TECHNICAL SUMMARY

Development of CMS Monitoring Procedures

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INTRODUCTION

One of the mandates of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 was the development of Congestion Management Systems (CMSs). Also included in the mandate was the development of statewide highway traffic monitoring systems. An important component in the development of these systems is the capability to measure travel time (and by extension delay and speed) accurately and reliably. This is particularly critical at a time when the construction of new facilities nationwide has virtually stopped and, as a result, most of the interest is now in the implementation of more localized solutions to mitigate congestion.

In the CMS project conducted for Baton Rouge, Shreveport, and New Orleans in 1995 and 1996, we developed a new GPS-GIS methodology for conducting travel time studies. The new methodology provides consistency, automation, finer levels of resolution, and better accuracy in measuring travel time and speed. These characteristics enabled the detection of traffic flow variability along routes much more efficiently than with traditional techniques. The new methodology automated data collection and data reduction procedures and provided improved procedures for documenting and analyzing travel time and speed data. As a result, we were able to collect and process large amounts of reliable travel time and speed data.

OBJECTIVE AND SCOPE

This research study is concerned with the development of a set of procedures for monitoring congestion using GPS and GIS. These procedures are meant to be used more as a planning tool than for everyday traffic monitoring. Under this assumption, a series of travel time runs are conducted along specified routes at specific time intervals. The procedures can also be used for before-and-after studies where the need for specific travel time runs is clearly defined. In either case, GPS data is kept, processed, and stored in a relational database for analysis purposes. This research study focuses on travel time and speed only and not on other variables like flow rates, traffic composition, availability of alternative modes of transportation, and characteristics of the highway network, all of which play an important role in the process of assessing congestion in urban areas. Likewise, this research project does not address specific implementation issues like ranking of congested sections or coordination with other transportation management systems.

RESEARCH APPROACH

Evaluation of GIS Packages

To select the most suitable software configuration for the project we made a comparison among the following existing GIS packages: ArcView version3, MapInfo 4.1, Maptitude version 3, and TransCAD version 3.1. Within each package we considered the following issues: general capabilities, linear referencing capabilities, compatibility with Intergraph's Modular GIS Environment (MGE) platform, capability to generate line diagrams (diagrams in which one axis is distance and the other axis is an attribute such as speed or travel time), export/import capabilities, and cost.

Spatial Model

GPS receivers record location in latitude-longitude pairs. Furthermore, GPS data files tend to have huge numbers of records, particularly if data is collected at short time intervals, for example every one second. As a result, formal procedures for linearly referencing, storing, and retrieving the GPS travel time and speed data efficiently become essential.

One way to circumvent the GPS data storage problem is by aggregating the GPS data into highway segments or links so that only segment (or link) travel time and speed data are stored in the database. One of the drawbacks of this approach is that the rich detail of the original data is lost because only segment data are stored in the database (the original GPS files may still exist, but they are not really usable unless they are retrieved and processed from scratch). Some of the information contained in the original GPS data include acceleration and deceleration patterns, control delay, and stopped delay, all of which occur regardless of any highway segmentation scheme considered. In order to access this information it is necessary to store all GPS point data in the database and provide a linear reference to each GPS point before attempting any GPS data aggregation. This referencing can be performed with the help of GIS dynamic segmentation tools. Unfortunately, using this capability has been, until recently, out of the reach for most agencies because of high data storage and processing demands. These limitations are quickly disappearing, though, as more affordable computers with much larger data storage capabilities and faster processors enter the market.

Data Collection Methodology (GPS Equipment)

As mentioned, the GPS equipment must be able to provide a positional accuracy of around two to three meters. Technology is rapidly advancing and in the short run, GPS equipment configurations will still be composed of GPS receivers and differential correction receivers. However, new GPS receivers have enhanced data storage capabilities, possibly rendering the use of on-board laptop computers unnecessary. Likewise, differential correction broadcasts can now be obtained from sources like the U.S. Coast Guard DGPS network or satellites, and not just from commercial, sometimes unreliable FM subcarriers.

Travel time runs

A set of runs must be scheduled to measure travel time, speed, and delay. In general, runs are made during the a.m. peak, p.m. peak, off-peak, and other specific traffic conditions. Recurrent congestion in a metropolitan area like Baton Rouge tends to be spread over a two to three hour period both in the morning and in the afternoon, although significant variations in traffic conditions do exist within each congestion period. Strictly speaking, runs should be scheduled at regular time intervals within each congestion period, for example every half hour, to determine which time period is the most congested. During the first phase of the CMS project, we detected particularly heavy conditions from 7:00 to 8:00 a.m. and from 4:30 to 5:30 p.m. At the very minimum, therefore, runs for congestion monitoring purpose should be scheduled within these time periods. For each time period the number of runs (or sample size) must comply with acceptable error tolerance specifications.

Database Management System

To manage GPS file data such as time stamps, speed, latitude, longitude, and satellite navigational data at regular time intervals we developed a geographic relational database that would linearly reference data with highway routes. One product from this data was the development of color coded maps.

CONCLUSIONS

The final report describes a set of CMS monitoring procedures which can be implemented on low cost PCs that are commonly available. The main contribution is a GPS-GIS methodology which can be used by district engineers, city traffic officials, and MPO planners for conducting travel time studies and monitoring congestion at various levels of resolution (from system to local). The set of procedures, collectively called Travel Time with GPS (TTG), include the following deliverables:

- A procedure for producing GPS-based network maps suitable for travel time studies
- A procedure estimating sample size requirements during the data collection process
- A procedure and accompanying software based on dynamic segmentation for generating a linear referencing system to all GPS travel time and speed data along arterial streets and highway sections
- A procedure for reporting travel time and speed data both in graphical and tabular formats.

The final report also includes a new methodology to measure delay at signalized intersections based on linearly referenced GPS data. This methodology is compatible with new Highway Capacity Manual procedures that focus on the measurement of control delay (which includes deceleration delay, stopped delay, and acceleration delay) as opposed to just stopped delay. Because it uses automated position and speed data collection devices (GPS receivers), the methodology can be used in situations where automatic and/or real-time delay measurements are needed.

Groups that may benefit from findings:

- district traffic engineers
- city
- MPO Planners