TRACK "A"
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FAST-TRAC UPDATE

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FAST-TRAC UPDATE

INTRODUCTION:

During the mid-1980's Oakland County, Michigan's population and employment burgeoned. Along with the growth came the concomitant problems of highway congestion and deterioration. The Road Commission for Oakland County faced a billion dollar price tag for resolving the crisis. At the existing level of investment in road construction, it would have taken the Road Commission one hundred years to meet the County's mobility needs.

The Road Commission was also looking for innovative ways to improve highway safety. Since 1978, this has been the Road Commission's top priority. As a result, millions of dollars were invested in highway safety improvements during the 1980's with remarkable results. How was the Road Commission to continue this success into the 1990's and beyond?

Road Commission managers recognized that a new paradym was required. The old way of solving such problems was no longer sufficient. Out of the crisis an opportunity arose, and the **FAST-TRAC** program was conceived.

FAST-TRAC stands for ***Faster And*** *Safer* ***Travel through*** *Traffic* ***Routing and Advanced Controls***. The program's mission is to implement a combined Advanced Traffic Management and Advanced Traveler Information System leading to improved mobility and safety on the roads and freeways of Oakland County.

The core components of the integrated system include: a) the Sydney Coordinated Adaptive Traffic System, or SCATS; b) Autoscope video sensors; and c) the Siemens Ali-Scout dynamic route guidance system.

SCATS:

SCATS is a computer-based area wide traffic signal control system. It is a complete system of hardware, software, and traffic control philosophy. In its adaptive mode, it operates in real-time, adjusting signal timing throughout the system in response to variations in traffic demand and system capacity.

This is a vast improvement over most existing traffic control systems, which rely largely upon uncoordinated, pre-timed traffic signals. With SCATS, signal cycle lengths, phase splits, and offsets are adjusted for optimal road system performance. These parameters can change with each cycle of the traffic signal in response to traffic flow.

SCATS contains a variety of features that benefit traffic operations and maintenance. It offers a flexible tool for complete arterial traffic management. First, it contains a range of graphic displays, allowing real-time monitoring and analysis of individual intersections, subsystems, and the whole network. Signal operations, detector performance, and congestion levels can be displayed.

System diagnostics are also part of the SCATS system. Many faults can be corrected from the traffic operations center or from laptop computers equipped with modems. When this is not possible - for instance, when a detector has failed or when a lamp is out - crews can be dispatched for quick response. Signal maintenance is facilitated as a result.

SCATS maintains a database of traffic information. This will relieve local units of government of the need to do traffic counts and other related studies. This information can be used for planning and business forecasts. The data will be valuable as the Road Commission explores the development of I.T.S. user services.

AUTOSCOPE:

Adaptive control requires a considerable level of traffic detection. A video image processing system has been installed to provide this detection.

The decision to use video in place of inductive loops was based on a number of considerations. First, the Road Commission does not have to tear up the road surface to install or repair the detectors. Traffic lanes need not be closed because the detectors can be accessed in most cases from the roadside.

Another factor is that one camera can provide detection **in** all lanes of a approach. This is not possible with loops where a detector is required in each lane.

In northern climates, the maintenance and installation of loop detectors can only be done in warm weather. With video, installation and maintenance can take place year round. In fact, the Road Commission's initial installation took place in February and March.

Video detection has proved to be quite flexible. It can be used during road construction and is effective on any type of road surface - even gravel. The Road Commission is looking at the potential for Autoscope to detect traffic incidents and to generate travel time data for better traffic signal synchronization and for traveler information services.

ALI-SCOUT:

The Road Commission is now in the process of integrating SCATS with the Ali-Scout dynamic route guidance system. Ali-Scout is made up of three primary components: 1) a central computer that contains route guidance information, 2) a system of roadside infra-red beacons, and 3) specially equipped vehicles with on-board navigation systems.

Drivers enter destination coordinates into the on-board computer or choose a pre-programmed destination. An infra-red communication link between the vehicle and the roadside beacons allows for the exchange of traffic and route guidance information. The Ali-Scout route guidance information is transmitted to the driver by both voice messages and a simple navigational display.

In its dynamic mode, Ali-Scout will guide drivers around congested areas, getting them to their destination in the quickest possible way.

SYSTEMS INTEGRATION PLANS:

The core FAST-TRAC components are linked through our traffic operations center, which not only serves as the FAST-TRAC nerve center, but also is the heart the FAST-TRAC systems integration efforts.

Important linkages will be provided with other systems and organizations. A comprehensive transportation information management system is being developed that will allow the Road Commission to monitor traffic conditions throughout the metropolitan area and provide residents and businesses with up-to-the-minute traffic information.

Systems will be developed to exchange data with the Michigan Department of Transportation (MDOT), the Suburban Mobility Authority for Regional Transportation (SMART), local police departments, emergency medical services, and commercial fleet operators.

Sources of data will be sensors, video cameras, vehicle probes, road construction and maintenance schedules, traffic incident reports, and weather information. These data will be transmitted to the FAST-TRAC operations center for processing. The plan calls for a geographic information system to manage the vast amount of data that will be processed. The data will be fused to provide useful information.

The integration effort starts with the original FAST-TRAC components. Efforts will focus on the exchange of data between SCATS and Ali-Scout in the near term. SCATS data will be used to derive surrogate link times needed for dynamic route guidance. Ali-Scout link times can be used to adjust traffic signal offsets in real time.

Data will be shared with local police, fire and EMS units. This will give them the input they need to improve response times for emergencies and traffic incidents, and the Road Commission will be able to better manage the traffic when these incidents occur.

Hooks will be provided to city administrative offices so they can monitor traffic conditions within their communities. Communities will also be an important source of information on local road construction and other local activities that will affect road capacity and safety.

The Road Commission will be able to monitor the whereabouts of the nearest dial-a-ride or fixed route bus, and even manage its own maintenance crews better through the use of advanced vehicle monitoring and communications systems. These on-board devices will also act as probes, sending valuable travel time data back to the traffic operations center.

One of the key features will be the integration of FAST-TRAC systems with freeway control systems operated by the Michigan DOT. A contract was recently awarded to instrument 148 miles of area freeways with sensors, highway advisory radio, ramp metering, changeable message signs and advanced communications hardware. This instrumentation provides the opportunity for integration with FAST-TRAC systems with the goal of offering the residents of metropolitan Detroit a seamless transportation system.

With incident management as a primary focus, the Road Commission and MDOT have set about defining the architecture and developing the systems needed to provide motorists with an integrated system for corridor management. Simply stated, the architecture allows the FAST-TRAC and MDOT control centers to share video and traffic data, providing for future growth to handle control messages and integration with other systems.

Each center will include a database system to manage the data that will be shared, a graphical user interface for operator monitoring and control, and the necessary interface equipment and software to allow the exchange of key transportation data.

Full duplex data and video transmission will be provided via a microwave link between the two operations centers. Real-time video images from arterial roads and freeways will be selectable for transmission to each control center simultaneously.

The user interface will give operators a comprehensive view of traffic conditions and enable them and researchers to formulate data requests for either arterials or freeways. Automated updates and alarms will also be generated.

Residents and drivers will benefit not only from improved traffic operations, but also from the new services that will be provided. Traveler information will be transmitted to traffic services like Metro Traffic Control and the Michigan Emergency Patrol. Interactive kiosks, cable TV, and the Internet will also be used to provide this information, as will variable message signs, highway advisory radio, radio data systems, and other vehicle-based systems.

MILESTONES:

The FAST-TRAC program has been in the works since 1991. In August of 1991 the Road Commission for Oakland County awarded a contract to install SCATS with video detectors at 28 intersections in Troy. At the same time, Siemens Automotive began installing its Ali-Scout system. On June 2nd of 1992, the systems were officially turned on, and the Road Commission entered a new age of traffic management.

More than 200 intersections are now under SCATS control. One-hundred Ali-Scout beacons are operational in east, central Oakland County and 800 vehicles are now Ali-Scout equipped, sending probe data to the traffic operations center.

A major milestone was reached when the Road Commission was able to install the advanced systems in time for the World Cup Soccer matches at the Pontiac Silverdome in June of 1994. By all accounts, the project was a huge success. New signal control programs not only eased the flow of traffic in and out of the Silverdome area, but also reduced the need for police intervention to control traffic for Silverdome events. These programs have been implemented numerous times since World Cup for a variety of special events. Similar programs are now in place for managing traffic around the Palace of Auburn Hills, home of the Detroit Pistons.

FACTORS IN SUCCESS:

The success of FAST-TRAC can be attributed to many factors, not the least of which is the commitment of the program participants. Each is committed to keeping FAST-TRAC at the forefront of I.T.S. programs worldwide.

Probably the most important success factor is that FAST-TRAC was conceived out of a serious, local need. Consequently, local support was easily attained.

The Road Commission has decades of experience in the area of intergovernmental coordination of transportation services and facilities. This is especially true in the area of traffic signals, where the Road Commission already maintains the signals in 58 of 61 communities in Oakland County. A history of mutual trust has been established.

Local support has been facilitated in other ways, too. The lure of 80 percent federal funding for the installation of SCATS can not be overlooked.

The FAST-TRAC program started small with no federal assistance. The initial project was completed by Road Commission field crews and managers. With the congressional appropriation of $10 million for **FAST-TRAC** in 1992, the scope of the program increased, and so did the challenge to a small organization like the Road Commission.

Field personnel and engineering staffs were increased slightly to take on the additional work, but the administrative burden was absorbed by existing staff in spite of new administrative tasks and requirements. Along with the receipt of federal funds came a mile-long list of federal regulations that were passed through to the Road Commission. The Road Commission was charged with all procurement, contracting, record-keeping, reporting, evaluation and auditing responsibilities. These responsibilities were normally carried out by MDOT.

In response to the challenges facing the Road Commission, a management structure was established. Committees were created, and new communication channels were opened to assist in the effort.

The Road Commission took on the seemingly unwieldy burden and succeeded where others are still struggling. What appeared to be a barrier to success was really a blessing in disguise. The Road Commission's small size enabled FAST-TRAC to move ahead rapidly, on a fast track. Fewer bureaucratic hurdles had to be overcome and decision-making was more expeditious than in larger organizations.

FUTURE CHALLENGES:

Continued funding for future deployment and operations will be critical success factors in the future. The national I.T.S. program must address this issue. I.T.S. technologies are expensive to install and maintain. Funding must be dedicated for the installation, maintenance and operation of the systems for continued success. New system features, such as computer equipment, video cameras, communication lines and the traffic operations center, have added to the life-cycle costs associated with traffic management.

The Road Commission is exploring innovative ways to generate the funds needed for continuing operations. Part of the strategy involves marketing traveler information and other value-added services, but the bulk of the funding undoubtedly will come from more traditional sources.

Another opportunity that must not be overlooked is to take advantage of private **sector** resources. The private sector is a rich source of knowledge, trained staff, equipment, and funding, all of which are needed for successful I.T.S. implementation and operations. Private sector participant roles should be planned and specifically defined. Mechanisms to procure required services and products should be well thought out and standardized to the extent possible to avoid contracting or audit problems later.

The relationships fostered with the private sector participants through FAST-TRAC have been beneficial as the Road Commission has adopted some of entrepreneurial spirit of these participants. New ways of doing business have been enacted, and the taxpayers are reaping the benefits.

The Road Commission is now exploring mechanisms for generating revenue from the data that is being collected and enhanced. An initiative, called MOTORCITI, will form the basis for generating and marketing traveler information services.

Future challenges also are expected as intellectual property rights are negotiated. Proprietary issues will come to the forefront as systems integration activities pick up steam. It may be easier to get complex systems to work together than to get companies with competing interests to work as a team.

Another major challenge is to overcome unreasonable expectations. When FAST-TRAC began, people expected traffic congestion to go away. Traffic managers may be able to whittle away at this problem, but they will never eliminate congestion. I.T.S. provides the tools needed to manage traffic better, not get rid of it.

Finally, it is wonderful to see that the U. S. DOT is promulgating the deployment of "Intelligent Transportation Infrastructure". The Road Commission for Oakland County has advocated this position for many years as a necessary foundation for I.T.S. It is now clear that traffic data collection and communications infrastructure are important elements of the national I.T.S. program.

It is also clear that national support is needed to deploy and operate this infrastructure and that the foundation must be established at the local level with those who own and operate transportation systems. As Congress considers reauthorization of the next transportation bill, these things must be incorporated.

A NATIONWIDE DEMONSTRATION OF ADVANCED TRAFFIC CONTROL **TECHNOLOGY**

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A NATIONWIDE DEMONSTRATION OF ADVANCED TRAFFIC CONTROL TECHNOLOGY

The mission of the Office of Technology Applications (OTA) of the Federal Highway Administration (FHWA) is to ensure the timely identification and assessment of innovative research results, technology, and products and the application of those that are found of potential benefit to the highway community.

The FHWA is working on many programs in partnership with public and private organizations to deal with traffic congestion issues. The OTA develops handbooks, training courses, test and evaluation projects, and demonstration projects to facilitate technology transfer to our customers, State and local governments.

A few years ago, OTA began a technology transfer project, Demonstration Project No. 93, which uses a large array of advanced traffic control technologies that are readily available which are greatly under used by highway agencies. This project provides the information and motivation that, if properly used, can achieve immediate congestion reduction results, particularly at urban intersections. In addition, the project has created an awareness among top administrators and managers of the significant role of traffic control systems in efficient traffic management programs and the need to allocate adequate resources to operate and maintain these systems regularly. The objectives of this project are as follows:

- Promote "concepts" of current technology: Hardware and software, leading to adoption and installation of more reliable and powerful traffic control systems
- Conduct full day hands-on with instructions on how to operate equipment and software
- Raise the level of awareness of top management of the Benefits, impacts, and resources associated with implementing advanced technology.

The project scope has been defined as:

- Focus on urban intersection control and not freeways
- Focus on operational technology rather than experimental
- Focus on state-of-the-art technology and not obsolete/old technology
- Technology must not be widely used

Twenty-five U.S. and foreign manufacturers joined with the FHWA to form cooperative partnerships in which industry supplied the latest available technology, at no cost to the Government, and the Government supplied labor, and resources to mobilize and demonstrate the technology to users. The private sector products are being exposed to a nationwide audience and the FHWA b fulfilling its responsibility to transfer new technology to the State and local jurisdictions.

The centerpiece of the project is a custom-built 48foot long (14.4m) tractor/trailer combination that is expandable to a 16-foot %4.8m) width. The vehicle is used as a mobile exhibit and classroom. The project is believed to be the most extensive demonstration of intersection control technology ever assembled in a mobile format. The 2-day presentation and an optional executive summary for top managers promote the adoption and implementation of technology through hands-on experience with the equipment. The exhibits are fully operational and simulate actual traffic control conditions. Experiences with similar hands-on demonstrations have proven that participants retain a high percentage of information presented through this interactive teaching technique. The technique is based on an old Chinese proverb: "I hear and I forget. I see and I remember. I do and I understand." Further, we realize that the individuals that need this information are usually not permitted to travel out of State to visit vendors or attend national conventions where this type of technology is exhibited and demonstrated. Thus, we have decided that the most effective technology transfer process is to physically take the technology to the users and spend the time to demonstrate how it works, without vendors.

Urban traffic congestion is recognized as one of the most urgent transportation problems facing the Nation today. Predictions indicate that congestion will increase at least four 400 percent by the year 2005 unless significant changes are made now. Until sophisticated long-term congestion management solutions are fully developed and deployed these changes must concentrate on using and maintaining state-of-the-art traffic signal equipment and software technology.

The benefits of basic improvement programs for signalized intersections are most often not documented and if so they are frequently taken for granted. "Before" and "After" studies have shown that the benefits of basic signal improvements can far exceed the cost of implementation and can usually pay for itself within two or three years. Among the most recognizable benefits of signal improvements are:

- reduced congestion
- higher operating speeds
- reduced fuel consumption
- reduced air pollutants
- reduced accidents
- reduced noise

In some of these cities economic growth has been stymied and air pollution from auto emissions has reached alarming proportions. Here are a few facts to illustrate the extent of the problem and its impact:

1. Two-thirds of all urban vehicle miles of travel in the U.S. occur on facilities

controlled by traffic signals: there exists more than 240,000 traffic signals and 60 percent or 144,000 of these need improvements such as signal retiming optimization and equipment upgrading.

2. One-fifth of all U.S. fuel is consumed in urban areas, on streets controlled by traffic signals.

3. Approximately 38 percent of all U.S. oil consumption is due to travel along our highways and urban streets.

4. On a national average, poor signal timing causes up to 15 percent excess vehicle delay, 16 percent excess vehicle stops, 7 percent excess travel time, and 9 percent excess fuel consumption. A recent signal retiming project in the city of Portland, Oregon, consisting of only 14 intersections, showed just a 2 percent reduction in fuel consumption that resulted in an astounding reduction of 39 tons of CO in one year. Similar studies performed by the Los Angeles DOT involving 800 intersections also revealed substantial savings, i.e., 50,000 hours per day of travel time, eight million vehicle stops per day, also, 26 percent reduction in emissions and 13 percent reduction in fuel consumption.

5. Fifteen to 20 gallons of fuel can be saved for each dollar spent on retiming traffic signals.

Studies by the U.S. Department of Transportation's Federal Highway Administration demonstrated that signal retiming and equipment upgrades are ranked among the most cost-effective improvements for arterial streets and signalized intersections. Today, many States and cities in the U.S. are experiencing similar findings with signal retiming and optimization projects. For example, the State of Virginia, in 1990, launched a statewide signal timing optimization program to improve overall arterial and intersection operations. Results reported for the Northern Virginia District--including coordination and optimization of 321 intersections--revealed a total benefit, including reductions in vehicle stops, travel time, and fuel consumption, of $72 million and a benefit-to-cost ratio of 200: 1. Specifically, the reductions were as follows: total vehicle delay (25 percent), vehicle stops (26 percent), travel time (IO percent), and fuel consumption (4 percent).

The California Fuel Efficient Traffic Signal Management Program (FETSIM) results, reported for the 1983-1994 period, also highlighted dramatic improvements due to signal retiming and signal equipment upgrades. Annual benefits of 35 million dollars were reported and the total annual cost of the project of $13.4 million was recovered in just three months.

These studies vividly point out that signal timing optimization and hardware upgrades can produce significant improvements, and that the cost to make these improvements can be quickly recouped when incremental benefits are projected over time.

Traffic control engineers in State and local highway agencies in the U.S. are faced with an array of rapidly changing electronic equipment and computer software products developed by the traffic control industry. There is a pressing need to track, compare, and evaluate these products. The workshop presentation and hands-on demonstration allows participants to operate and evaluate most of the leading electronic traffic control technology on the U.S. market today. For example, new advancements in traffic signal controllers, intelligent vehicle detectors, advanced communication systems, high-resolution computer graphics, distributed and hybrid signal systems, and digital signal processing are featured. Most operational products whatever their origins, if actively marketed in the U.S., are eligible for inclusion in the project.

The delivery of this project has and continues to be supported by a technical support contract. This contract provides an expert in the field of traffic signal control equipment and software. A professional driver who has a valid commercial driver's license is also provided, in addition, to an on-site technician who is responsible for the scheduling of presentations, reserving travel accommodation for the team traveling to the site of the presentation, and liaison with a private sector partner.

As of November 1995, 70 demonstrations of the project have been presented to audiences representing 49 States, Puerto Rico, and the Virgin Islands since beginning the project's nationwide tour in January 1993. More than two thousand traffic professionals and managers have participated in this project.

Additional presentations of this project are planned for the first half of 1996.

The benefits of this project are difficult to state in a tangible manner. Many comments have been received from participants that express a genuine appreciation for this project. Occasionally, the presentation coincided with conferences on related subjects. In some locations, the presentations have been concurrent with an ongoing study or analysis of traffic signal operations. Many participants have especially liked the unbiased presentation of the variety of technology and that the demonstration is current state-of-the-art technology.

THE ATLANTA TRAVELER INFORMATION SHOWCASE

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What Is the Traveler Information Showcase?

The Atlanta Traveler information Showcase is a four-month demonstration from June l to September 30 of what traveling in metropolitan areas is going to be like as intelligent transportation infrastructures continue to be built.

The Showcase is providing the public with up-to-the-minute traffic information continually gathered through a variety of information technologies. Commuters and other travelers can then learn about accidents, vehicle breakdowns, road maintenance and other incidents in order to figure out alternate routes to get to where they're going instead of ending up stuck in the middle of a trafficjam.

What Is ITS?

Intelligent Transportation Systems (ITS) are the application of telecommunications, information and computer technologies to the needs and problems of the U.S. highway, rail and transit infrastructure. Using sensors, computerized traffic control systems and electronic navigation, these technologies, many of which were developed for aviation, the space program and the defense program, are now being deployed to make the movement of people and goods easier, safer and less polluting.

About The Fact Sheets

These fact sheets provide a thumbnail sketch of each of the component systems that make up the Traveler Information Showcase. The fact sheets offer-a historical overview of the Showcase; list the services and information available via each of the fn/e Showcase technologies plus the Georgia DOT's interactive kiosks; briefly describe how the technologies work, how travelers use the technologies and how the information is presented to the user. Three articles that describe the Showcase technologies and how they work are attached to give the reader a clearer understanding of the benefits and promise of Intelligent Transportation Systems.

Slevin, Jonathan

ATLANTA
Traveler Information Showcase
1996

Fact Sheet #1

1. Atlanta was chosen to host the Traveler Information Showcase for a number of reasons that include:

- From 1982 to 1992, congestion in the metropolitan area grew by 29 percent.
- The city's population grew by 36 percent from 2.4 million to 3.3 million from 1983 to 1993.
- In the most recent Texas Transportation Institute congestion survey (1992), Atlanta was rated tenth most congested out of the 50 largest cities in the United States.
- During the summer of 1996, 2.5 million and possibly more athletes, coaches, spectators and other visitors are expected to come to Atlanta for the Olympic and Paralympic Games.
- In the spring of 1996, the Georgia Department of Transportation will open its $ 11 million Transportation Management Center in Atlanta, part of the $ J 40 million Advanced Transportation Management System that will collect real-time traffic information that can be distributed to travelers.

2. The genesis of the Showcase:

- Discussions were held at the Federal Highway Administration's Joint Intelligent Transportation Systems Program Office in early 1994 on how to expedite the deployment of ITS technology;
- Transportation Secretary Federico Pena announced the Showcase at the Fourth ITS America Annual Meeting held in Atlanta on April 18, 1994;
- The U.S. Department of Transportation's Joint Program Office sent out a Request for Information in November 1994 to potential private sector participants. From the responses, the core participating companies were selected.

3. How will data be collected for the Showcase?

- More than 350 full pan, zoom and tilt closed circuit video cameras and fixed video cameras equipped with image processors known as Autoscopes will be deployed throughout the metropolitan area.
- Metro Traffic will have spotters in aircraft, helicopters, mobile units and slow scan cameras. Information will be updated every 15 minutes during rush hour and every 30 minutes during the rest of the day.
- Radar sites throughout the region will measure traffic density and speed.
- Georgia DOT will have mobile spotters on the roads.
- Along J-75 and I-85 within the J-285 beltway surrounding Atlanta, 63 miles of fiber optic cable will be laid. Another 125 miles of fiber optic cable will be laid along major arterials in the metropolitan area. The fiber optic cable will link all of the components of the Transportation Management System and the Showcase with the Transportation Management Center.

4. What will be the lasting legacy of the Showcase?

- Atlanta and Georgia will inherit all of the software, hardware, communications networks, surveillance devices, the Internet web site and the cable TV channel.
- Public outreach supporting the project will introduce the public to the benefits to be derived from ITS.
- The Showcase will serve as a template to other regions; states and localities *on* how to create a multi-jurisdictional public/private partnership.
- Engineers and other technicians working to bring the Showcase on-line by the June 1 start-up will in the process confront, analyze and overcome many of the same problems and situations that otherjurisdictions looking to create similar complex systems will face and will thereby serve as a model for other locations.

HOUSTON'S REAL-TIME INTERNET TRAFFIC REPORTING SYSTEM

Dan Hickman
Texas Transportation Institute

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BACKGROUND

Houston's Automatic Vehicle Identification (AVI) Traffic Monitoring system began operation during the fall of 1993. The travel time data being collected by this system was used by personnel within the Houston TranStar transportation and emergency management center, to identify areas of congestion, possible incidents, and as a guide for placing messages on area changable message signs.

The travel information collected by the AVI system could also be beneficial for use by commuters in planning trips. With planned projects to disseminate the information, such as the "Houston Smart Commuter" project, still several years away, there was a need to identify a method to quickly distribute the information to the traveling public. The two primary methods identified were 1) through existing media reports via radio and television; and 2) through the growing on-line services via the Internet World Wide Web.

During the fall of 1994, a system was developed to capture the existing map image used within Houston TranStar and transfer it to an Internet World Wide Web server at one minute intervals. This allowed Internet users to access the map. The system first became operational in December of 1994 and was advertised to the public in February of 1995. Since then, the site has seen continued growth, reaching approximately 10,000 monthly users accessing the site and a monthly total of more than 130,000 accesses in February 1996.

AVI SYSTEM OVERVIEW

Houston's Automatic Vehicle Identification (AVI) system is currently used as the real-time data source for Houston's Internet Traffic Map. The AVI system collects real-time information depicting travel conditions on Houston area freeways. This travel information is in the form of travel times between the AVI sensors. From these travel times, average speeds between sensors are calculated.

The AVI system uses vehicles equipped with transponder tags as probes into the freeway system. Transponder tag "readers" are placed at "checkpoints" at approximately 2 to 8 kilometer (1.2 to 5 mile) intervals along freeways and high occupancy vehicle (HOV) lanes. These "readers" detect probe vehicles as they pass checkpoints within the system. The tag identification number, along with the exact date and time are recorded each time a probe vehicle passes a checkpoint. These tag records are transmitted to a central computer which records each vehicles progress calculating their travel time and average speed between checkpoints. This information is then made available to traffic operators within Houston TranStar and to the public through the Internet web server, changable message signs, and media reports (1).

The AVI system currently covers about 440 directional freeway kilometers (225 miles) and 80 non-directional HOV Lane kilometers (50 miles). Expansion of the system to most remaining freeways and for other research purposes is planned during 1996.

The main source of the vehicle probes are commuters using the "EZ-Tag" automatic toll collection system installed by the Harris County Toll Road Authority (HCTRA). As of March, 1996, HCTRA had over 60,000 EZ-TAGS issued to commuters. It is expected that the number of EZ-TAG's issued by HCTRA will grow significantly in the future because of new cost and time savings incentives being provided to EZ-Tag users (2).

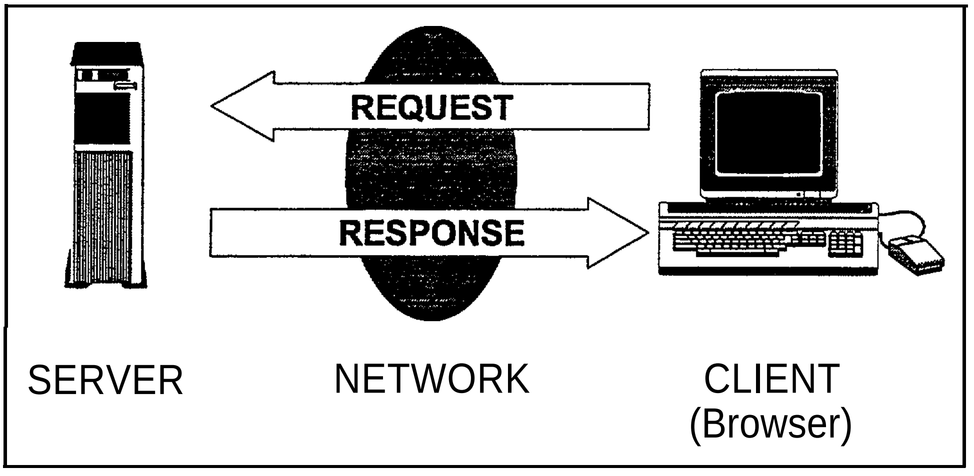
In addition to the EZ-TAG's, over 4000 tags were purchased and issued as part of the AVI system. These tags were issued to vehicles traveling in areas with low tag volume including HOV lanes and roadways in areas far from tollroad facilities (1). As of March, 1996 the system processes over 250,000 tag read records each day.

INTERNET WORLD WIDE WEB OVERVIEW

The world wide web standard is being used to publish Houston's Internet Traffic Report. The world wide web, also known as "www" or the "web", has by far become the primary method of publishing information on the Internet (3). On the web, users can easily point and click their way to related topics without having to learn complicated access methods. Government, universities, companies and private individuals can easily publish information in the form of text, graphics, sound and animation.

The web consists of three principal software/hardware components; 1) servers; 2) clients and 3) networks. See figure 1.

Figure 1. Internet World Wide Web Components



1) Servers contain the information to be accessed and serve this information out to clients. There are several types of servers used on the web, with the primary being web servers, news servers, and ftp (file transfer) servers. A web server is made up of a computer system, the web server software and various supporting software programs sometimes needed to manage information. One important type of supporting software program which is essential in publishing dynamic information is called a Common Gateway Interface (CGI) program. This tool allows the server to execute an external program which can perform some action, such as access information from an external database, and then serve that information to a client.

2) Clients, also called browsers, are the programs used to access information from servers and present it to the user. Web clients such *as Netscape 's Navigator* and *NCSA 's Mosaic* are able to access many different types of servers using standard communication protocols.

3) Networks are the TCP/IP protocol communication connections used by the Internet network.

Information on the web is divided into logical units called “pages”. Each page has it’s own address that is used to identify the page. Users can access pages through a browser by either typing in the address if the user knows a specific address or by simply clicking on a link provided in a page. These links are programmed into web pages so that users can easily access other related pages without having to type in a possibly long address.

Primarily, communications on the Internet are performed on a “request/response” basis. The client sends a request to the server and the server then responds with the requested information. Actual connections between servers and clients are normally short, only staying connected while transmitting information.

The Internet has experienced tremendous growth in the past several years since being opened for commercial use (3). In 1995, on-line services, such *as Prodigy, America Online* and *Compuserve* have added the ability for users to access the web through their services. This has added greatly to the number of users with access to the web and has made the Internet a way of publishing information on all of these services without having to deliver information to each service individually. Also, many businesses and individuals are connecting to the Internet through commercial Internet access providers. Overall, the Internet has become a way to publish information, such as traffic conditions, quickly and to a growing number of users.

HOUSTON TRANSTAR'S INTERNET TRAFFIC SYSTEM

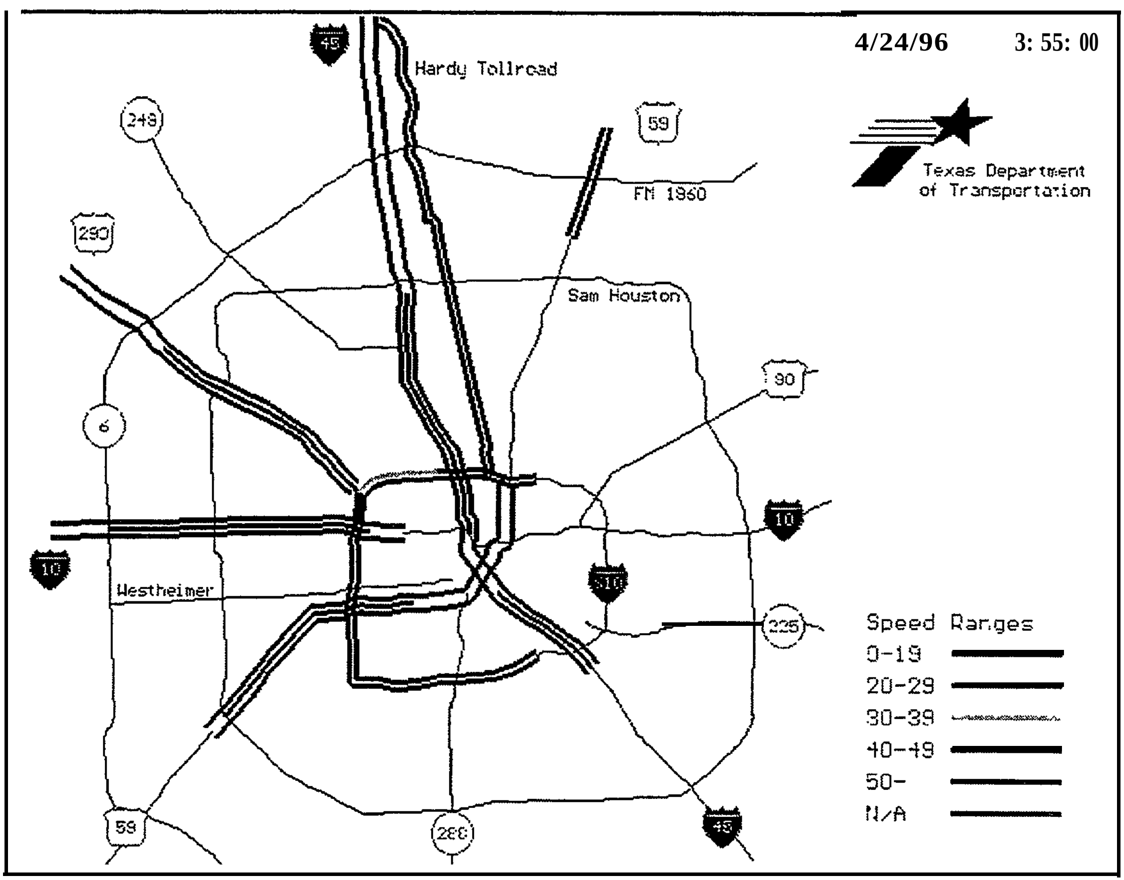
Capabilities

Houston TranStar's Internet traffic system provides 6 primary features to users.

1. A Houston map showing 5 color-coded speed ranges.
2. Ability to 'click' on a specific roadway segment and obtain detailed travel data.
3. Detailed travel data reports by freeway.
4. General TranStar information pages
5. Signup of probe volunteers through an on-line signup form.
6. A data feed provided to a **local** traffic advisory service.

The color-coded map display allows users to glance at the entire freeway system to quickly identify problem areas. A sample map image is shown in figure 2. The color-coding is not evident on the figure, but on the computer screen the lines are colored using six different colors to identify speed ranges. The display shows speeds in both freeway directions as well as on the HOV lane using up to three color-coded lines. The two outer lines represent the freeway lanes in each direction. If three lines are present for a roadway, the middle line represents the HOV lane. Data for the HOV lane changes direction as the HOV lane operation changes direction. Roadway segments are marked as "Not Available" using a gray line if no information has been collected in the past 30 minutes.

Figure 2. Sample Color-Coded Map Image



To allow the user to access more detailed information about specific roadway segments, two features were added. The 'clickable map' feature allows the user to select a specific roadway segment with their mouse. The system then provides them with detailed information about the roadway segment including, the roadway name, the beginning and ending cross street names, the length of the segment and the last collected travel time and average speed. A sample of this information is shown in figure 3.

Figure 3. Sample Segment Data Report

Houston Real-Time Traffic Report

You Selected The Following Roadway Segment :

Roadway I-45 North Freeway **Traveling** Northbound

From I-10 **To** Crosstimbers

Distance 2.90 Miles

Last Data Sample taken at 16:12:10

Last Travel Time Sample 8 minutes, 22 seconds

Last Speed Sample 20 mph

Another feature is provided which lets the user view the detailed information in tabular format for a complete freeway. This allows the user to view the travel time and distance information for a complete freeway so they can better plan the length of an upcoming trip. A sample of this information is shown in figure 4. The far right column shows a graphic which is color-coded based on the speed using the same legend as the image in figure 2. This allows users to quickly locate problem areas.

Figure 4. Sample Tabular Data Report

I-45 Gulf Detailed Data

Freeway Northbound

From	To	Data Age	Dist (miles)	Travel Time	Speed (mph)	
Broadway	Woodridge	16:10:30	1.30	1:17	60	●
Woodridge	Wayside	16:12:04	1.60	1:35	60	●
Wayside	Scott Street	16:12:43	2.55	6:12	24	●
Scott Street	I-10	16:12:00	4.20	7:56	31	●

The detailed information, along with descriptions of how the system works, may help users to better understand the type of data that the system collects, allowing them to better interpret the information.

The system includes static information as well. A description of Houston TranStar and it's goals is included. Also, information about Houston's HOV Lane Operations and Motorist Assistance **Program** are included on the site.

The system has been useful in recruiting volunteers to become traffic probes by placing an AVI transponder tag on their vehicle. Information about the program along with an on-line signup form was published on the web site. Specific, low tag volume roadways were targeted to obtain more volunteers for these roadways. As of March, 1996, there have been over 200 tag volunteers recruited through the on-line form and many others have learned about the program through the information pages on the web.

Most recently, the system is being tested for use in providing a data feed to a local traffic advisory service. Their system automatically accesses a data file on the server which is updated every 15 seconds with new data. This allows them to utilize the data in their own display and analysis software programs.

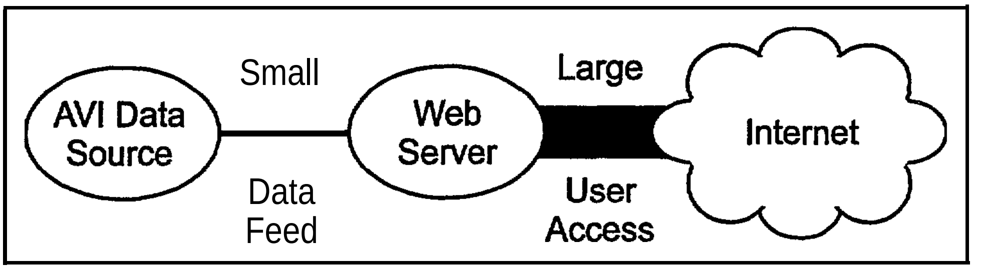
Design

Server and Network Setup

Initially, a web server computer and web software had to be configured. The computer being used to serve out the information is a workstation running a Unix operating system. The web server software being used is from the National Center for Supercomputing Applications (NCSA) and is available free of charge at World Wide Web address *"http://hoohoo. ncsa. uiuc. edu/"*.

The next step was to setup the basic web pages by writing their html (hypertext markup language) code. Then, an Internet network connection was obtained for publishing of the data. The Internet connection is the primary expense of operating a web server. For this reason, we used a server at a remote site that already had the large network connection needed to provide access to web users. A smaller, less expensive network connection was obtained for use in transferring the data from the AVI system to the web server. This is outlined in Figure 5. This has saved tremendously on the cost of operating the system.

Figure 5. Initial Network Configuration



Data Capture

The base map shown in figure 2 is created using a software program called "AVIview" (shown in Figure 6) which was originally developed by TTI for Houston's AVI traffic monitoring system. Reuse of the AVIview program made development of the system faster, only taking approximately 2 months to develop the initial system. Development of the original AVIview program took approximately 4 months to complete. Other functionality, such as the detailed data reports and 'clickable map', took approximately 1 month to complete.

In order to use the existing AVIview program to generate the Internet map display, AVIview was modified to include a screen capture routine that could be executed on a timed basis. This routine captures the screen image and then saves it to a disk file in the 'GIF' image file format which is one of the primary image formats used on the web. The GIF format has data compression routines built in so that file sizes are minimized. A commercial programming library was used within the AVIview program to perform the screen capture.

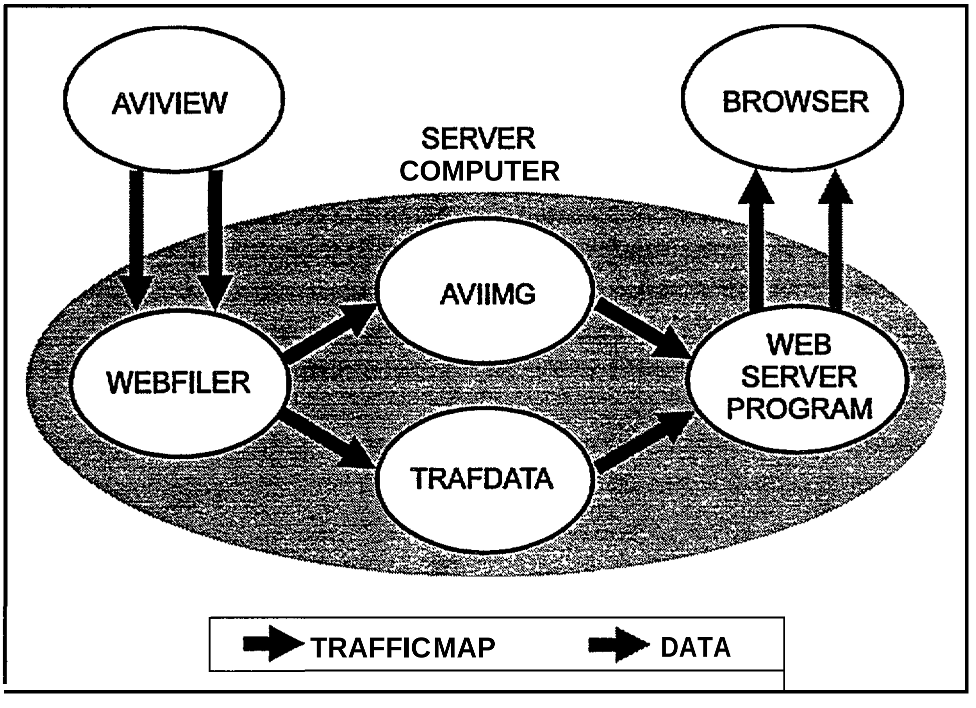
To produce the detailed data reports and the clickable map function found on the web site, a data file containing travel information and a data file containing roadway segment coordinates are stored along with the image file. The AVIview program is also used to create these data files. This functionality was programmed into the AVIview program along with the image capture function. A 80486 PC computer is dedicated for executing the AVIview program to create the data files for use by the web server.

Data Transfer

After the image and data files have been captured, they must be transferred to the web server. Two methods have been used to accomplish this. One method is to use a "Network File System" (NFS) connection between the AVIview PC and the web server. This NFS connection provides a transparent link between the machines so that when the files are saved by the AVIview program, they are actually saved to the web server, ready for access by the server programs.

Another method has also been used. Instead of using NFS to provide the link, the files are transferred using Internet "File Transfer Protocol" (ftp) programs. AVIview is programmed to store the files onto the PC's local disk drive and then execute the ftp program to transfer the files to the web server. Each time the files are sent, a new connection is established which is terminated when the transfer is complete. This way, if a network failure occurs, the ftp program will automatically attempt a new connection at the next data update.

Figure 6. System Data Flow



Access Coordination

A web address usually refers to a specific file stored on the hard disk of a web server. Initially, during development of the system, the map image file was stored directly onto the web server for immediate access by the web server program to send to users. This worked in most cases, but problems occurred when the file was updated at the same time someone on the Internet was accessing the file. This caused the user who was downloading the file at the time of update to receive an image that was cut off and distorted at the bottom.

Two methods have been used to solve this problem for both the map image file and the roadway segment data file. In the initial method, two additional programs were developed to execute on the web server computer to manage access to the file. The first program, called *webfiler*, executed at all times in the background and was responsible for managing updates to the image file that the web server was serving to users. *Webfiler* made sure that no one was accessing the image file before copying an updated file in it's place. *The* second program, called *aviimg was* a web Common Gateway Interface (cgi) program and was responsible for transferring the image file to the web server each time a user accesses the page. The *aviimg* program held a lock on the image file while it was serving it to users. This allowed the *webfiler* program to check to see if the file was locked to determine whether the file was being accessed. If the file was locked, then *webfiler* would wait until it was unlocked before updating the file. This method fixed the problem of users receiving a garbled image file, but caused another problem in the process. During busy times, when the map was being accessed constantly for several minutes or more, *webfiler* would never have a chance to update the image file, delaying the update and reporting an outdated image. To fix this problem, a second method was implemented.

The second method has a similar structure to the method described above. The *webfiler* and *aviimg* programs were modified to achieve the same result in a different manner. Instead of using only one file to be served out, multiple files are used. Upon each update, the files are updated in sequence. For example, if two files are used, the updates would be stored in a file sequence of filel, file2, filel, file2, file1 , . . . When an update is made, *webfiler* copies the file to the next filename in the sequence and then stores this new name to a shared file. This allows *aviimg* to determine the current file to serve out by reading the filename from the shared file. If two files are used in the sequence, there will always be at least one whole update cycle available for *aviimg* to serve out the file before it is updated again to that serving of the file will not be interrupted.

Clickable Map Feature

The ‘clickable map’ feature was added to the map to allow users to ‘click’ on a specific roadway segment and receive detailed information on the segment. This was accomplished in part by utilizing a standard web feature called Image Mapping. Image Mapping allows you to define regions of a graphic image in the form of a point, square, circle, or polygon and map those regions to a new web page address. These regions are defined in a mapping file on the server. When the user clicks on a mapped image, the client sends the x and y coordinates that were selected to *the* web server. A program on *the* web server, normally called *imagemap,* uses the mapping file to translate the coordinates to a specific region of the image and return the resulting web address specified in the mapping file.

Creation of the mapping file is performed by the AVIview program since it is the program that creates the image. As AVIview draws the map, coordinates are calculated and stored which define a polygon around each roadway segment line. One polygon is created for each roadway segment. This file is stored onto *the* web server for use by *the imagemap* program.

On the web server, a cgi program called *trafdata* was developed which is executed whenever a user selects a roadway segment on the map. This program is referenced through the mapping file with a parameter matching the id of the roadway segment that was selected by *the* user. *Trafdata* uses this id to look up the detailed roadway segment information and create a web page containing the detailed data which is transmitted to the user through the web server program.

Detailed Data Reports By Roadway

The detailed data reports which are shown for entire roadways are also created by *the trafdata* program. A parameter is sent to *trafdata* identifying the roadway. *Trafdata uses this* id to look up data for all roadway segments on the roadway and create a web page containing the detailed data tables which is sent to the user through the web server program.

Data Feed for News Media Access

As described in the System Capabilities section, the web server is used to publish a data file for access by the media. Currently one traffic advisory service is accessing the file for use in their own software systems. A data file is stored by AVIview every fifteen seconds and is placed on the web server in the same manner as the AVI map image. *The webfiler* program and along with a cgi program coordinate access to the file as with the other files.

Security

One concern when connecting to the Internet is security. The Internet is a worldwide network allowing access to your computers from millions of users around the world. One way of restricting access is by using a ‘firewall’. A firewall acts as a filter between an internal network and an external network such as the Internet, allowing unwanted traffic to be turned away and wanted traffic through. Firewall’s are not always perfect, though. Hackers are always attempting to find ways to break through firewalls and sometimes they succeed. Maintaining firewall systems can be a continuous cycle of discovering new ways of breaking the firewall and then patching the leak. This may cause the installation and operation of an up-to-date firewall system to be time consuming and costly.

Houston TranStar’s networks are not currently connected to the Internet, primarily because of security concerns. This has made transferring of the data to the web server difficult. To solve this problem, the AVIview computer was setup to act as a “gateway” or “firewall” between TranStar and the Internet. Since the data being transferred for this system is well known, creating the custom interface was not as difficult as creating a firewall that could handle all types of data from any source or to any destination. The data for this system has a specific format, source and destination, so that only this data is allowed to pass and no other.

Operation

Primarily, the system operates autonomously with little need for human intervention. The data updates are initiated by the AVIview program, the files are managed on the web server by the *webfiler* program, and the web pages are served to users by the web server software. There are some operation and maintenance activities, though, which do require human intervention.

Operators monitor the system by monitoring error messages and by regularly accessing the web site itself. If the AVIview image or data files are not updated as scheduled, the *webfiler* program automatically issues an electronic mail (email) message to an operator warning that the system has failed. Another email message is issued when the system becomes operational again.

An email address is provided to web users which allows them to submit questions and comments about the site. An operator monitors and replies to these email messages on weekdays. This has been an important way of measuring user satisfaction with the system and identifying areas for improvement. On average, one to two email messages are received each day. Questions are primarily about how the system works, when it will be expanded to other roadways, or what other services might be provided. Many of these questions have been compiled into a "Frequently Asked Questions" (FAQ) page to answer commonly asked questions. Most comments are positive and thankful for the system. Several of these comments are listed in Figure 7. Many other comments include helpful suggestions on improving the system.

Figure 7. Sample Email Comments.

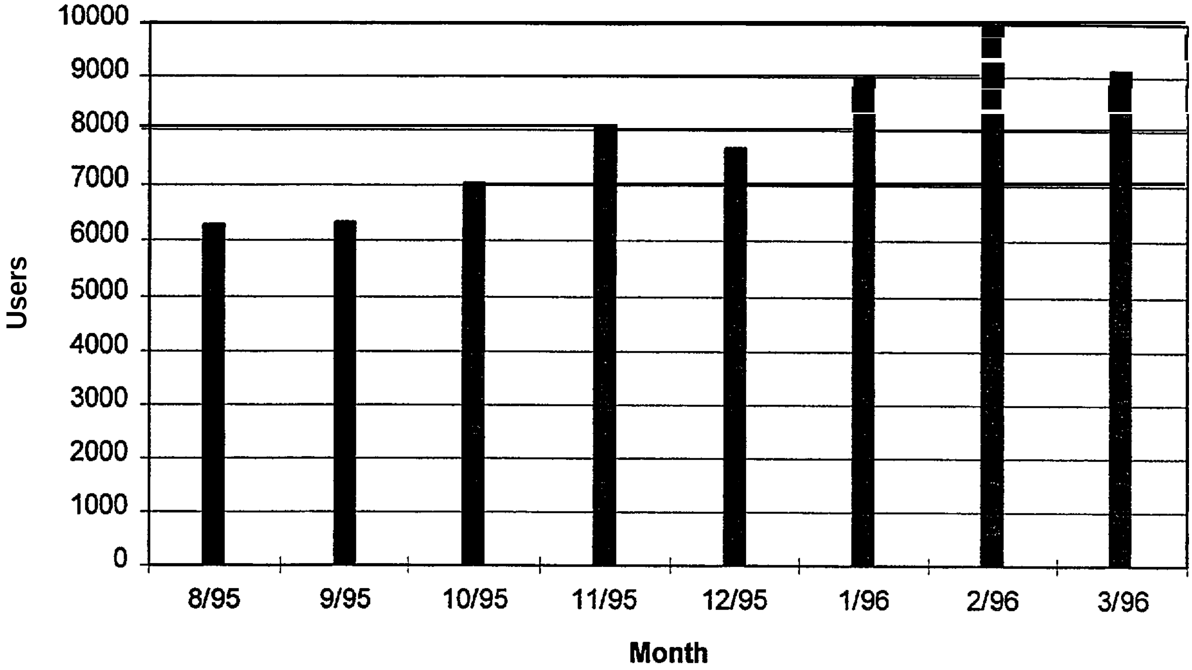
Date	Comment
1-25-96	"Just wanted to say thanks for the map, and I'm looking forward to watching it develop more in the future."
2-4-96	"Thank you ever so much for the Traffic Map. It is extremely useful, especially this last weekend and the dubious weather. I try to check on it each morning at home, then catch it again at the office It has become indispensable."
2-5-96	"Great www site! One of the most useful I've seen..."
2-6-96	"Howdy. I am in Houston, and wanted to let you know that you are doing a great job. The addition of a freeway summary was a great idea. It is so easy now to view the entire area, and then see each segment without clicking on each individual piece."
3-l-96	"Just wanted to let ya'll know that your home page is awesome. I utilize it every night before I go home, to determine which way I should go. Living out towards Katy on I-10, you never know what traffic will be like!! Thanks for providing such a great service for Houston"
3-2-96	"Thanks so much for a great service, reliable information and assistance in getting around Houston. This service has proven invaluable on many occasions, especially when updated information (radio reports) are not available. It is interesting to see the individual reports for each portion of town. Keep up the good work and thanks again!"

Usage

Use of Houston's web traffic site has grown continually since it was advertised in February, 1995. The site has been featured in local news programs and newspapers including a front page article in the Houston Chronicle on March 10, 1995. Most Houston related web sites have links pointing to the site which makes finding the site easy if you do not know the address to key in.

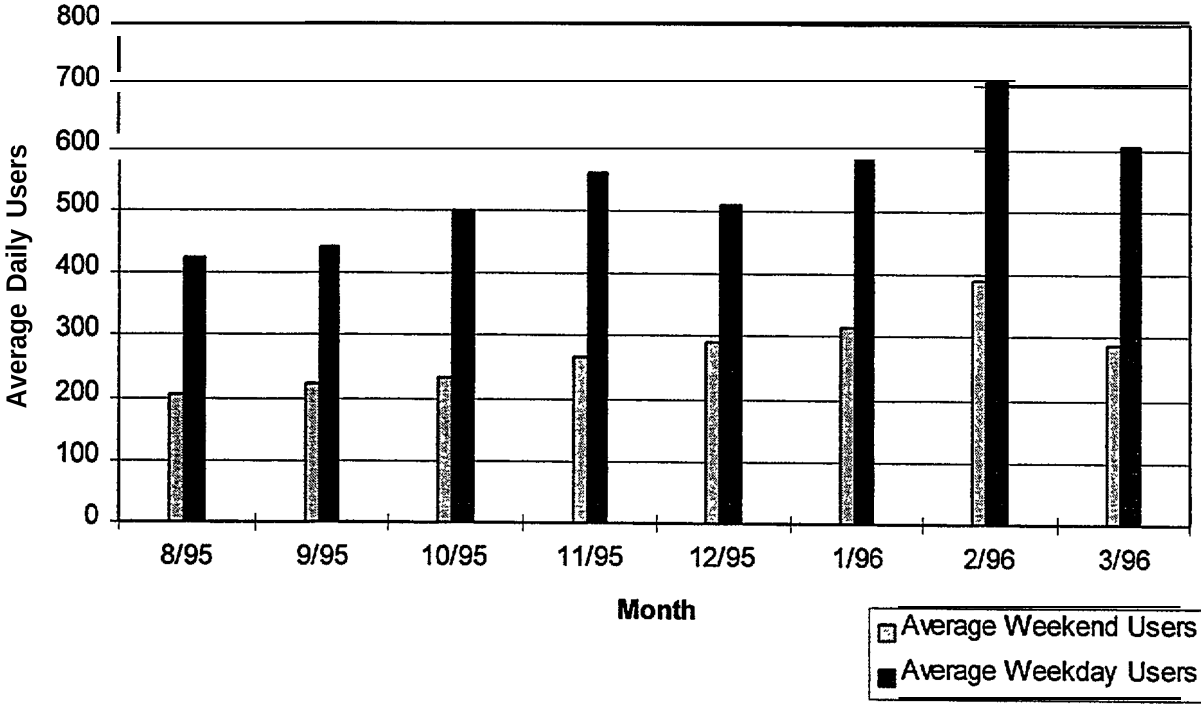
The estimated number of users who access the site each month is shown in the chart in figure 8

Figure 8. Total Monthly Users



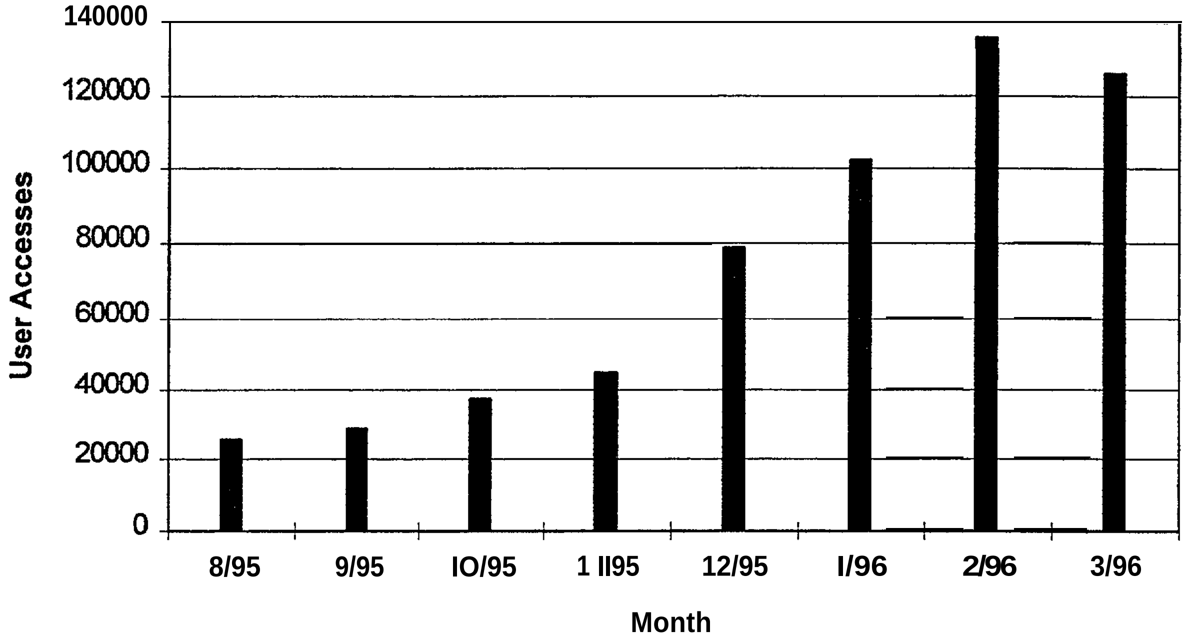
The estimated number of average daily users is shown in figure 9. This chart shows the average number of users on weekdays compared to weekend days.

Figure 9. Average Daily Users per Month



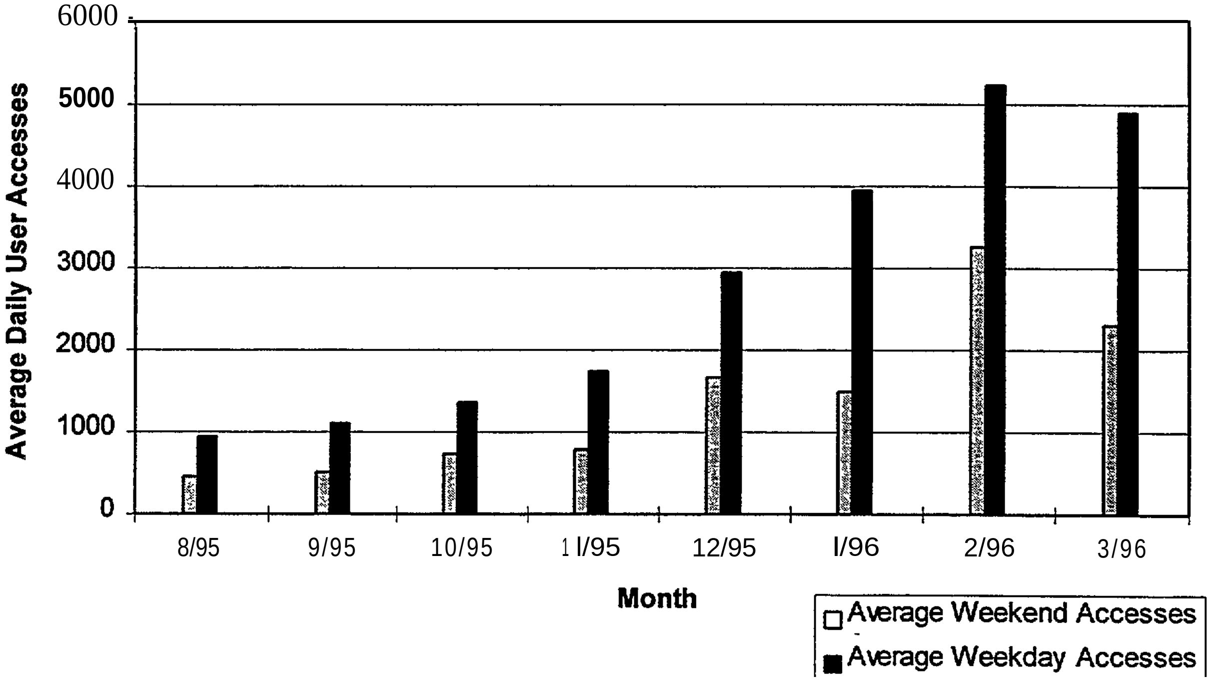
The number of total user accesses per month are shown in the chart in figure 10.

Figure 10.Total Monthly User Accesses



The average daily accesses are shown in the chart in figure 11. This chart shows the average number of accesses to the traffic map on weekdays compared to weekend days.

Figure 11. Average Daily User Accesses per Month

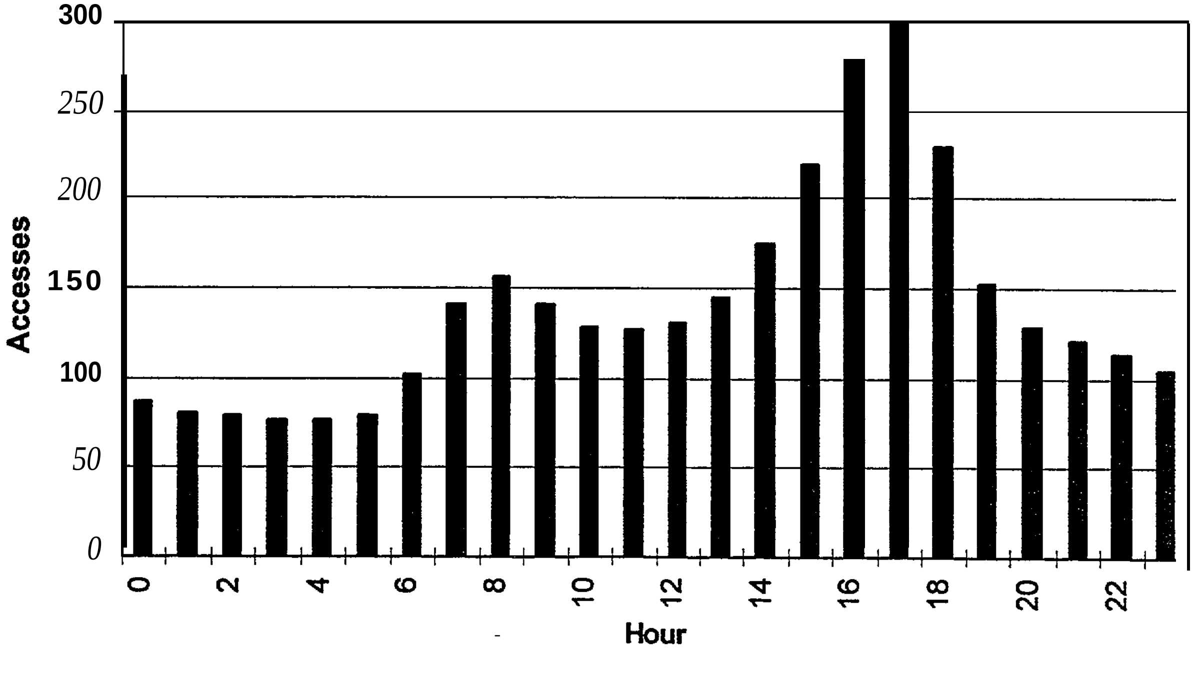


Notice that the number of accesses is much larger than the number of estimated users. This is due to the fact that many users will access the map several times during a day or month. Also, in December, 1995 a feature was added which, for users of *Netscape 's Navigator* browser, causes an up-to-date map image to be automatically reloaded every two minutes if they leave the map page active on their browser. This caused an approximate 30% increase in user accesses to the map.

The web server keeps a record of each access that is made to the system, so that these estimations can be made. When calculating the daily or monthly number of users, there are two potential errors that may occur which make these values estimations. The web server logs the Internet network address of the remote computer. Many networks, especially those providing access over dialup telephone lines, allow users to share an Internet network address. Many times, a specific telephone line is assigned an address. In this case, multiple users could dial into a single phone line at different times during a time period reporting only one user which would result in a low estimation of users. At the same time, one user might dial into several different phone lines at different times during a time period reporting the user at multiple addresses which would result in a high estimation of users. It is impossible to determine the extent of these errors, but overall, these errors may cancel each other out giving a reasonable estimation of the number of users.

The chart in figure 12 shows the daily average number of user accesses per hour for the Month of February, 1996. This shows that the site is accessed the most between 4 pm and 6 pm. This is probably because many people have access to the Internet at their work place. There do appear to be persons accessing the page in the morning before their trips to work but this number is much lower.

Figure 12. Accesses By Hour



Future Expansion

As new systems become operational within the Houston TranStar Center, we hope to provide more information to users through the web site. This information could include expanded AVI sensor coverage, travel speeds collected through inductive loop sensors, incident and construction reports logged by TranStar operators, and high water warnings collected through area flood sensors. Also, more general information about TranStar and it's projects will be provided on the site.

CONCLUSION

In conclusion, we have found that the Internet has proven to be a cost effective way to quickly publish real-time travel information to a growing number of on-line users. The system has also proven useful in providing travel information to the news media for further distribution to commuters through radio and TV reports. I would definitely recommend this type of system for other metropolitan areas, especially as use of the Internet and other on-line services with Internet access continues to grow.

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