



Project Summary Report O-4745-S

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Project O-4745: Using Archived ITS Data and Spatial Statistics for
Optimizing Incident Response at Transportation Management Centers

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Using Archived ITS Data to Optimize Incident Detection and Management

PROJECT SUMMARY REPORT

Transportation management centers (TMCs) generate enormous amounts of data. Examples include detector data, automated vehicle identification (AVI) data, closed-circuit television (CCTV) camera video streams, alarm data, incident data, system diagnostics data, operator log data, changeable message sign (CMS) data, lane control signal (LCS) data, and lane closure data. Most of the data generated by TMCs support TMC real-time operations. In practice, TMCs have tended to archive only a few data elements, with the rest of the data being overwritten after a short time period or simply discarded.

Today, archived intelligent transportation system (ITS) data applications have tended to focus on ITS data as a resource for transportation planning and/or research, mainly for the generation of aggregated system performance measures such as corridor travel times, speeds, and delays. As the number of applications of ITS data increases, interest is growing in finding ways to use such data to optimize TMC operations. One specific area of interest is the development of techniques and procedures that use archived ITS data to help optimize incident detection and management practices.

What We Did...

The goal of the research was to develop procedures to characterize incident information using archived ITS data, roadway information, and ITS inventory information in a geographic information system (GIS) environment. To meet this goal, we:

- characterized incident data archival practices in Texas;
- developed a prototype geodatabase of ITS infrastructure using the San Antonio TMC (TransGuide) as a test case;
- characterized spatial and temporal patterns in the distribution of incidents in San Antonio;
- developed a process to calculate incident delay using archived ITS data;
- examined the incident detection process at TransGuide, with a focus on the automatic incident detection algorithm;
- evaluated the feasibility of increasing incident alarm thresholds; and
- developed ITS data quality control and completeness tests.

For the analysis, we used archived lane and incident data at TransGuide from March 2002 to April 2004. The lane data included 3.4 billion 20-second speed, volume, and occupancy records

from nearly 1,500 detectors. The incident data included more than 20,000 incident records and associated CMS and LCS messages displayed by operators, as well as more than 200,000 incident alarm records.

What We Found...

We developed a prototype geographically referenced traffic and incident database (Figure 1, Figure 2). Although this work was specific to TransGuide, many of the procedures and findings also apply to other TMCs. To drive the development of the geodatabase, we developed data models that included both GIS features and archived ITS traffic and incident data. Several data sources were available, including as-built schematics in Bentley MicroStation® format and scanned images documenting the location of ITS equipment in the field, and 1/2-foot resolution aerial photography to provide context to the vector data. The aerial photography was critical to identify the correct location of ITS devices since it enabled the identification of a wide range of features such as pavement markings, lane configurations, traffic support structures, and even in some cases loop detectors. It also made it possible to identify cases where the as-built schematics did not correctly reflect conditions on the ground.



To characterize spatial and temporal patterns in the distribution of incidents on TransGuide's instrumented freeways, we compiled a dataset of more than 20,000 incidents covering major accidents, minor accidents, stalled vehicles, and debris. The analysis included a number of categories such as time (month, season, day of week, and time of day), severity, sectors and corridors, and weather.

To assess the TransGuide incident detection algorithm effectiveness, we used data from the incident scenario database, which contained a listing of messages displayed in response to individual incidents on the ground, and the alarm event database, which contained alarms triggered by the incident detection algorithm in response to events on the road. The lack of a common link between the two datasets led to the use of a "fuzzy" spatio-temporal query methodology to match records from the incident scenario database and records from the alarm event database. Matching alarm and scenario data enabled the determination of performance measures such as incident detection rates and false alarm rates (Figure 3). The overall incident detection rate was 20–27 percent, depending on the type of incidents considered. The overall false alarm rate was 0.0039 percent. To complete the analysis, researchers also prepared maps showing the spatial distribution of incident detection rates and false alarm rates on a sector by sector basis.

These results led to an assessment of the feasibility of modifying current incident detection alarm thresholds to help optimize TMC incident detection practices. We developed a prototype offline tool called Incident Detection Algorithm Tester (IDAT) to measure the effect of the speed alarm threshold on the number and timing of alarms generated by the system. For each case analyzed, we ran IDAT using five alarm threshold values: 25 mph (current minor alarm threshold at TransGuide), 30 mph, 35 mph, 40 mph, and 45 mph.

Results showed that as the alarm threshold level increased, the average number of alarms increased exponentially and the average incident detection time decreased linearly. There was a correlation between congestion

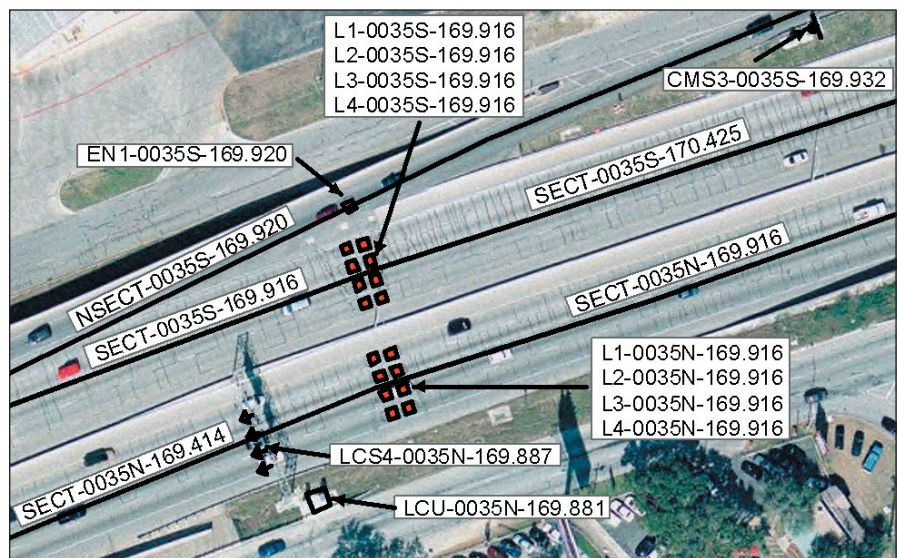


Figure 1. ITS Features in the GIS.

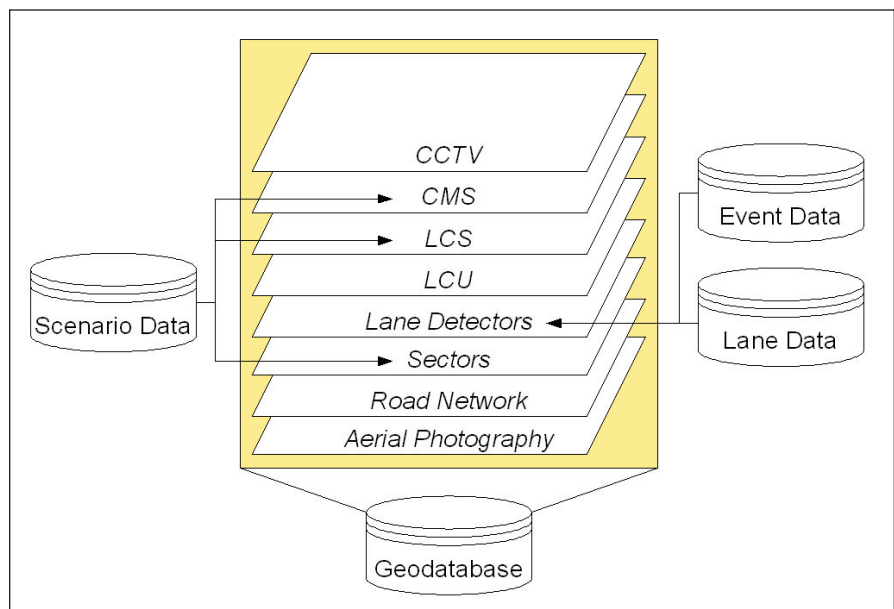


Figure 2. ITS Geodatabase Concept.

levels and the number of alarms generated by the algorithm, as well as a correlation between congestion levels and average incident detection times. In general, incident detection took considerably longer (between 60 and 100 percent longer) under congested traffic conditions than under uncongested traffic conditions.

The ITS data quality control and completeness analysis included an evaluation of spatial and temporal trends in the distribution of quality control flags. Of the 3.4 billion lane data records in the database, about 126 million records (or 3.7 percent)

had "abnormal" combinations of speed, volume, and percent occupancy values. The analysis also found significant differences in data quality control testing results between the Traffic Operations Division (TRF) and Naztec LCU firmware currently in use at TransGuide. The data completeness analysis included an aggregate evaluation of completeness by LCU server and a detailed evaluation of completeness at the individual detector level. At the individual detector level, the analysis showed that, on average, the completeness rate for all detectors was about 80 percent. The



overall completeness rate for Naztec LCU detectors was higher than for TRF LCUs (84 percent versus 71 percent, respectively).

The Researchers Recommend...

Recommendations from the research findings include the following:

- Apply the geodatabase and associated archived ITS data model, including the implementation of a relational database archive of raw speed, volume, and occupancy data and incident data. The prototype geodatabase developed in the research used architecture information and archived sensor and incident data from TransGuide. However, it is sufficiently generic to enable implementation at other TMCs with relatively minor variations.
- Use high-resolution, e.g., ½-foot, aerial photography as background on operator console maps. In combination with CCTV cameras and interactive maps displaying ITS features, aerial photography could become an invaluable asset to help optimize TMC operations.
- Implement database queries to document spatial and temporal patterns in the distribution of incidents. This includes the development of graphical user interfaces (GUI) to automate the production of queries, reports, and maps.
- Implement the minimum recovery time concept included in IDAT. The minimum recovery time simulates the alarm closing process by enabling an alarm to close automatically if the calculated moving average value is consistently larger than the minor alarm threshold for at least the duration of the minimum recovery time. Incorporating a minimum recovery time into the real-time incident management process at a TMC would enable the system to automatically close alarms after moving average speeds have “recovered” after a reasonable period of time, therefore helping optimize real-time operations.

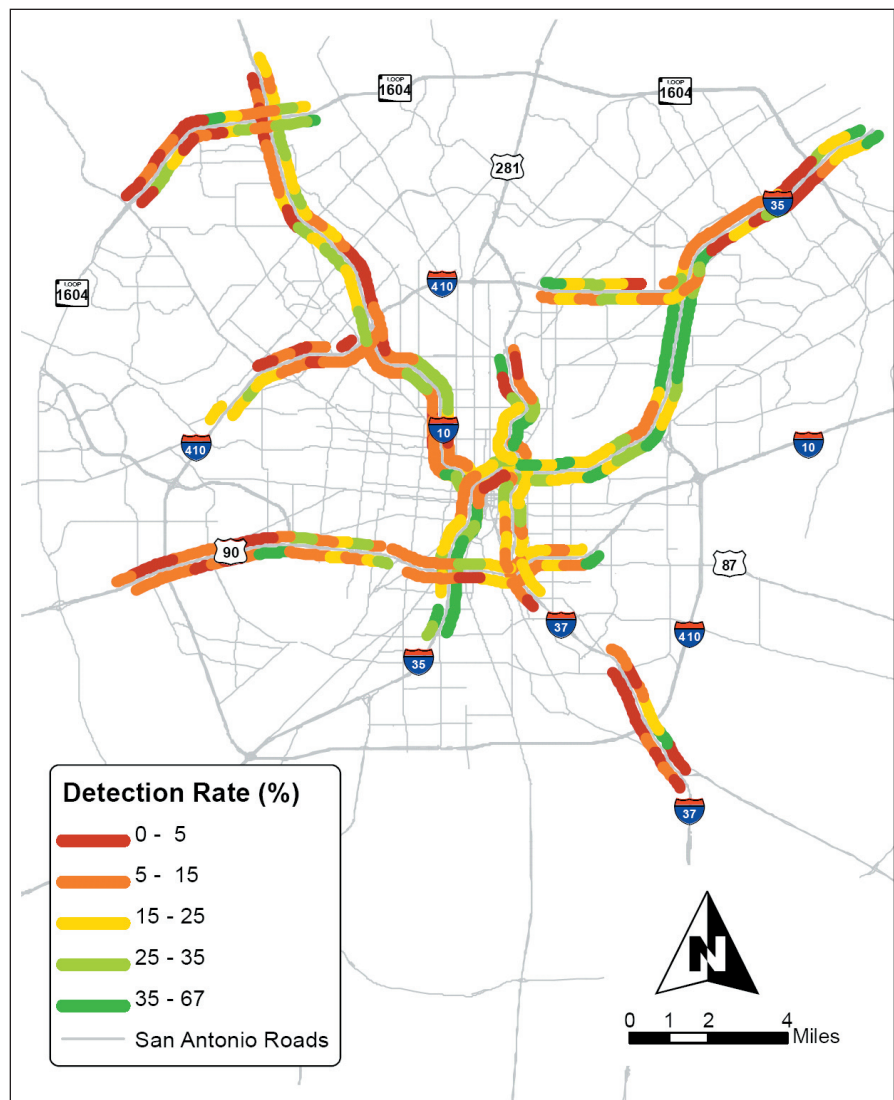


Figure 3. Distribution of Detection Rates by Sector.

- Increase the minor alarm threshold at TransGuide to 35 mph. The expected impact of increasing the minor alarm threshold to 35 mph would be a 10 percent increase in the number of alarms (at least half of which would be in the form of true alarms) and a 30 percent decrease in incident detection times. Further reductions in detection times would be possible by replacing the two-minute moving average speed formulation with another one that minimizes the offset caused by the moving averages (up to two minutes).
- Incorporate data quality control tests into the formal TMC database design process to enable the documentation of data quality

issues as soon as the data are received from the field. Related recommendations include adding a unique date/time stamp to the lane data archive that does not depend on the seasonal changes between central standard time (CST) and central daylight time (CDT), and developing code and GUIs to automate the query building process.

- Automate the queries to derive lane detector data completeness measures, both at the LCU server level and at the individual detector level. This includes the development of code and associated GUI to automate the query process needed to produce summary tables, charts, and maps.



For More Details...

The research is documented in:

Report 0-4745-1, *Incident Characteristics and Impact on Freeway Traffic*

Report 0-4745-2, *Incident Evaluation Procedures and Implementation Requirements*

Report 0-4745-3, *Incident Detection Optimization and Data Quality Control*

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