to deploy notifications with the flexibility to create unlimited groups. The messages can be deployed to pagers, email and blackberry with text or by phone using voice.

Harris County

The Harris County Public Infrastructure Department's (HCPID) Traffic Management and Operations Section manages the operation of the County's signal infrastructure and communications system from offices located within Houston TranStar. The scope of these activities includes management, operation, and construction of the County's traffic signal communications infrastructure.

In 2005, HCPID added 145 miles of fiber optic cable links to the Houston TranStar infrastructure. These activities include connecting to four existing hub buildings located throughout the County. These hub buildings are currently being integrated to the center via the ATM network and have current capability to receive video data from arterial cameras. A total of 63 HCPID arterial cameras have been added to the Houston TranStar network. Harris County has also connected more than 250 traffic signals into (and these are now monitored from) Houston TranStar.

TranStar Incident Management and Traveler Information Systems

TranStar's traveler information systems are the cornerstone of the partner agencies traffic management function and its ability to respond to and manage incidents. Houston TranStar is a national leader in the breadth and timeliness of its real-time traveler information systems.

Monitoring systems at Houston TranStar provide extensive information of value to motorists as well as to traffic management operators at Houston TranStar. Information is provided to motorists by four primary means: DMSs, HAR, the Internet, and the local media.

The 169 DMSs provide information on traffic incidents and planned construction, giving location, travel direction, and nature of incident or activity. The system is also used to display travel times, weather alerts, and Amber alerts. There were 131,811 operator activated messages displayed on DMSs in 2005. The types of DMS messages included:

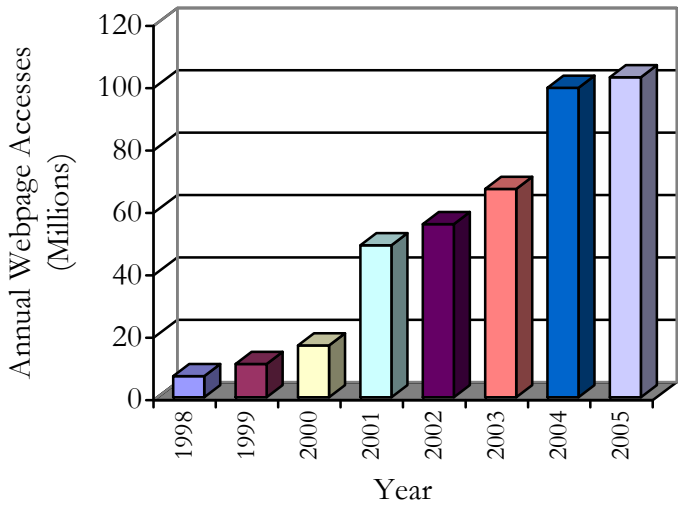
- 80,621 operator activated messages for incidents;
- 30,128 operator activated messages for road closures or construction;
- 3,125 operator activated messages for weather-related events;
- 1,160 operator activated messages for ozone alerts;
- 253 operator activated messages for safety campaigns or public meeting announcements;
- 1,833 operator activated messages for special events;
- 11,076 operator activated messages for miscellaneous purposes;
- over 1.38 million automated travel time messages
- over 23,500 Galveston-Port Bolivar ferry wait time messages
- for Amber Alerts:
    - 2,591 messages for statewide Amber Alerts
    - 24 messages for statewide Amber Alert tests

HAR broadcasts travel information at the 12 HAR sites located throughout the area. HAR was activated to broadcast 817 messages in 2005.

Local Internet and media outlets use the TranStar CCTV feeds and Internet-based incident reporting capabilities and travel time reporting systems in their daily traffic reporting functions. Local radio and television stations have access to Houston TranStar's travel time data, incident data, and the freeway cameras and use this information frequently during peak period broadcasts. In addition, traffic service organizations are housed on the operations floor of Houston TranStar. Operational highlights for the TranStar website in 2005 included:

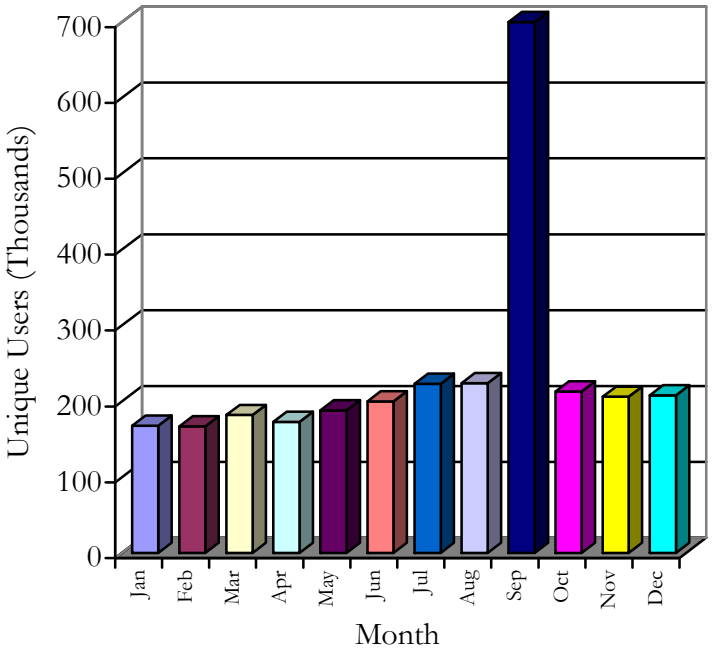
- Total website accesses increased from 99.2 million in 2004 to 102.6 million in 2005, a 3.4 percent increase (see Figure 2).
- Average unique monthly users increased from 163,000 in 2004 to 237,000 in 2005, a 45 percent increase (see Figure 3). There was a large increase in accesses in September due to the Hurricane Rita evacuation.
- The number of personalized travel speed text messages increased from 7.2 million in 2004 to 13.7 million in 2005, an increase of 90 percent.

Figure 2. Website Access Trends



- The number of views to freeway speed charts increased from 588,000 in 2004 to 800,000 in 2005, a 36% increase.
- Access to the route builder system increased from 531,000 total accesses in 2004 to 1.5 million total accesses in 2005, an increase of 282%.
- Views of CCTV images increased 193% from 2004 to 2005, from 4.4 million views in 2004 to 8.5 million views in 2005.
- Traffic alert subscribers increased from an average monthly subscriber base of 2,750 in 2004 to 3,900 in 2005, an increase of 42%.
- Experienced a 623% increase in views of construction-related alerts, from 700,000 in 2004 to almost 4.9 million in 2005.
- Deployed publicly viewable cameras for monitoring construction progress of the IH 10 Katy Freeway Reconstruction project at Beltway 8 and IH 610 (West Loop);
- Deployed publicly viewable cameras for monitoring

Figure 3. 2005 Monthly TranStar Website Unique Users



construction on the IH 45 Galveston Causeway.

- Deployed publicly viewable cameras for the City of Houston Rail Monitoring initiative.
- Enhanced the Houston TranStar Traffic Information Website (http://traffic.houstontranstar.org) to a higher bandwidth Internet connection and upgraded router services. This increased the capacity of the website and dramatically improved response times during periods of heavy usage such as severe weather events.

The evacuation in advance of landfall of Hurricane Rita precipitated an unprecedented use of Houston TranStar traveler information systems. During the days of September 20-23 Houston TranStar was at the center of evacuation and emergency response activities, and the frequency and intensity of traveler information from Houston TranStar far exceeded any other previous event since the inception of the center.

As Figure 3 shows, the distribution of unique users of the TranStar website over 2005 clearly indicates that the month of September 2005 overshadowing all other months. This shows the impact that the events of Hurricane Rita had on the distribution of traveler information through the TranStar website. The month of September 2005 accounted for 17% of the yearly number of accesses to the site. With 17.5 million accesses there were more than double the 7.7 million average monthly accesses during September.

The number of unique users during September 2005 at more than 700,000 was more than 3.5 times the normal month's users. Analysis of originating IP addresses indicated that for a short time during the Rita evacuation more website hits were coming from outside the Houston area that originating within the region. Speed chart views were also more than four times the normal rate for the month of September as compared to the average of all other months.

Incident Management

Freeway incidents are a major cause of congestion in the Houston area, and the detection, response, and clearing of incidents is a vitally important function of Houston TranStar. The Houston TranStar agencies play a major role in incident response management and information dissemination. Incidents are entered into the Regional Incident Management System (RIMS) operations database by agency personnel. In total for 2005 there were 13,894 incidents recorded by Houston TranStar operators, 13,385 entered by TxDOT staff and 509 entered by METRO staff. The distribution of these incidents, by facility, for 2005 is shown in Figure 4. Incident location and status are automatically provided on the traffic website. Operators develop and activate DMS messages providing information on the incident (e.g., traffic direction, location, type incident, lanes blocked). Temporal patterns of incidents by hour of day, by day of week, and month are illustrated in Figures 5 & 6 and give some indication of when the center is most active.

Figure 4. Distribution of Managed Incidents (Number, Percent)

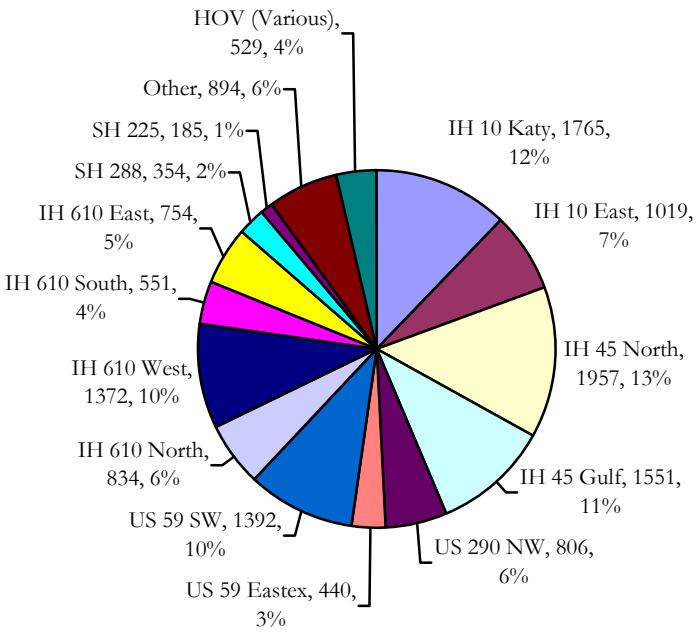
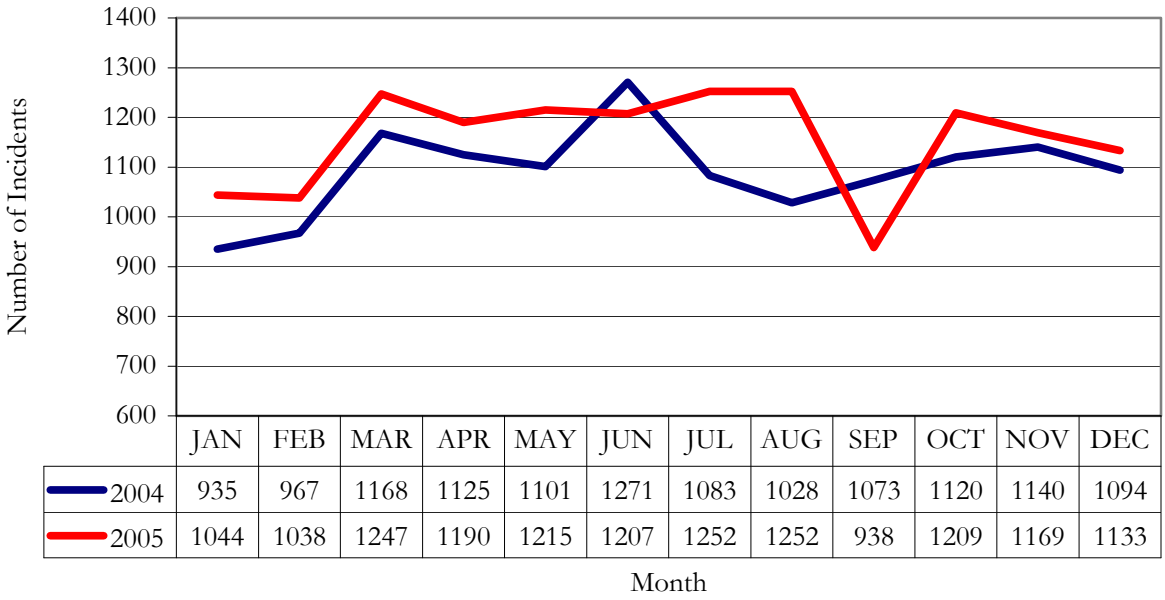
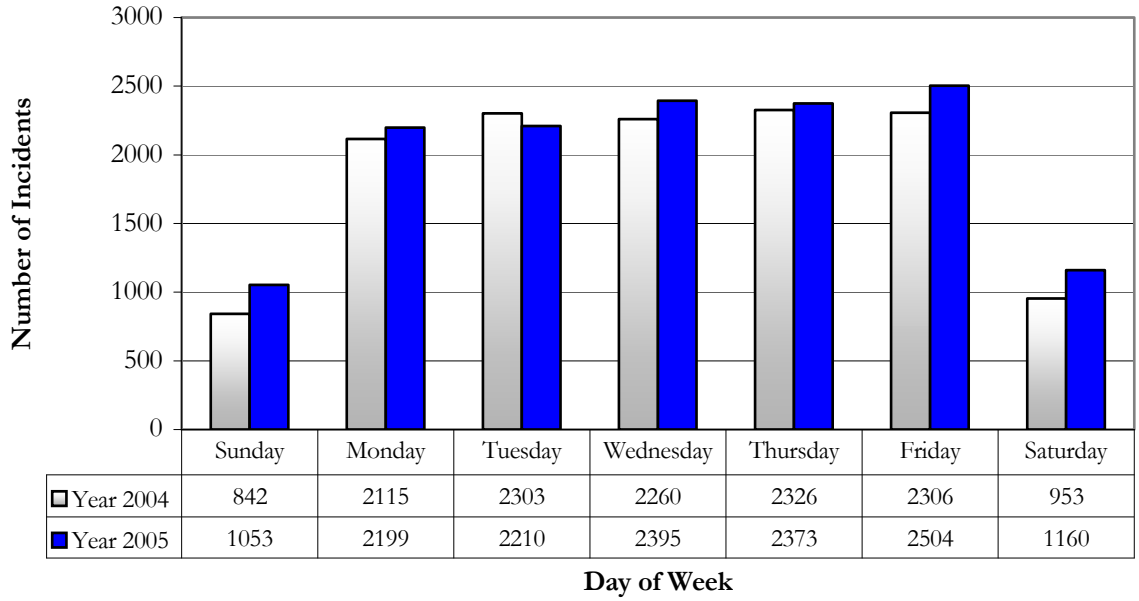


Figure 5. Incident Distribution by Month



	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
2004	935	967	1168	1125	1101	1271	1083	1028	1073	1120	1140	1094
2005	1044	1038	1247	1190	1215	1207	1252	1252	938	1209	1169	1133

Figure 6. Incident Distribution By Day of Week



	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
Year 2004	842	2115	2303	2260	2326	2306	953
Year 2005	1053	2199	2210	2395	2373	2504	1160

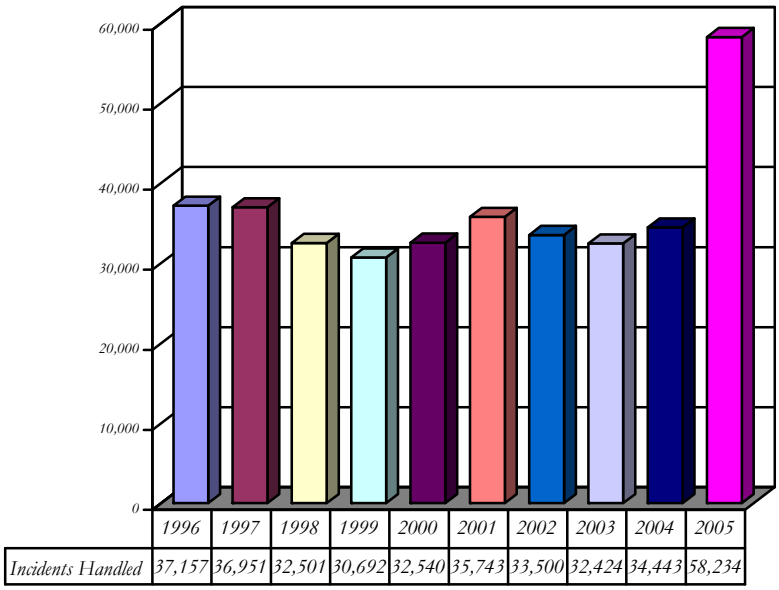
Motorist Assistance Program (MAP) & SafeClear

The Motorist Assistance Program (MAP) is one of the most visible services operated by the Houston TranStar agency partnership. MAP started in 1986 with two vans operating eight hours per day. The program has expanded significantly since, operating 16 hours per day on all major freeways. The program expanded in 2005 to include the participation of METRO Police in addition to Harris County Deputies. There were 58,234 types of assistance handled by MAP in 2005. This was an increase of 69% over 2004 levels. A breakdown of the types of services provided by MAP personnel is shown in Table 1. A historical perspective of the MAP program assists is shown in Figure 7.

Table 1. MAP Activity in 2005.

MAP Activity	Number of Incidents
Traffic Control	19,319
Other	8,058
Directions/Info	6,255
Mechanical	5,234
Flat Tire	4,878
Wrecker	4,037
Stall	3,673
Accident	2,731
Abandoned Vehicle	1,641
Fuel	1,405
Debris	1,003
Total	58,234

Figure 7. MAP Assist Summary by Year



SafeClear, the City of Houston's fast-tow program was also instituted in 2005. SafeClear is intended to bring quick response to disabled vehicles in order to reduce the occurrence of secondary crashes in the freeway queue.

Emergency Response

This region is vulnerable to natural, manmade, and technological emergencies and/or disasters. The Emergency Operations Center has activated for many types of incidents including hazardous material incidents, truck crashes, pipeline ruptures, train derailments, chemical explosions, flooding, tornadoes, thunderstorms, tropical cyclones (including named tropical storms and hurricanes), fires, and industrial accidents. Houston TranStar's partners assist the EOC during the activations by providing unique technical and managerial expertise, as well as additional manpower and facility support. The joint effort by the

Houston TranStar agencies enables faster response times in dispatching the appropriate equipment and manpower, which results in more effective and efficient responses that reduce the loss of life and property of our citizens.

The Harris County Office of Homeland Security & Emergency Management (HCOHS&EM) operates from Houston TranStar. The City of Houston OEM is located in the City's Houston Emergency Center (HEC) with close coordination maintained with Houston TranStar. The HCOHS&EM expanded its stream flood monitoring system to 129 sites along the 22 watersheds in the County, in addition to the dedicated sites for the METRO rail system and Park and Ride facilities. HCOHS&EM also operates, with TxDOT, a roadway flood, wind, and ice monitoring system.

Due to the fact that heavy rainfall can cause traffic problems/accidents, interactive rainfall alarms were set up to be sent to the pagers of key response and emergency management personnel to help in the monitoring of the situation. To further support Houston TranStar's mission, the HCOHS&EM has created a redundant website to ensure the ability to provide information to the public through its School Closing Notification System, Ozone Warning System, Media Alert Notification System, Rain Fall Maps, and Stream Level Templates. Harris County continues to expand its regional radio system, which is currently being used by numerous agencies in the area. This radio system gives the Emergency Operations Center the ability to communicate with the largest number of responders and governmental agencies of any radio system in the region.

Houston TranStar's unique ability to coordinate traffic management, emergency management, and homeland security, the Emergency Operations Center continues to act as a base for regional and multi-jurisdictional training and exercises. In recognition of this ability, the State of Texas has designated the EOC and Houston TranStar as its Regional Operations Center for evacuations. Houston TranStar's mission is to coordinate and enhance the operations of the regions offices of emergency management (all city and county OEM's in the region). To accomplish this, the Emergency Operations Center has the ability to monitor and coordinate regional transportation routes based on current and

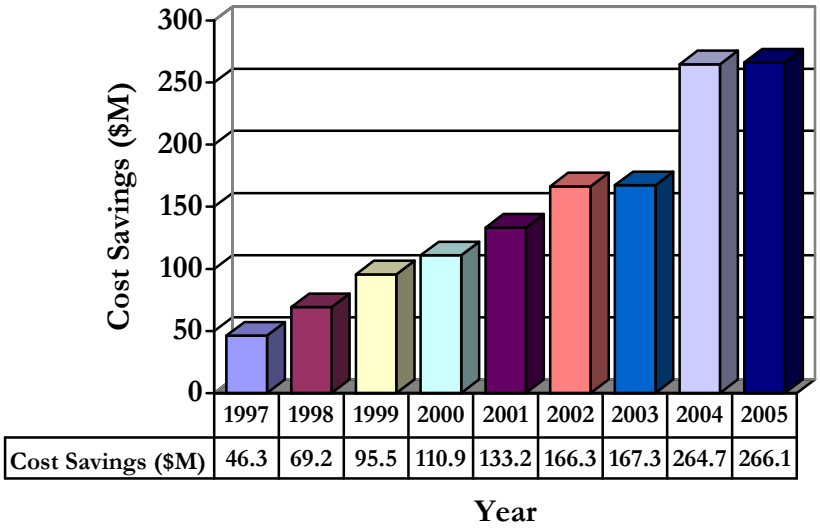
forecasted weather conditions. The EOC can communicate with those agencies and jurisdictions having homeland security roles. The facility provides meeting and training space not only for partner agencies, but other agencies and jurisdictions within the region.

ESTIMATED TRANSTAR OPERATIONAL BENEFITS

Determining the benefits of Houston TranStar is limited and treated conservatively since many of the benefits are not easily quantifiable and some are intangible. However, this report develops estimates of those benefits which are quantifiable; such as the cost of motorist delay savings (in time and dollars), fuel savings (in gallons and dollars), and emissions reductions (in tons of emissions). For the past nine years this report has used an approach which estimates the operational benefits in terms of freeway motorist delay savings.

Traffic delays on the freeway mainlane system were estimated using the AVI travel time monitoring system and traffic volumes from the TxDOT annual volume-roadway inventory files. The procedure for evaluation uses national benchmarks and experience to establish Houston TranStar quantitative goals for expected benefits. The expertise of Houston TranStar staff is relied upon to estimate performance of the transportation systems in terms of percent attainment of the goals.

Figure 8. Annual Traveler Cost Savings



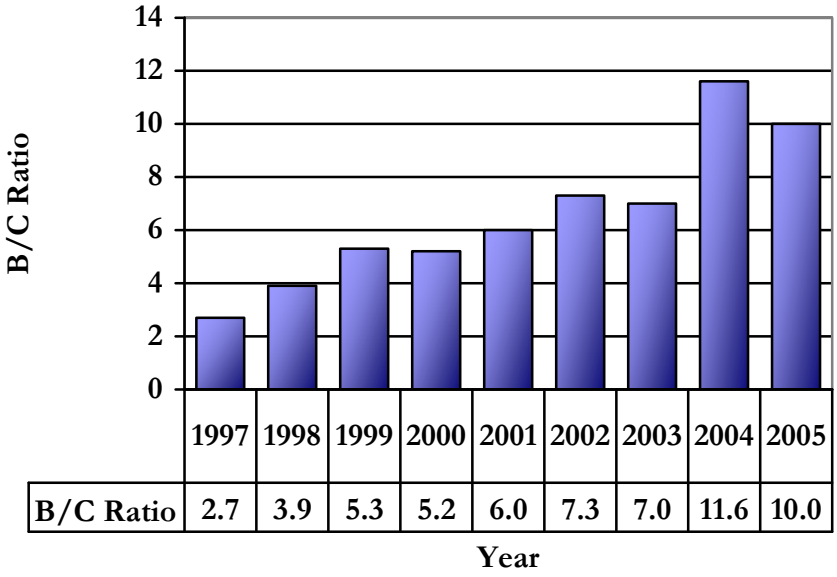
	1997	1998	1999	2000	2001	2002	2003	2004	2005
Cost Savings ($M)	46.3	69.2	95.5	110.9	133.2	166.3	167.3	264.7	266.1

The estimated costs of congestion in the Houston TranStar region were calculated to be over $720 million in 2005. Annual benefits in the reduction of travel time were estimated to be 11.9 million vehicle-hours with an estimated monetary benefit of $216.8 million. The savings in travel time are equivalent to reducing fuel consumption by 22.2 million gallons for an additional savings of $49.3 million. Thus, the total 2005 motorists' savings was approximately $266.1 million (see Figure 8). Since 1997 (when benefits were first estimated), Houston TranStar has saved Houston area motorists over $1.3 billion in reduced delay cost.

Reduction in the amount of fuel consumed also results in a reduction of exhaust emissions. Based on U.S. Department of Transportation (USDOT) Bureau of Transportation Statistics, the reduction of 22.2 million gallons of fuel is equivalent to a reduction of 480 tons of hydrocarbons; 3,105 tons of carbon monoxide; and 699 tons of nitrogen oxides.

A benefit/cost analysis for 2005 was performed, comparing the benefits discussed previously to the annual costs of Houston TranStar. Annual costs include annualized capital costs, annual operational costs of the Houston TranStar systems, and the annual cost of operation and maintenance of the field installations. The annualized cost estimate is $26.6 million, which divided into the annual benefit of $266.1 million, yields a benefit/cost ratio of 10.0. Benefit and benefit/cost information is illustrated in Figure 9.

Figure 9. Benefit/Cost Ratios (1997-2005)



There was a slight increase in delay savings and but a small decrease in benefit/cost ratio from 2004 to 2005. The increase in delay savings reflects the increase in operational efficiency measures used in estimating delay savings, as well as the compounding effects of increased gasoline prices, value of congestion (cost/vehicle-hour), and the magnitude of estimated congestion. The decrease in benefit/cost ratio was a result of the significant investment in the Asynchronous Transfer Mode (ATM) infrastructure system upgrade ($6.77 million) that was fully included as a 2005 cost and was annualized over the life of the center.