



Guidebook for Development of Traffic Monitoring Systems for Major Traffic Generators in the State of Texas

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Development of Traffic Monitoring Systems for Major Traffic Generators in the State of Texas

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An Assessment of a Traffic Monitoring System for a
Major Traffic Generator to Improve Regional Planning

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The purpose of this guide is to aid the Texas Department of Transportation (TxDOT), Metropolitan Planning Organizations (MPO), and other state and local agencies to develop an effective traffic monitoring system for new major traffic generators in their metropolitan region. This guidebook will provide you, the transportation planner and engineer, with a better understanding of the considerations that need to be taken when developing a monitoring system for these types of large generators.

When a new large traffic generator is constructed in a region, local and sometimes regional traffic patterns are impacted. Regional planners and engineers need accurate, adequate data in order to understand the location and magnitude of the impact. TxDOT Project 0-5531, *An Assessment of a Traffic Monitoring System for a Major Traffic Generator to Improve Regional Planning*, looked at the state-of-the-practice in major traffic generator monitoring systems around the country, while focusing on a single, new major traffic generator in the State of Texas. The City of San Antonio gained a Toyota Motor Corporation automobile manufacturing facility in the southern area of its metropolitan region. The opening of this facility provided an opportunity to analyze the impact on transportation in the immediate area and region wide. Since the new traffic generator is located in an isolated area where traffic volumes are light, researchers could more easily monitor changes in traffic characteristics and apply lessons learned to other future mega-traffic generator sites. The results of this effort provide the foundation for this guidebook.

The guidebook is organized to provide you with an understanding of major traffic generators, how to develop an effective monitoring system, and to analyze the impacts with the data collected from the system. By creating and maintaining a comprehensive and effective system for collecting, transmitting, archiving, and reporting traffic data for major traffic generators, planners and engineers can use this information to improve regional planning efforts and better incorporate these traffic generators into their respective transportation networks and future plans.



Major Traffic Generators and Regional Planning

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1. Major Traffic Generators and Regional Planning

Large-scale traffic generators in an urban or rural area are designated a major or special traffic generators. The terms are also used fairly interchangeably in both the academic literature and in the practice. The definitions of major and special traffic generators vary widely. For the purposes of this guide, the term major traffic generator is used.

Special Traffic Generator

A general description provided for a special traffic generator is a *facility, business, industry, or other land use that generates large amounts of traffic*. Examples include:

- Schools,
- Shopping Centers,
- Hospitals,
- Airports,
- Public Service Buildings,
- Military Installations,
- Prisons,
- Landfills,
- Regional recreation facilities, and
- Regional Malls.

Within the State of Texas, different communities have different definitions of a special traffic generator. Some examples of this include:

- anything significant occurring outside of normal weekday traffic,
- international bridges, and
- high school events.

Other cities in Texas simply define them according to their travel demand model. For travel demand model purposes, special generators are large facilities that generate irregular traffic patterns in the course of a day. These are primarily hospitals, universities, and airports, but not industrial sites. These types of facilities are coded based on the expected trip generation rate and incorporated into the travel demand model. For example, the Dallas-Fort Worth Regional Travel Model considers three types of special generators:

- Regional Shopping Malls with greater than 500,000 square feet,
- Universities and Colleges with over 1,500 students enrolled, and
- Hospitals with over 300 service employees.

Major Traffic Generators

The definition of a major traffic generator varies widely and is proportional to each community. Broad definitions found refer to concentrated land use resulting in high traffic demand.

NCHRP Report 548 defines a major traffic generator as ...

“[a] land use that generates a high traffic volume to and from the site, usually defined in terms of vehicles per hour or vehicles per day. Volumes used to differentiate major versus minor vary widely.”

Another definition provided in 23 CFR 470A Appendix A states a major highway traffic generator ...

“...means either an urbanized area with a population over 100,000 or a similar major concentrated land use activity that produces and attracts long-distance interstate and statewide travel of persons and goods. Typical examples of similar major concentrated land use activities would include a principal industrial complex, government center, military installation, or transportation terminal.”

Some cities have defined a major traffic generator as any establishment that generates or is projected to generate traffic which significantly lowers or could adversely affect the current level of service of a state highway.

Some state or municipal codes provide a more quantitative threshold for defining ‘high traffic demand.’ For example, the New Jersey State Highway Access Management Code defines a major traffic generator as the use or uses which generates a total of 500 or more vehicle trips per day directly accessing a State highway to and from the use or uses. In the City of Clearwater, Florida community development code, a major traffic generator means a facility that generates in excess of 1,200 vehicle trips per day.

Planners and engineers need to consider their local and regional context when determining whether a new traffic generator is considered major.

One development that may not be perceived as significant in a large metropolitan area may have a very large impact in a smaller community. From a regional planning perspective, a new major traffic generator is a source of economic development, regional prestige, and should be factored in planning for future land use and impacts. Experience and professional judgment play a role in determining the significance of a new traffic generator.

Regional Planning

Regional planning involves the inter-coordination of several different governments and agencies to address and solve issues within a metropolitan area. The key problem in planning for a metropolitan region is political. Local governments, by themselves, are inadequate to address effectively metropolitan area problems. Traffic flows do not respect municipal boundaries in a metropolitan region. However, the local level is where the power and responsibility for implementation of regional policies lies.

Transportation is the issue that is most agreeable to regional planning. Regional urban planning is an important function which has been strengthened with recent federal transportation legislation including the Intermodal Surface Transportation Efficiency Act and the Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users.

Regional planning helps regional policy makers adopt various policy and program decisions to expand, maintain, and manage the various transportation infrastructures within their region. It also helps them meet other federal requirements such as attainment of clean air standards. The results form the Metropolitan Transportation Plan and the Transportation Improvement Program.

MPOs are increasingly finding intermodal issues to be very important. This is due in part to the focus placed on this topic by federal transportation legislation.

Interest in freight planning or goods movement is increasing at the national level. Trucks disproportionately contribute to pavement wear and damage and also contribute to congestion on choked roadways because they both consume more physical space compared to passenger cars and must allow greater headways to advance vehicles allowing safe following distances. Finally, heavy-duty trucks contribute significantly to an area's mobile source emissions based on current emission modeling frameworks.

Traffic Impact Analyses

Traffic impact analyses (TIA) are conducted by municipalities for major developments including those expected to generate significant increase in traffic. The threshold for a TIA varies across municipalities and agencies. TIAs are used to predict traffic changes and effects on level of service and recommend roadway and safety improvements to the nearby and adjacent intersections or roadways in response to the major traffic generator being developed. The TIA study looks at development size and use and determines the effect of that use on the existing roadway system. This should lead to a roadway system that accommodates the proposed land use and may recommend mitigation measures to foster efficient traffic flow around the proposed site.

TIAs are not typically integrated into the regional plan.

They are used primarily as part of the approval process at the local municipal level. For TIAs to be included in a regional plan, the project would have to be a large-scale development.

Impacts of Major Traffic Generators

Major traffic generators will have an impact on the local and regional transportation system. The extent of this effect is subject to the scale of the generator and the size of the metropolitan area. The most basic effect is intersection and roadway capacity improvements. In many instances, infrastructure improvements to the roadway system are part of the development package offered by the area hoping to attract the major generator. Even if not part of a development package, roadway improvements may still be necessary.

The size and location of the major traffic generator is crucial to the extent of improvements.

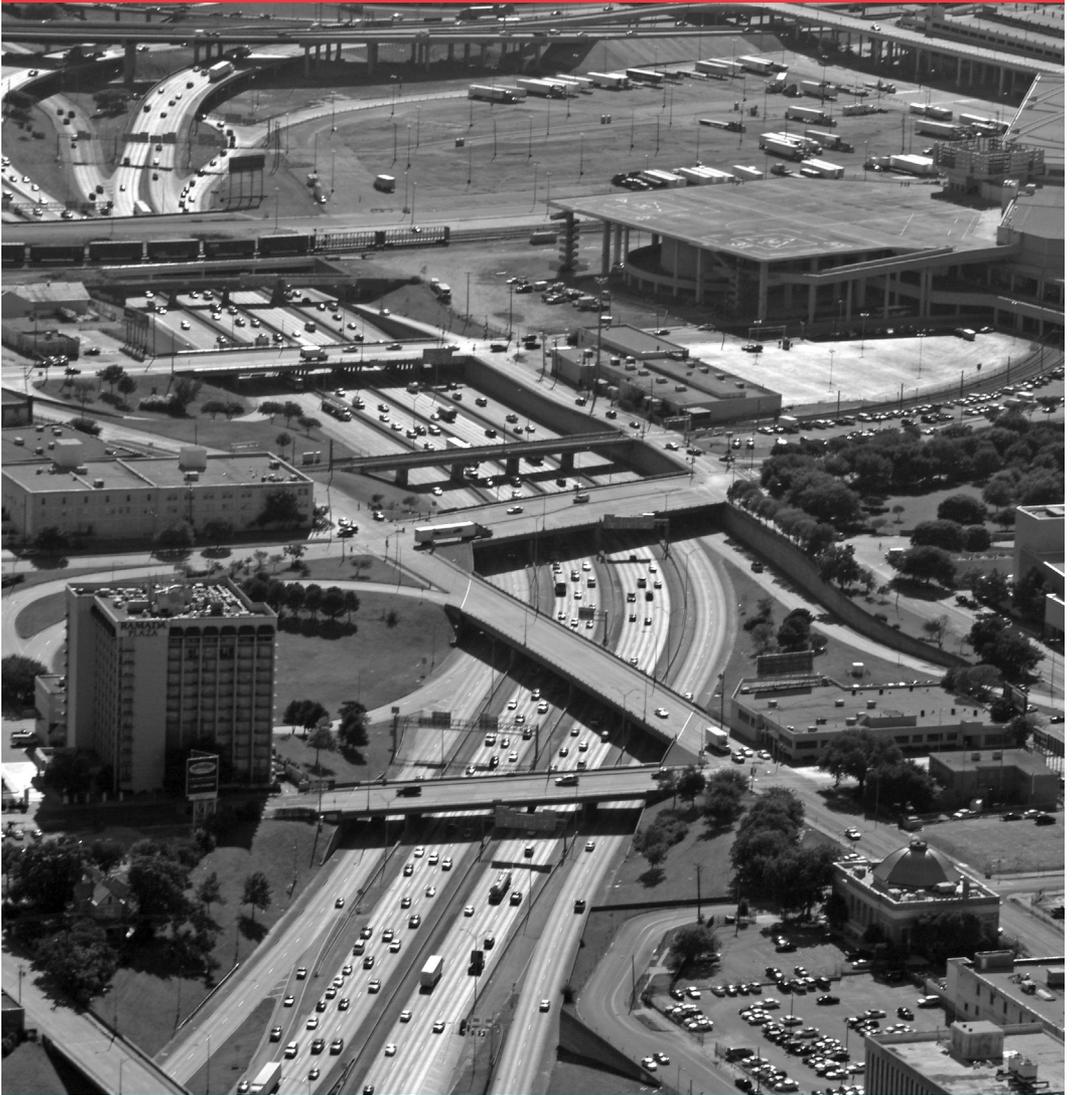
If located along a major corridor in a metropolitan area, the required improvements could be costly and extensive. If in a more rural location, needed expansion in capacity or operations could be less.

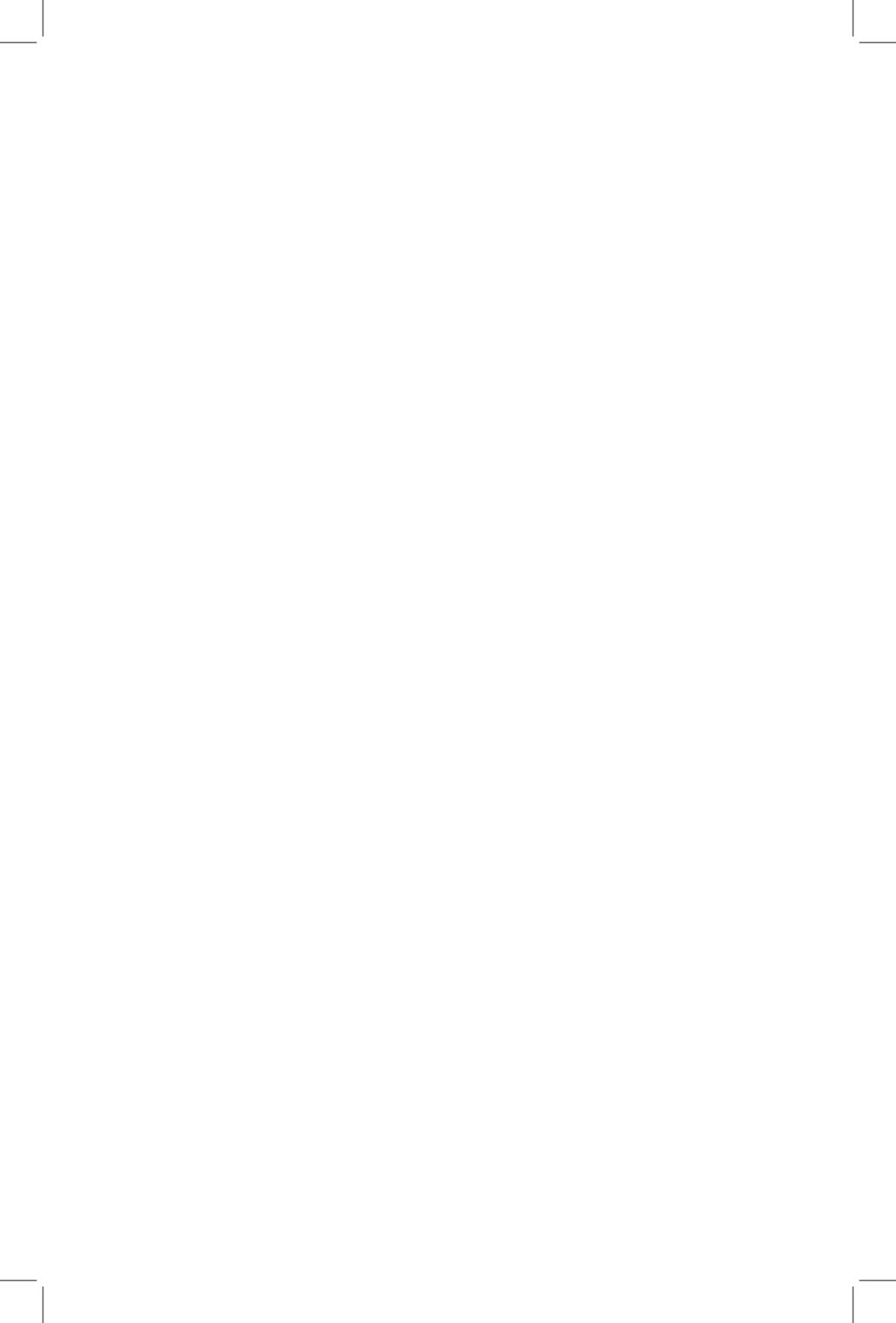
Indirect impacts of major traffic generators in an area include:

- Changes in land use
- Changes in land values
- Development of supporting services for employees of the generator
- Development of supporting services for the major generator itself

Developing a Traffic Monitoring System

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2. Developing a Traffic Monitoring System

There are several reasons to monitor a major traffic generator for regional and transportation planning purposes. They include:

- Provides feedback to the planning process
- Monitoring system becomes a performance indicator
- Allows for testing of specific traffic monitoring devices and technology
- Promotes inter-agency cooperation
- Experience helps planners address the next major generator in their area

The traffic monitoring system can provide timely feedback to local and regional planners as impacts occur at or near the new traffic generator. They will be able to more quickly recognize commute pattern changes in the area, increased congestion on the road network, and higher land uses being developed in the area.

The implemented system will become a performance indicator for plans and TIAs. Planners can validate the assumptions and output of the TIAs used for the new development along with attendant local and regional plans.

Traffic data collection requires several different types of devices and technologies to monitor road networks. Developing a traffic monitoring system for a new generator provides TxDOT with an opportunity to test new devices and technology, if new sites are deemed necessary.

When considering a traffic monitoring system, different agencies and levels of government will be involved. For the Toyota plant in San Antonio, for example, the city, county, MPO, the TxDOT-San Antonio District, and TxDOT Transportation Planning & Programming Division's Traffic Analysis Section (TPP) were all involved in developing the system. In some cases, other municipalities, business organizations, federal and military authorities could be involved. The agencies must agree on several issues regarding the monitoring process, such as availability of funds, the locations of the collection sites, the types of data collected, the warehousing of the data, the personnel to analyze the resulting collected data, and the dissemination of the results. Successful implementation of a monitoring system requires good inter-agency cooperation.

Finally, the process of planning and implementing a system provides local and regional planners with experience that will help make development of the next system, if desired, that much easier.

Early implementation is better!

If regional agencies decide to develop a traffic monitoring system for a major traffic generator, starting earlier is better. Having a system in place will allow for good before/after analysis and provide a much better sense of the impacts to the region as a result of the generator. An early start allows planners the opportunity to acquire more resources (funding, equipment, agency and political support). Finally, any problems that arise have a greater chance of being solved before data collection begins.

Take stock of your resources.

Planners must assemble funding, equipment, personnel, and require work and support of others outside of their organization to develop and implement a system. Knowing what is available to start with will provide focus to what resources must be gathered.

Define the study area.

Defining the study area around the major traffic generator is crucial. In one sense, available and future resources will help to define the area, but other considerations are necessary. Generally, major roads are an intuitive borderline for a study area. The study area in San Antonio was contained by three Interstate Highways and one major local roadway.

More sites mean more data.

The area around a major traffic generator could have an adequate number of data collection sites in place. However, the proposed monitoring system may also require new collection sites. Data collection locations must be sufficiently comprehensive to capture the “before” and “after” traffic movements. Sufficiency depends on size of the study area and resources available to purchase the necessary equipment and manpower, if necessary.

Coordination between the TxDOT District and TPP is essential in locating new sites. The sites will be placed so that monitoring the major generator is accomplished, but they must also be placed at locations that contribute to the Department’s statewide monitoring system. This is an important consideration as the Department may also make available the funds necessary to extend the size or increase the density of the monitoring net to further related agency interests.

Traffic data collection site locations should also consider existing land uses around the generator, along with future development plans in the area.

Traffic Data Collection

Monitoring of activity on the transportation system in all areas of the state is a basic task for state departments of transportation. Traffic varies over time and place. It is necessary to understand and be able to monitor all of these activities and changes in travel to make correct decisions about the design, operation, and maintenance of roadways. The State of Texas has an extensive traffic monitoring network. Analysis of this collected data serves many purposes for officials at state and local agencies.

Use of available, historical traffic data in the vicinity of the new major generator is a key building block in developing a monitoring system.

There are several types of traffic data that are gathered as part of a monitoring system. They include:

- Traffic Volume
- Vehicle Classification
- Weigh-in-Motion
- Survey Data

Traffic Volume

Volume is the total number of vehicles passing a point on a transportation facility during a given time period, usually expressed as annual, daily, hourly, peak or off-peak traffic volumes. Short duration volume counts are traditionally the primary focus of most statewide traffic monitoring efforts. Traffic count programs are used to compute Annual Vehicle Distance Traveled (AVDT), which is useful for describing system-wide vehicular travel and trend tracking purposes. Volume counts are performed manually and automatically.

The three main elements to traffic volume counts are:

- limited continuous count element (CCE),
- Highway Performance Monitoring System (HPMS) data collection, and
- special needs and short term counts.

HPMS counts are conducted to meet federal reporting requirements. It provides a statistically valid statewide estimation of AVDT.

Vehicle Classification

Vehicle classification allows the monitoring of changes in truck volumes and changes in vehicle fleet mix (the percentage of travel by specific vehicle types) to be tracked over time. Vehicle classification is obtained through both automatic and manual techniques. Each method is collected separately. As with volume counts, the monitoring cycle is annual.

The monitoring period is 48 hours for automatic vehicle classification (AVC) and 24 hours for manual collection.

Classification is separated by direction and stratified using HPMS functional classes and area type. Vehicle classification is scheduled regionally due to the size of the state, moving from south to north during the monitoring cycle.

AVC uses lane sensor devices to record vehicle data. AVC equipment provides reliable vehicle classification at locations with typical roadway speeds of 45 mph or faster. AVC data is manually retrieved from the field once a year by connecting the field equipment to a computer module on which the data is stored.

Manual vehicle classification data is provided to TxDOT from contractors who collect visual classification data manually in the field. Data is initially recorded by handwriting the results on forms that are then manually inputted to an electronic computer file for easier data analysis.

Weigh-in-Motion Data

Weigh-in-motion data collection is intended to accurately measure the dynamic traffic loads that are being applied to particular pavement sections over time. Weight data are necessary for converting truck volumes into the axle load estimates needed as an input to pavement design and maintenance procedures. Highway WIM systems are capable of estimating the gross weight of a vehicle as well as the portion of the weight that is carried by the axle and axle group on the vehicle.

WIM requires the most sophisticated data collection sensors of all monitoring site technologies, the most controlled operating environment, and the most costly equipment set up and calibration. WIM data are also the most important in that it provides a greater range of data than volume counts and vehicle classification.

Survey Data

Roadway intercept surveys are another technique to use to monitor major traffic generator sites. They can provide a greater level of detail than machine traffic counts can, assuming drivers are willing to provide the information. The roadway intercept survey can determine the vehicle's previous origin and future destination. All data elements can be collected, clarification and follow-up to responses can be done immediately, and data is available sooner. These surveys are more expensive due to high necessary staff resources at multiple locations and required traffic control measures to ensure safety of staff and respondents. Greater coordination between authorities and agencies is required, and the survey is weather sensitive.

Location of the major generating facility is a factor in using an intercept survey. In a less dense or rural setting, roadside intercept surveys can be safely and efficiently conducted if attention is given to the specific location, coordination with authorities, costs, and resources for the survey. In denser, more urban locations, a more flexible approach is needed in light of potential physical conditions at the survey site. Weigh stations, rest areas, and truck stops are conducive to surveying commercial vehicles on high volume facilities in the State of Texas.

Other Data Sources

The core of a traffic monitoring system of a major generator will be the traffic data gathered in the study area. There are still a number of non-transportation data sources that planners can use to better understand impacts.

Changes in land use adjacent and in the vicinity of the new major traffic generator allows for other sources of data to be considered for incorporation in a monitoring system. In addition, the impacts to travel patterns at or near the generator affect the way in which traffic data is used in monitoring the area.

Land Use Changes

After a major traffic generator is developed other companies that support and/or facilitate the new business also begin to develop. The area surrounding the generator is likely to develop and the land uses change. As a result, several different types of available data could be considered for inclusion in a monitoring system. These data types are:

- Aerial photography
- Building permits
- Utility hook-ups
- Available economic data

Aerial photography, or photos, can be used to observe the physical changes occurring such as new buildings, building density, changes in green space, an increase in the number of lanes of a particular roadway, or roadway density.

The limitations of using aerial photographs are:

- Availability of photographs from the past
- Dissimilar techniques used in collecting the past photographs (i.e., altitude, photographic method)
- Difficulty acquiring the photographs
- Photographs may not be applicable to the study time frame

MPOs and TxDOT or large municipalities are likely sources for aerial photographs. In some cases, current aerial photographs are available online, but historical photos are usually not. Historical photographs can be requested from sources for comparative purposes. Hardcopy photos are preferred for making comparisons.

To compare current land use activity to past activity, a uniform grid can be placed upon each aerial photograph. The percentage of land use and/or roadway improvements could then be measured per square mile and compared. Careful examination could reveal changes in commercial/retail use, industrial use, residential uses (single family and multi-family could be disaggregated), institutional usage (i.e. public schools, hospitals, etc.), and roadway improvements. For each corresponding square on both past and present maps, the usage is calculated by area and a percent of the square mile is determined. The percentages from before and after are then compared to see if there is any change.

Building Permits

Building permits can be used to observe changes in building activity within an area. Building permits are used by municipalities to regulate conformance to building codes. These permits are granted through the local municipality and/or the county where the new major traffic generator is established. Many cities publish city-wide permit data on their website and by use of a public information request data can be stratified to the zip code and street level.

Building permits give some indication of construction or development activity; however permits issued do not imply construction occurs.

The application of permit data is influenced when the study area is not fully in city limits. Part of it may be outside of city limits and partly in limited-control city limits. Regulation of building permits may differ in each part. Permits may not be required outside of city limits. This can have an adverse impact on a comparative study.

Utility Hook-Ups

Utility hook-ups such as electricity or water may also allow for observation of new business activity within an area. Water connectivity is less useful given that water is supplied to a building (single or multiple tenant), whereas electricity is supplied to each tenant in the building as tenants lease space. Problems similar to those discussed regarding building permits can arise when the study area is partially in city limits, part outside of city limits, and/or partially in limited-control city limits. Also in the era of electric utility deregulation, if more than one electricity provider is available, then collecting the number of electricity hook-ups from each electricity provider may prove to be a challenge.

Economic Data

Economic data from the State data collection agencies may be an indicator of number of businesses segregated into North American Industrial Classification System (NAICS) codes. Many of these agencies provide data online for public use. An open records request or a call to the agency can provide refinements of the data (e.g. stratification by zip code, or county, or region).

Travel Impacts

Travel patterns will change when a major traffic generator is developed. Traffic volumes, types of vehicles, travel times, travel purpose, and number of incidents can all be affected in the area surrounding the traffic generator. A monitoring system needs to be in place to record the before and after travel patterns.

Traffic counters must be in place in order to observe traffic volume changes. The data may come from both existing count locations and additional stations installed to increase count coverage. TxDOT has a statewide monitoring system that uses short-term and long-term count stations to collect traffic volume and vehicle classification. TxDOT annual counts are adjusted for seasonality (monthly or seasonal factor) and traffic mix (axle factor). TxDOT saturation counts, collected every five years, are short-term volume counts with axle counts divided in half and are not seasonally adjusted. Some counties also have short-term volume count stations in place, for areas not within city limits. The historical data from these traffic monitoring programs can give a picture of the travel patterns previous to the construction and opening of the major traffic generator.

Travel Times

Given the expectation of a change in travel patterns, travel times can be expected to change. The purpose of travel time data collection is twofold:

- To generate a speed profile for the affected corridor per direction (usually peak direction) at a given time of day, and
- To determine instantaneous speeds at given check points or mile-marks along the corridor.

Corridors

In order to assess changes in travel times for priority corridors in the affected area, frequency of corridor timings and corridor priority needs to be selected. Once corridor selection occurs, corridors located outside the study area need to be chosen for comparison purposes. Within the study area, corridors that are likely to be impacted should be listed from highest to lowest priority.

Monitoring Periods

In consideration of time and costs, monitored time periods of the day need to be carefully selected. The traffic volume during morning and afternoon peak periods may change due to a major traffic generator as well as mid-day or overnight periods. A major traffic generator can cause the volume peaks to shift.

A distance measuring instrument (DMI) can be used to develop both speed profiles and instantaneous speed rates for each corridor under study. The DMI is an electronic unit installed into a vehicle which polls the transmission for the speed of the vehicle. The vehicle is then driven along the corridor of interest. A crew of two is used to collect the data: one to drive and the other to operate the computer.

Travel time information is usually collected during peak periods; however awareness of the timing of impacts from the generator should be taken into account. For example, a sports and events stadium may have impacts in weekend periods. Data should be gathered in the time periods expected to have impacts from the major generator.

At least three travel time runs in peak direction is desired. This also generates at least two travel time runs in non-peak direction as well. Assuming two crews, an example schedule for an AM and PM peak periods is shown in Table 1.

Table 1. Travel Time Departures per Peak Period.

AM Peak	PM Peak
0600 – 0630	1600 – 1630
0630 – 0700	1630 – 1700
0700 – 0730	1700 – 1730
0730 – 0800	1730 – 1800
0800 – 0830	1800 – 1830
0830 – 0900	1830 – 1900

Other Considerations

The number of crews needed depend on the length of the corridor and the amount of congestion present. If the corridor is less than five miles in length, then one crew is sufficient. If the length is between five and ten miles, then one or two crews is needed depending on anticipated congestion. Longer than ten miles, two crews are needed to make at least three travel times along that corridor.

For comparison purposes, travel times should be taken previous to the implementation of a major traffic generator, shortly after implementation, and some time thereafter.

This should enable measurement of the impact of the major traffic generator.

Run times need to be selected with an anticipated change in traffic patterns. Standard procedures for collecting travel times during peak periods indicate Tuesday, Wednesday, and Thursday as the best days to collect the data. Travel times are not collected on days with incidents (accidents, stalled cars, etc.), inclement weather (rain or ice), and major construction. Standard procedures also call for the floating car method to be used when collecting data. The rule to follow is “pass the same number of vehicles that pass you doing as little or no lane changes as possible.”

For comparisons, travel times need to be collected a minimum of one day previous to implementation and a minimum of two days on the corridor after implementation of the major traffic generator. Each day would consist of travel time measurement for each peak period.

Costs

Costs associated with collecting travel times are as follows:

- Five hours for two persons per crew
- Time to/from site (approximately one hour)
- Testing time (approximately three hours)
- Mileage/gas
- Field prep time [need to know mileage of roadway to be traveled and identify milepoints for each checkpoint (over/underpasses or apexes of entrance/exit ramps)]; collection equipment needs to be calibrated]
- Office prep time (one to two hours) and data reduction (one to two hours)
- Staff time for office time and field prep time
- Out of town travel expenses

Travel Purpose

With the addition of a new major traffic generator, a change in driver motives can effect a change in traffic patterns in the surrounding area. Motives may include a new job, new business opportunities, meals, and other purposes. Origin-destination (O-D) data collected from workers and commercial trucks around the major traffic generator can be useful in understanding the purpose, trip origin and route, and trip destination and route.

O-D data collection can be performed by intercepting the vehicular traffic leaving the traffic generator, if feasible. Intercepting traffic leaving the generator is most likely to have the least impact on plant operations (i.e., shift workers are not impeded from arriving on-time for work). Data collected can be categorized into commercial, employee, and other.

Questions to be answered by the collection process include:

- Where are you traveling from?
- Where did you travel from to reach the location and which route did you take?
- Where are you now headed and which route do you plan to take?

TxDOT Transportation Planning and Programming (TPP) Division has an existing contract through which travel survey data is collected. It may be possible to coordinate with TPP to execute the collection of this data for a short period after the traffic generator is operational.

Trip Generation Rates

A new major traffic generator will increase the number of trips within the region. For example, a new manufacturing plant will generate new employment thereby generating new trips within or to the region. Raw materials and finished goods are needed in the manufacturing process thereby increasing truck and rail transport trips into the region. The finished product will need to be transported to the intended sales destinations also increasing truck and rail traffic from the region. With the new generator, other businesses may increase in the immediate area or region to help support plant operations or to serve the employees. Other business will also cause an increase in trips. Current trip rates in the area should be documented before opening to assess differences in the future number of trips.

Incident Data

As more traffic volume is generated and traffic patterns change, the likelihood of accidents can increase. Conducting a comparison between past and current incident data may be problematic. Limiting factors to conducting a successful incident comparison include the following:

- Fender benders are not likely reported thereby giving an incomplete picture;
- The past crash data may not be geo-coded very accurately;
- The summary data may not be reliable; and
- The data likely to be on paper records requiring substantial staff effort to review, select, and record.

Modes of Travel

A major traffic generator may increase usage of other modes of travel such as water, rail or air. An increase of freight by rail can induce increased maintenance and/or upgrade to existing rail facilities. More trains can cause an increase in traffic delays at at-grade rail crossings. Data comparison of rail freight before and after the plant completion would take into account the following:

- Number of trains
- Freight tonnage
- Length of trains
- Number of at-grade crossings

Greater usage of other modes of travel can increase traffic delays and can affect travel time runs.



Data Analysis, Archiving, and Reporting

3





3. Data Analysis, Archiving, and Reporting

Depending on the type of traffic monitoring system developed, a variety of data types will be collected and used for analysis. When analyzing the data collected from a monitoring net, the challenge is to match the various sources and types of data in order to measure changes on the road network. Typical matching scenarios can include:

- Short-term data with continuous data,
- Historical data with current data, and
- Travel time data and commuter surveys with traffic data.

After data has been collected, comparisons can be made using three methods:

- The data collected from the new traffic monitoring sites in the study area before the major traffic generator opens can be compared to the data collected afterwards;
- The data collected from existing traffic monitoring sites associated with new traffic monitoring sites can be compared using data before and after the plant opens; and
- The data collected from the new and existing traffic monitoring sites in the study area can be compared to traffic monitoring data collected from control sites outside the study area.

Traffic Volume

Traffic Volume: Changes at New Sites Only

This method allows for direct comparison at the same location using volume data. For determination of a significant difference in volumes, a paired t-test would be sufficient. The data collected before and after implementation can be paired by location and a test for significant difference between before and after counts can be performed. Most of the newly installed sites lack a count history. Any sites with over six months of data can be analyzed with the consideration that the few sites may not be enough to be representative of the study area.

Traffic Volume: Changes at New Sites using Historical Existing Site Data

A paired t-test would be sufficient to test for the detection of a significant difference in the before and after implementation volumes at the historical locations. The new sites will have little or no history. Determination of equivalency of collected data is needed between the new site and the associated historical site in order to answer the question, “Is the new site and the associated historical site collecting equivalent data?”

Figure 1 below displays the concept. The boxed 'H' represents historical data. There are three boxes to represent the data collected over a number of years. The new site, box 'N', comes on-line and starts collecting data. If the boxed 'H' and the boxed 'N' are deemed equivalent, then data collected from the new site can be associated with the historical data. This is important since many new data sites collect continuous classification data as well as continuous volumes, whereas many of the historical sites collect only one 48-hour period each year.

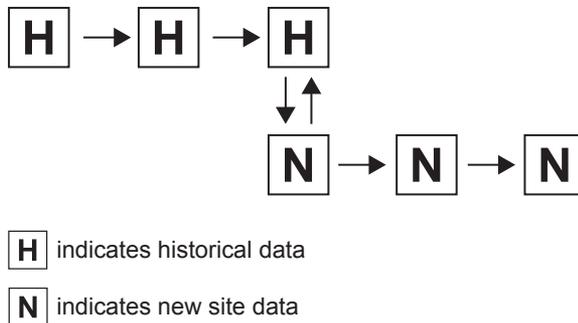


Figure 1. Illustration of Equivalency between Historical Data and Data Collected from New Sites.

Three considerations follow:

- Point estimates of average daily traffic (ADT) volume,
- 24-hour distribution of volume, and
- Coverage.

Point Estimates of Volume

A point estimate of volume is ADT collected at a given point in time, namely data collected on a particular day. The idea is to determine if there is a significant difference in the volume collected by the new data site versus volume data collected by the associated historical site. To perform a test of significance, volumes need to be simultaneously collected on both sites over a 24-hour period for a number of days. These observations are restricted to Tuesdays, Wednesdays, and Thursdays to avoid abnormal traffic patterns. Between 10 to 30 days are needed for observation. The data can then be paired by location (same link of roadway) and a test for significant difference between the counts can be performed. If the test shows no significant difference at a site pair, then historical data can be used for the before and after comparison. If the test shows a significant difference, historical data may not be used for before and after comparison at the new traffic monitoring site.

24-Hour Distribution of Volume

A 24-hour distribution of volume is 15-minute counts over a 24 hour period. The idea is to determine if there is a significant difference in the volume distribution collected at the new traffic monitoring site versus volume data collected by the associated historical traffic monitoring site. To perform a test of significance, the distributions need to be collected on both sites over the same 24-hour period for a number of days. These observations are restricted to Tuesdays, Wednesdays, and Thursdays. A minimum of five days observation is needed. The data can be paired by location (same link of roadway) and a test for significant difference between the distributions can be performed using the Kolmogorov-Smirnov test. The Kolmogorov-Smirnov is a distribution free test for general differences in two populations. This test is used to see if the distributions are significantly different. If the new traffic monitoring site is not significantly different to the associated historical site, then the data collected by the new site can be compared against the historical data.

Coverage

The last consideration is coverage. If new sites are installed, a subset of sites (one-third is sufficient) should be selected for equivalency testing. The subset of sites should be selected from both in the immediate area of the generator and further out within the study area. Initial testing of these selected sites should give an indication whether to test the remaining sites.

Traffic Volume: Control Comparison

A third method measures the change in volumes outside the study area which is most likely not to be affected by the new traffic generator. The percent change measures for the control group can then be compared to the percent change measures for the new and existing locations in the study area. Because the impact on traffic patterns is assumed to be correlated to the proximity of the plant, the percent change measures for the new and existing locations in the study area should be stratified by distance from the generator and comparisons can be made for each stratum to the control group.

Traffic Mix

Traffic Mix: Changes at New Sites Only

This method allows for direct comparison at the same location using classification data. For a determination of a significant difference in vehicle class distribution at the new sites, a χ^2 test may be implemented with categories associated with each vehicle class or class grouping. Grouping can be achieved by collapsing classes into groups using the FHWA Traffic Monitoring Guide (TMG) traditional categories:

- Passenger vehicles (cars and light pick-ups)
- Single unit trucks
- Single combination trucks (tractor trailer)
- Multi-trailer trucks

Traffic Mix: Changes at New Sites Using Historical Existing Site Data

Similar to the previous method, a χ^2 test may be implemented with categories associated with each vehicle class or class grouping to test for the detection of a significant difference in the before and after implementation volumes at the historical locations. The determination of equivalency as discussed in the 'Traffic Volume: Changes at New Sites using Historical Existing Site Data' section applies to the classification data as well. This is important since most of the new traffic monitoring sites collect continuous classification data whereas most of the historical sites do not collect any classification data. Again, if the new site is equivalent to the associated historical site, then the data collected by the new site will provide information for comparative analysis.

Traffic Mix: Control Comparison

The final method measures the change in volumes and distributions outside the study area which is most likely not to be affected by the new major traffic generator. The percent change measures in the various classes for the control group can then be compared to the percent change measures for the new and existing locations in the study area. Because the impact on traffic patterns is assumed to be correlated to the proximity of the generator, the percent change measures for the new and existing locations in the study area should be stratified by distance from the traffic generator and comparisons can be made for each stratum to the control group.

Data Archiving

Collecting and warehousing the data are integral to the monitoring process. The data has to get from the collection site to a centralized access point such that an analyst or interested agencies can retrieve the data. This should be established at the beginning of the process.

All agencies involved in the monitoring program should have access for analysis purposes.

Before being made available, data should be checked for format, consistency, and validity. For example, a vehicle classification count may unexpectedly have zeroes for each record in one direction.

Several types of data are collected and then sent by modem to a receiving agency (i.e., TxDOT). Other data types need to be downloaded from the collection site and carried to the receiving agency. The data received would then be formatted and compiled into a database or several databases depending on the variety of data sources used. This compilation of data can be characterized as a data warehouse. This data warehouse would then be made available to an analyst or other interested agencies.

A data request process needs to be in place.

Good relations with the differing data gathering sources need to be established. Automatic transmittal of data is the goal, but may not be possible. Some data may need to be downloaded by hand at the data collection site (i.e., automatic vehicle classification sites). Occasional problems may require on-site visits (i.e., resetting a modem). Several of the agencies involved may be responsible for their own equipment. These agencies may have different time tables for maintenance and/or repair of the equipment which may impact on the effectiveness of the monitoring net.

Data Reporting

There are numerous ways to report the data: graphs, GIS maps, tables, and presentations. Reports depend on the use of the results and the intended recipients. Examples from the analysis performed for the San Antonio case study are provided below. They illustrate a few of the types of data reviewed and some of the presentation techniques listed.

Figure 2 displays the travel time indices observed for the morning peak in the southbound direction on a corridor near the major traffic generator (Toyota plant). The corridor accesses the northernmost Toyota plant gate and ends at Lone Star Pass. The intersection of Applewhite Rd. and Lone Star Pass leads to another Toyota plant gate.

In Figure 2, the solid line (2008) is noticeably higher than the dashed line (2007) in most time intervals. The highest peak for 2008 occurs from 6:20 am to 6:40 am at a travel rate index of 1.7, 70 percent longer than free flow traffic times. 2007 indices are much shallower than 2008 indicating that traffic takes longer to travel the same segment of roadway in 2008 than 2007.

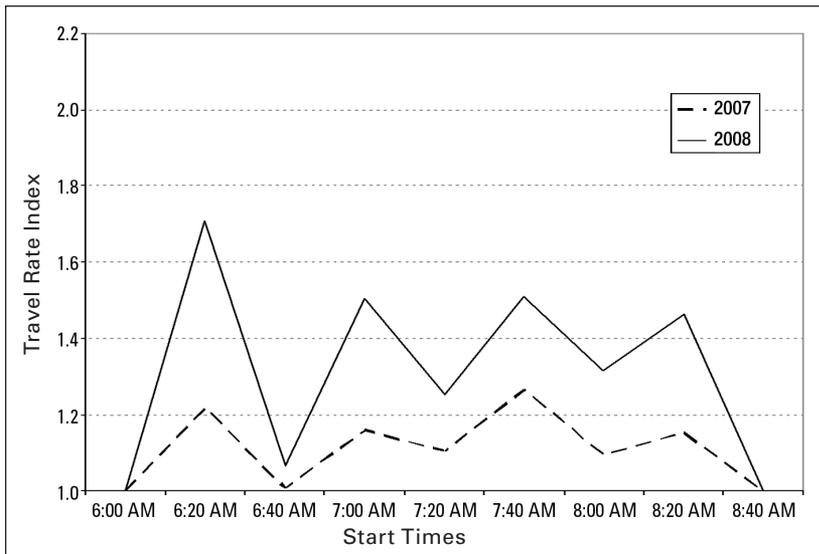


Figure 2. Applewhite Rd. (AM Peak), Zarzamora St. to Lone Star Pass, Southbound

Figure 3 shows the southbound traffic volume comparisons for data collection site 314 during the 6 a.m. to 7 a.m. hour. The volumes are calculated as an average of the second Tuesday and Wednesday of each month. The dashed line represents volumes collected from November 2006 to March 2007. The solid line represents volumes collected from November 2007 to March 2008.

The volume for the older data (dashed line) is higher during November through January and drops to near 200 for February and March. Toyota instituted a shift change in February 2007 which may account for the drop in volumes. The newer volumes (solid line) are fairly steady and higher than February and March of 2007.

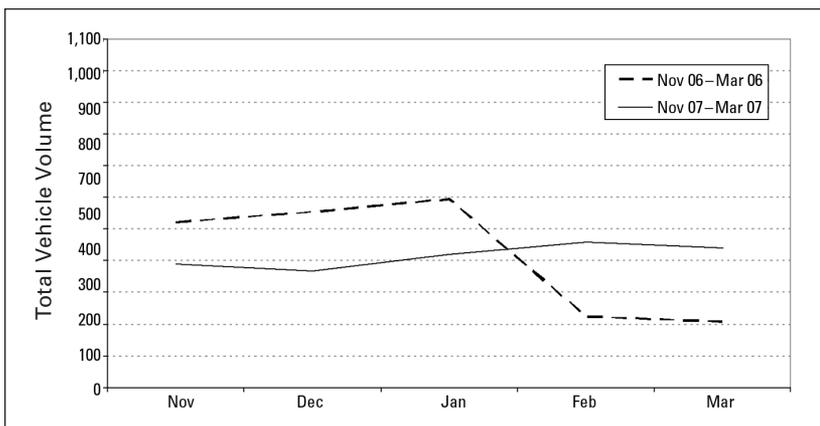


Figure 3. Total Vehicle Volumes, Site 314 Southbound, 6 AM to 7 AM

Figure 4 shows the southbound truck volume comparisons for data collection site 314 during the 6 a.m. to 7 a.m. hour. The volumes are calculated as an average of the second Tuesday and Wednesday of each month. The dashed line represents volumes collected from November 2006 to March 2007. The solid line represents volumes collected from November 2007 to March 2008.

The volume for the older data (dashed line) increased about 400 percent in March 2007 from February 2007; otherwise the volumes were steady and low. Toyota instituted a shift change in February 2007 which may account for the change in truck volumes. The newer volumes (solid line) are fairly steady and low. There is a little difference from year to year except for the large increase in March 2007.

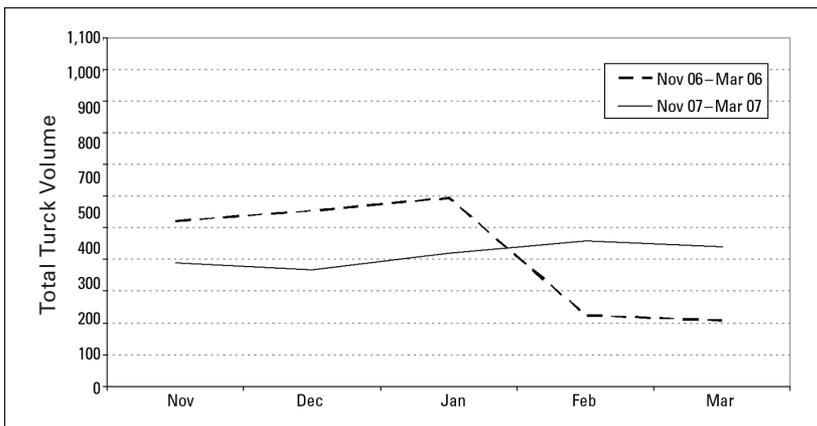


Figure 4. Total Truck Volumes, Site 314 Southbound, 6 AM to 7 AM

These three graphs illustrate what can be measured and compared using travel time data (travel time indices), vehicle volumes, and vehicle class data (truck volumes) from the study area. Figure 2 indicated that it took longer to travel the corridor in May 2008 versus May 2007. Figure 3 indicated that trucks were coming in the morning in 2006 with an abrupt decrease in February 2007. One year later, about 400 vehicles were traveling past site 314 which is higher than the February and March 2007 volumes. Figure 4 shows very low volumes for both sets of data with an exception in March 2007 which is most likely due to the shift change at the Toyota plant.



