Using ITS-derived Data for Transportation Planning, Programming, and Operations

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prepared by

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Advanced Transportation Management Systems (ATMS) and Freeway Management Systems have been set up in a number of major urban areas and are also being initiated in a few rural or statewide applications. Most of these systems are being adapted to provide data to Advanced Traveler Information Systems (ATIS) as well. These systems can produce torrents of data within their surveillance area that characterize the real time performance of portions of the local and state highway and transportation systems. These data are primarily used to carry out the particular Intelligent Transportation System (ITS) functions for which the system was established, such as incident management or traveler information. The phrase "ITS data" is being used here to refer to data derived from these various ITS technologies and systems.

As the number of ATMSs increase nationwide, and as they provide more comprehensive coverage, there has been an increasing awareness of the potential for adapting their automated data for other objectives. One in particular is providing information for use by transportation planning and/or programming activities. There are several such planning activities which would benefit significantly if effective archiving of ITS-derived data was easily and widely available.

This paper explores general opportunities, constraints, and the potential for automated data gathering through application of ITS techniques and methods. One statewide planning example is given of how ITS-derived information could be used in improving the efficiency and effectiveness of the Highway Performance Monitoring System (HPMS). Several examples are presented that would use ITS-derived data as a key to main streaming ITS into Metropolitan Planning and Programming Processes, which include the following:

- Improving monitoring of transportation system performance,
- Improving validation of regional travel demand models,
- Researching and developing improved modeling structures,
- Using ITS-derived visualizations to communicate the nature of congestion, and
- Conducting assessments of local traffic and parking impacts using ITS data.

1. The Need for Links Between Operations Data and Planning Information

One hallmark of transportation planning has been the ability to organize data and information about past and current transportation systems so as to better analyze and forecast future transportation use. That is generally the case whether the transportation planner is working for a local, county, metropolitan, regional, state, or Federal agency. While planners have often had their own resources to collect pertinent primary data for their purposes, considerable reliance has also been placed on the use of secondary sources. Such secondary data are usually obtained from operational activities that use the data for their own primary purposes. A combination of primary and secondary data is used in producing information for transportation planning activities.

*Note: This is a variation of a paper initially prepared for and presented at the ITS America Workshop on ITS Data as a Planning Resource, January, 1998.

Planners have been under increasing pressure, as have most others in government and industry, to do more with less. At the same time, more complex planning requirements have led to expectations of greater accuracy and relevance in the data used for planning activities. Program planners and budgeting staffs have also been under similar pressures. Thus, the prospect of a seeming boundless source of data on the performance of the transportation system is becoming increasingly tantalizing to knowledgeable planning and programming staffs. In recent years planners have been focusing more attention towards congestion management systems as well as shorter-term and finer-scale forecasting. However, few resources are available to planners to help with these endeavors.

The implementation of ATMSs, primarily for the operations purposes of traffic and incident management and/or traveler information, is a rapidly developing area. ATMSs are being done at the local, statewide, and multi-state corridor levels. The operations staffs are also working with constrained budgets and pressures to be efficient and effective in achieving their main missions. Thus, the ATMS operators are appropriately putting their focus on improving the day-to-day transportation system efficiencies. They generally have had few if any resources for summarizing monitored data or to produce information for the effective use of it by transportation planners and decision makers. However, the general need for improved links between operations data and planning information to aid in decision making has been a topical issue at several recent conferences, including the following:

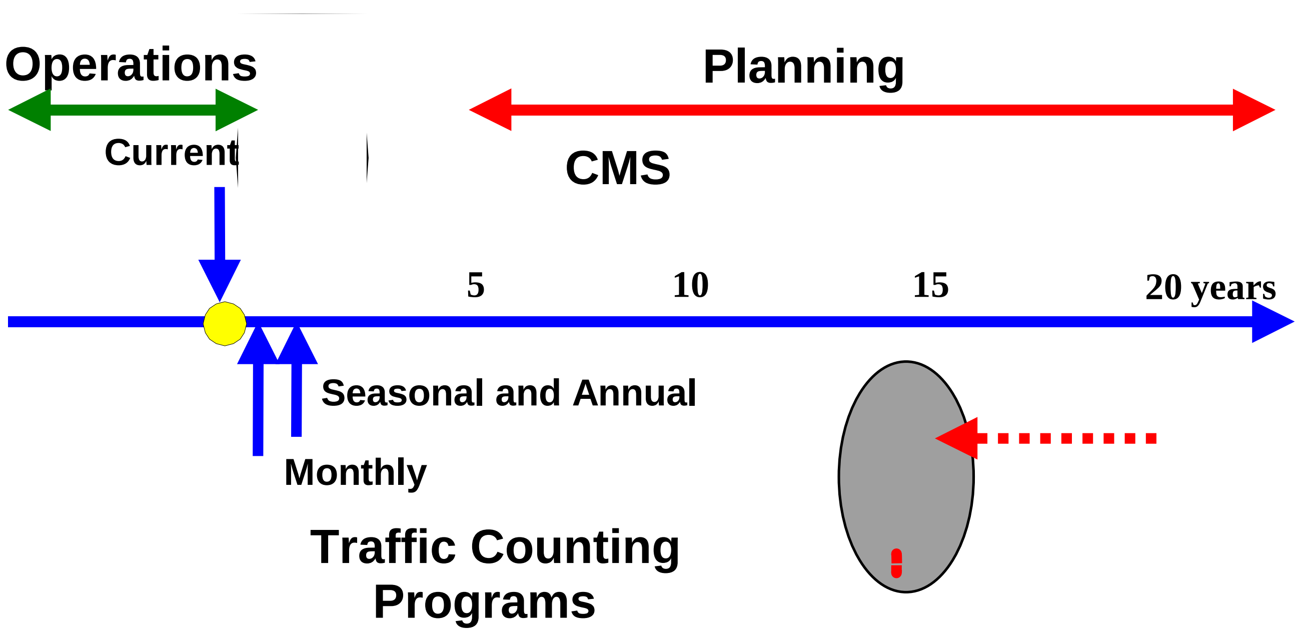
- TRB Conference on State and Local Data Needs, March, 1997,
- PTI/Urban Consortium Conference, with AASHTO and NACTO on Opportunities for Intergovernmental Cooperation on Intelligent Transportation Systems,
- ITS America Annual Meeting, Session on Surveillance Data for Planning, Development, and Operations, June, 1997,
- TRB Conference on Getting Serious About Congestion - Setting a Strategic Agenda for the 21st Century,
- A National Conference on the Highway Performance Monitoring System, July, 1997, and
- ITS America Advanced Traveler Information System (ATIS) Business Models Workshop, October, 1997

2. Institutional Differences and Perspectives in Operations and Planning

Operators and planners tend to have some different perspectives in viewing transportation, reflecting institutional differences, that have a bearing in addressing the data linkage need discussed above. These differences include: (1) time frames for data collection, (2) levels of geographic aggregation, and (3) communicating approaches with decision makers and users using visualizations.

A. **Time Frames for Collecting Data:** As illustrated in Exhibit 1, daily, weekly, monthly, seasonal, and annual summaries of selected monitored transportation conditions could provide information to the operators of the ATMSs as well as to planners. ATMS operators usually deal with current, minute-to-minute conditions. However, they rely on

Exhibit 1. Time Frames for Collecting Data



historic information to set time of day “thresholds” for various operational indicators that are needed to select a particular action or response to a situation. Again as shown in Exhibit 1, planners have usually dealt with long term trends and forecasts of five to twenty years in the future. They rely on widely spaced home interview travel surveys and the Census Journey-to-Work survey that is collected once every ten years. They use surveys or summaries spaced yearly, or once every two, three, or four years apart, to monitor those long-term changes. Thus, as illustrated in Exhibit 1, there tends to be a gap in the time frames most often used to monitor and summarize travel patterns, particularly in the day-to-day, week-to-week, month-to-month, and seasonal changes within each year.

State and local travel monitoring and traffic counting programs have usually monitored such month-to-month time intervals at control stations, particularly to develop factors for use in transforming hourly or daily counts to annual averages. While the relatively small number of control stations may give valid samples for statewide and federal monitoring purposes, that sample may not be sufficient for use in distinguishing among areas within a metropolitan area. The data being gathered by the ATMSs, if extensively sampled and summarized, could provide a function similar to the control stations. It is believed that the decision makers and the public will better understand summaries of travel and traffic patterns if the summaries also show seasonal and other short-term variations, as well as the annual and longer-term trends.

B. Level of Geographic Aggregation: Planners and operators can view travel and traffic conditions at different geographic scales, including point, segment, facility, corridor, and network levels. However, their responsibilities tend to have them focus at different levels of geographic aggregation. Operators appropriately focus their attention on specific locations along facilities, particularly for purposes of traffic operations and incident management. For those purposes geographic aggregation is not important. To deal with geographic variations in recurring congestion, operators have developed techniques and measures that conceptually or graphically illustrate conditions in ways that do not have to rely on seeing individual vehicle movements. However, such summaries are usually limited in their geographic extent to specific general areas or travel corridors that are more severely congested. In addition, ATMSs are currently very freeway-oriented. Several of the ATMSs are just beginning to collect arterial data and are addressing issues of how to geographically aggregate and visually display appropriate data and information about the arterial system.

Planners tend to be more focused on dealing with the overall travel and traffic patterns within their jurisdiction. In addition to studying specific locations they also want to aggregate geographically all of the facilities and services within their area. For purposes of detecting long-term trends and small incremental changes, planners need to have data and information throughout their whole area and for each of the functional classifications and/or administrative system, including arterials and more local roads. They also are interested in major constriction points, such as bridges or tunnels.

C. Communicating with Decision Makers and Transportation Users Using Visualizations: Key components to effective operation of an ATMS are the visualization techniques that enable operators to see patterns and events as they are occurring. Various detector technologies monitor characteristics such as vehicle volume, speed, and/or lane occupancy, which are also compared with expected threshold values for that time increment. When the comparison appears to indicate that an incident has occurred, or telephone calls from the public appear to indicate such, the operators use Close Circuit Television (CCTV) and communications from field personnel for verification. The CCTV is also then used as a tool to better assess the situation and select appropriate incident management responses. The feeds from the CCTV can also be effective means of showing relative severity of incidents to the traveling public. However, such visualizations are most effective only within a limited range of distance, angles of view, and lighting.

Planners have developed means to illustrate wide variations in congestion conditions and other travel patterns in order to communicate more effectively with decision makers. Such visualization techniques become even more important when attention is given to ways planners and operators communicate with the public. Publicly-oriented visualization approaches have also been an important feature of weather information programs. Experience from weather monitoring has shown that the public can effectively get information from maps that illustrate weather patterns if they are overlaid on top of familiar political boundaries, such as those of states, counties, or the Interstate System. The addition of conceptual animation, such as the time-lapse movements of cloud patterns or the changing location of precipitation by intensity shown in vivid colors, makes it relatively easy to show in a summary fashion the very complex weather changes that recently occurred. Similar visualizations tools could help planners and operators better understand the dynamics of recurring congestion and better address some root causes that may not now be apparent. Such visualizations are being developed by this author using ITS derived data.

3. Relevant ITS Data and their Use in Operations, Planning and Programming

There are a number of transportation planning and/or programming activities which would benefit significantly if archiving of ITS-derived data was to become widely available, as discussed below.

A. Statewide Monitoring of Transportation System Performance -- the Highway Performance Monitoring System: For a number of years prior to the widespread establishment of ATMSs, the State DOTs have been working cooperatively with the Federal Highway Administration (FHWA) in the submittal of various reports in support of the Highway Performance Monitoring System (HPMS). The information about the system is used by US DOT decision makers and Congress in monitoring and assessing system performance and in developing and evaluating highway programs and funding.

Estimates of Annual Average Daily Traffic (AADT) are used as a key variable in the HPMS data, as are factors for determining peak hour traffic. As ATMSs expand in their number and scope it is expected that there will be increasing opportunities for states to collect and submit AADT and related data derived from ATMS and other ITS technologies. Examples include:

- vehicle volumes and travel,
- vehicle classifications,
- percent of travel by vehicle type,
- vehicle occupancy,
- some accident and/or incident data, and
- some data on current pavement conditions related to weather and climate zone.

Indeed, in work performed by the Texas Transportation Institute (TTI) by Turner et. al., they indicate that one of the applications of the San Antonio loop detector data has been that of replacing/supplementing HPMS counts.

B. ITS-derived Data as a Key to Main streaming ITS into Metropolitan Planning and Programming Processes: From an operator's perspective, an effective way to mainstream and champion their projects is to promote data derived from their systems as an aid to planning, programming, and decision making activities being performed through MPOs. From a planner's perspective, there are several ITS data-related activities that offer opportunities for helping them meet their responsibilities.

1) Improved Monitoring of Transportation System Performance: One of the responsibilities of planners and MPO officials is to monitor periodically the performance of the transportation system with respect to achieving the objectives of the Long Range Transportation Plan. Archiving of selected data that is routinely captured by the ATMSs could be helpful for this purpose. Data that would be of use to planners include:

- directional volumes by roadway segment for selected time periods,
- average travel speeds for those segments,
- vehicle classification summaries including percent of trucks by weight range,
- transit vehicle effective speeds, and if available
- transit boardings and alightings along transit routes or corridors, which could be used to monitor shifts in maximum load points on the routes.

An example of such a monitoring effort is a report prepared by the Washington DOT entitled, *A Preliminary Analysis of Central Puget Sound Freeway Network Usage and Performance and the WSDOT Flow System,* for the Seattle area. In addition, ITS-derived data should be very beneficial in meeting the intent and expectations associated with the monitoring portion of Congestion Management Systems. Experience elsewhere has shown that monitored data are often given more weight and credibility by decision makers, the press, and the public than the results of modeling and forecasts.

This activity may also be beneficial to operators in at least two ways. Firstly, the feedback to the operators of the information resulting from the ITS data would also provide the operators with more insight regarding travel patterns and characteristics. Secondly, the availability of the resulting information may help refine or reduce some of the operator's work effort with regards to developing historical trends for use in setting decision thresholds for operational strategies.

2) Improved Calibration and Validation of Regional Travel Demand Models: The current travel demand models used by MPO staffs are periodically updated to reflect changing demographic and other underlying conditions affecting people's travel behavior. It is expected that most of the data sets used to calibrate these model updates, such as trip origin and destination patterns, would continue to come from traditional data sources, such as home interview travel surveys and responses to the Census Journey-to-Work questions. However, ITS technologies can act as a secondary source of data.

The Houston TranStar ATMS is part of the ITS Priority Corridor Program and one of its projects to be undertaken in 1998 is relevant — ITS Technology for Data Collection Transportation Planning. The project is to be conducted by the Houston-Galveston Area Council, the MPO for the Houston area. The project will investigate the needs and requirements of the Houston area planning agencies and match those requirements with the current and future data collection capabilities of Houston TranStar. The transportation planning data assembly developed during that project will be integrated into the existing architecture of the Houston TranStar system. The data collected by TranStar will be processed, formatted, and archived allowing planners to retrieve the stored information on their schedule and as they need the information. The overall objective of that project is to develop an automated system to collect, summarize, and present the data collected by the TranStar ATMS for use in transportation planning purposes.

Model Calibration: One interesting example that might help in the model calibration process comes from the San Antonio, Texas area. Their system for detecting incidents will rely on an intensive distribution of vehicle tags that can be read as each vehicle passes a reader device. The tags are being distributed randomly without tracking which vehicle has which tag. However, each tag nevertheless has a unique identifier that can be used to monitor vehicles as they pass from reader to reader. Algorithms will be used to calculate average travel times and speeds for the sample of vehicles in a particular increment of time. That change in average speed on the roadway segments between readers will be used to indicate that recurring congestion or an incident is taking place.

With regards to that data being useful for model calibration, the same data, with some additions to the summary programs and algorithms, can be used to monitor dynamic origin and destination patterns over an extensive network for different time periods. Indeed, in work performed by the Texas Transportation Institute (TTI) by Turner et. al., they describe how similar data being derived in the Houston area can be used to develop Origin - Destination Matrices. However, those origin and destination patterns will not provide the more complete pattern obtained in sample home interviews and will not be associated with trip purpose. Nevertheless, they could help in parts of the calibration process. In general in other areas it is expected that most of the utility of the ITS-derived information would be its use in the model validation process, as discussed below.

Model Validation: In validations, comparisons are made between outputs of a calibrated model with one or more sets of known/observed characteristics of the transportation system to check the degree to which the model results replicate the observations. Validations can also use a time period that differs from that used in developing and calibrating the model. By periodically drawing samples of pertinent travel characteristics collected by ATMSs, a time series of data would be available to use to validate parts of the model outputs over a broader set of conditions. It should also be noted that the situation of only partial geographic coverage of ITS-derived data, or the data being limited to only part of the transportation system, such as freeways, should not be a critical hindrance in model validation. That is because the validation processes does not need complete coverage to be useful, while in the calibration process complete geographic and trip purpose coverage is generally a necessity. However, as ATMS coverage expands over time, the more widespread availability of data will be even more helpful in enabling more thorough validations. Therefore, it would be beneficial to planners to begin to have the availability of ITS-derived data sooner than later.

Using "Dynamic Screen Lines": Traffic volumes collected at "Screen Lines" are often used in such validations, and with properly located detectors "dynamic screen line" information could be developed from the ITS data sources. Currently such screen line information is based on the average conditions for each screen line counting station where the data are usually observed for each station at a different time. It can be hypothesized that ITS-derived data, collected at the same time at each of the screen line stations, may show a somewhat different and useful type of result. The dynamic screen line volumes may show overall lower variability in the screen line total than is now found by collecting data at different times at different screen line counting stations. The lower variability would mean a more accurate determination of the screen line total for use in model validation.

3) Researching and Developing Improved Modeling Structures: This type of activity is seen as being fundamentally different from the monitoring, calibration, or validation activities discussed above, although those activities may be used as steps in this model building activity. In the past, the particular approach to modeling travel behavior in each area has been in part conditioned by the availability of various kinds of data and/or particular types of variability within the data sets. Therefore, the availability of new kinds of data, or more data on variability, might lead to planners and researchers developing new model structures based upon the new data resources. There are probably many valuable approaches to incorporating new features or structures in the models, and two examples include:

Accounting for Incidents and Closures: Incident logging and monitoring efforts, being performed with increasing completeness and sophistication by operators, may provide new types of data that planners could use in new model structures. That could include building in some characteristics of random closures or constrictions in the networks in the model formulation. Thus, the often cited situation that roughly half of the congestion experienced in an area is associated with incidents could be examined in a planning context. This could provide a planning tool to assess the effectiveness and appropriateness of a broader range of projects and services.

Accounting for Weekly and Seasonal Variability: Another example could relate to the recurring variability in observed transportation system use that occurs within weekly and seasonal cycles. New model structures could be developed that produce ranges of variation, in addition to average conditions. Models structured in such a way could enable planners to assess the benefits and adverse impacts of plan alternatives more thoroughly, and could be used by operators to simulate new operational approaches.

C. Conducting Assessments of Local Traffic and Parking Impacts Using ITS Data: There is a group of planners who typically work at the subregional and local level for whom the availability of ITS-derived data would also be beneficial. These staffs usually work for transportation, traffic, parking, public works, or land use planning agencies. One of the major activities of these staffs is conducting transportation, traffic, and parking impact studies associated with specific land development proposals or more general land use master plans. The impact studies are often done within a regulatory context.

Increasingly, this planning is done as part of legal framework that can lead to extensive transportation improvement as conditions of approval. Given the stakes involved, current and accurate data indicating transportation conditions are needed for each case review. As such, the data and information that underlay such studies is often thoroughly reviewed and sometimes strongly contested by parties who feel that the proposed development will adversely affect their interests. Further, while the geographic area of impact of any one case may be relatively confined, the cumulative area covered by all of the cases during a year generally requires current data and information about conditions everywhere through out most urban areas. The net effect of these situations is that the availability of ITS-derived information would likely result in better impact studies that could be prepared at lower costs to the developers who typically contract for the studies.

An example of an effort to initiate such a local land use planning/traffic impact study application using ITS data comes from Montgomery County, Maryland. The ATMS for Montgomery County is among the more advanced ones in the nation and has as its basis the management and control of the signal system, which contrasts to most other ATMS systems that are freeway based. Thus, along with the management of the freeways in the County (done in conjunction with the Maryland DOT), the County manages the operations of over 600 signalized intersections from the ATMS operations center. This aspect of extensive arterial coverage makes it more feasible there to consider using the ITS data as an aspect of the traffic impact study review process. A cooperative project is underway between the operators of the ATMS and the Planning Department to establish data transfers to help the Planning Department in their model calibration as well as in possibly providing data that could be used in performing traffic impact studies.

It is suggested that this type of application could also make for a good showcase of the use of ITS-derived data. In addition, this type of application would also have the potential to involve some public-private partnerships, given the potential direct benefits to different private sector groups. Such partnerships could involve a more generalized approaches that could be widely applicable throughout a given jurisdiction. Alternatively, some of the private sector interests may have only a very localized or area specific interest and would only want to participate in a project that might be a good individual example, but would not be too applicable to other cases or areas.

4. Operations Planning and Traffic Flow Simulation Research and Models

There are other groups of transportation professionals whose responsibilities and work could benefit from the availability of ITS-derived data. Among these are operations planners and researchers who develop various macro and microscopic traffic flow models. One example reported in the literature is work performed by the Texas Transportation Institute (TTI) by Turner et. al.. They briefly describe how data from the Houston’s TranStar was used in calibrating the

FREQ Simulation Model of traffic operations and flow. That model in turn was used in alternative analysis.

Another group who could benefit from the availability of ITS-derived data are the researchers who are developing traffic flow models, as well as local operations staffs who are applying such traffic simulation models. There are models that are oriented to simulating freeway operations, arterial network simulations, transportation corridor operations, and overall integration of traffic operations. Those models tend to rather data intensive in their input requirements. It appears that some of the data now being derived through ITS technologies might be very helpful to the application and further development of such models. Such opportunities and needs should also be accounted for in the operations of the ATMSs.

5. Issues and Opportunities

Even though the use of ITS-derived data in planning and operations applications has great potential, several issues must be addressed before the process is fully developed. These include:

> **Institutional Issues.** Separate agencies and/or departments within the same agency are responsible for ITS operations and transportation planning. For the development of a system that links ITS data to planners, ITS operations and planning personnel must work together closely and keep communications open. From a business perspective, ITS operators must view planners as another client in the sense that data to support planning and operation functions can be provided. Likewise, planners must incorporate ITS strategies into their standard "toolbox" of transportation improvement options. The establishment of the ITS data link is a good first step to achieving these goals by making ITS operators and planners more fully aware of each others needs.
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> **Data Privacy and Security.** As with all forms of advanced information technologies, the privacy of individuals must be respected at all times. In fact, the perception of ITS as another form of government intrusion (the "Big Brother" complex) may make it unpalatable to many citizens. If ITS data are now to be saved for later use by planners, extreme care must be taken to ensure that individuals are not uniquely identified in the stored data. In addition, privacy preservation must be effectively communicated to the public so that political pressure is not brought to bear.
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> **Development Costs.** Intelligent Transportation Systems that have the extra feature of processing and storing ITS data streams involve additional development and maintenance costs. Funding for ITS typically comes from operations budgets and operations personnel may be reluctant to pay for the data archiving feature because they do not view it as being directly relevant to their mission. The issue of who pays for establishing the ITS data link must be addressed before the process can move forward.
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> **Data Quality and Editing.** ITS data collected by field surveillance equipment are prone to errors due to equipment malfunctions, calibration "drift", and communication disruptions. Therefore, it is clear that raw data from the field must be subjected to quality

control and editing procedures before they are sampled, summarized, and stored. In particular, if data are to be used for comparisons across urban areas, standard procedures for flagging and treating both missing and erroneous data should be developed. At a minimum, each metropolitan area should be aware of data quality problems and systematically address them.

Data Management, Manipulation, and Access. Given that the funding and data quality issues mentioned above have been reconciled, there still exists issues related to how the raw ITS data are transformed into useful planning information and how that information is accessed by planners. Standard definitions of summarized data elements (e.g., AADT) can help but are not necessarily sufficient. For example, freeway loop detectors measure vehicle speeds at distinct locations; transforming these speeds into other congestion measures (such as travel time or travel rate) is problematic.

Coverage. Planners must recognize that ITS data may not provide as complete spatial and temporal coverage as required for planning applications. For example, not all freeways in an area may be covered by electronic surveillance. As pointed out earlier, traditional planning data sources will continue to be important in meeting planning needs. Therefore, ITS data should be seen as a supplement to -- rather than as a replacement for -- traditional planning data sources.

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