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Application of Global Positioning System (GPS) to Travel Time and Delay Measurements

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Introduction

In 1996, a research performed to investigate the use of a Global Positioning System (GPS) unit as a tool for collecting travel time and delay data for Delaware roadways. As the results were favorable, an annual data collection was conducted since then. Over the past 6 years, the use of the GPS unit has been proven effective and accurate in the collection of data. Annual reports documenting this effort, as well as summary of the collected data, have been compiled. The *Application of Global Positioning System (GPS) to Travel Time and Delay Measurements-1997 Phase* report describes the testing of the applicability and accuracy of the GPS system, while the report of the *1998 Phase* provides a step-by-step procedure for the data collection.

Over the past years, travel data were typically collected during peak-travel times between mid-September and Thanksgiving. The year 2002 will be the first year in which data was collected in the summer as well as in the fall. This report describes our methodology to collect these data, as well as a summary of the collected data.

Methodology

With travel time and delay data collected in the past 5 years have shown to be useful in monitoring congestion trends in Delaware, the Delaware Department of Transportation (DelDoT) made the decision that data should be collected during the summer months on the major travel routes to and from the shore points. This information is critical to analyze the travel patterns around the Delaware beaches and to monitor congestion on the roads.

The roads that were covered were predetermined and assigned to us by DelDoT. They are the major routes taken by beach travelers. In general, the roads covered were divided into two groups:

• South-North roads: These included SR 1, US 13, US 113, and SR 896/71, which are primarily used by people coming to and from the northern points (New Castle County, Pennsylvania, New Jersey, Cecil County in Maryland, etc).

• East-West roads: These included the roads that are traveled by people from Maryland, Virginia, and Washington D.C. on their way to the Delaware shores (SR 404, SR 14, SR 16, SR 20, SR 24, and SR 26).

Once the routes were determined, the next task was to choose control points and create the data dictionary files. Dictionary files are listings of all the attributes being collected (control points, delay reasons, etc). These are extremely helpful because they allow attributes to be recorded by simply selecting the correct one from the list. The control points were chosen where major roadways intersected the routes that were being studied. Once the control points were decided upon, they were entered into data dictionary files using the Pathfinder editing system which allows control points and specific attributes to be added, deleted or edited. For the first time this year, all of the dictionary files were updated so that it would be possible to collect the number of lanes and speed limit changes on roadway segments while collecting our travel data.

One step that was useful in this particular study was to drive the roads to be covered before the actual data collection began. While each route was traveled, the distance between each set of control points was recorded. Not only did these pre-collection runs assist our teams with gaining familiarity with the road, but the distance measurements were very helpful with actual data collection because some control points were easily missed. Since the length of each segment was known, the vehicle’s odometer could be used to estimate the distance to the next control point.

Data were collected on four different occasions each weekend during the peak summer period in July and August. It was decided that the majority of beach-travelers would make their pilgrimage to and from the shore points on Friday and Sunday afternoons and throughout the day on Saturday. Thus, data were collected starting between 4 p.m. and 5 p.m. on Friday and Saturday afternoons, between 8 a.m. and 9 a.m. on Saturday mornings, and then between 3 p.m. and 5 p.m. Saturday afternoons. These periods were chosen based on our observations during the preliminary studies and our discussions with DelDOT's professionals as well as local businesses. The rationale is to follow the pattern of people who work during the week and spend weekends at the shore. In general, southbound and eastbound data collection occurred on Friday evenings and Saturday mornings (toward the beach) while northbound and westbound data collection occurred Saturday and Sunday evenings, when the weekend beach traffic returned home.

Two vehicles, each with a driver and a data-collector, were used in this study. With the number of routes to be covered and the number of trials needed to obtain at least 2 successful runs of each, using two vehicles instead of one was a great advantage in allowing the project to end on time.

Each road was covered at least twice in each direction to guarantee the accuracy of the data that was collected. This was based on the statistical analysis presented in our 1997 report. In several cases, due to problems with the equipment or large irregularities in the travel patterns (accidents, extreme congestion, construction, etc.) the roads were traveled again to ensure that along with temporal fluctuations, typical peak beach-traffic patterns are captured. Once all the data were collected, exported, and printed, they were analyzed and summarized on a road by road basis, as it appears in the data summary section of this report.

Interpretation of 2002 Summer Data

This report includes a data table with all of the collected information arranged by route name. The left most column contains the name of the route being covered. Each route is then broken up into the different segments and data is provided in each direction (NB/SB or EB/WB respectively). To the right of the categories, the table contains the information explained below.

- Distance (Miles) – This is the distance in miles for the given segment of roadway shown to the left. In the case that under “Route” when the term “Total” is specified, the distance is for the total stretch of roadway from the first control point to the last control point.

- Mean Peak Travel Time (Seconds) – This is the average time in seconds that was taken to travel the length of the segment shown to the left. Again, in the case of “Total” appearing in the "Route" column, the time is recorded for the entire roadway from the first control point to the last control point.

- Mean Peak Travel Speed (mph) – The average speed of the test vehicle travelling from one point to the next is the Mean Peak Travel Speed. This value is given in miles per hour and is obtained by dividing the "Distance" of the segment by the "Mean Peak Travel Time."

- Total Peak Delay (Seconds) – This is the time in seconds spent in delay travelling through the given segment shown to the left. *By definition, delay is the time when vehicle speed drops below 5 miles per hour*.

- Peak Delay Source – This is the reason for the delay noted in the previous column. Reasons for delay can be due to signal, construction, accident, congestion, pedestrian crossing, train, etc. Traffic signals are the main cause of delay.

- Mean Peak Running Speed (mph) – This is the average speed in miles per hour that a vehicle would travel through the section of roadway if delay were not experienced. The running speed, R, is obtained by the following equation:

$$R = \frac{\text{Distance}}{\text{Mean Peak Travel Time - Total Peak Delay}}$$

- Percent Time in Delay – This is the percentage of time spent in delay for the route segment shown. The percentage is found by dividing the "Total Peak Delay" by the "Mean Peak Travel Time", then multiplying the quantity by 100. Example:

$$\text{Percent Time in Delay} = \frac{82.08\,\text{sec}}{360\text{sec}} \times 100 = 22.8\%$$

- Number of Lanes – This represents the number of lanes for the given segment of the roadway shown. For those that have more than one number in this column, this shows that the number of lanes change during that segment.

- Posted Speed (mph) – This represents the posted speed limit for the given segment of the roadway shown. Once again, for those that have more than one posted speed in this column, this means that the posted speed changes during that segment.

Conclusions

Although data collection with the use of a GPS unit was performed in the past, 2002 was the first year in which travel times and delays were collected and summarized during the summer with a focus on areas around the Delaware shore points. The use of the GPS methodology proved successful in the summer trials. The travel time and delay data collected could serve as a precedent for any information that may be collected in years to come and will enable overall trends in beach traffic to be tracked.

While no previous data has been collected in the summer, many of the routes and control points are the same as those usually covered in the fall and comparisons can be made. Also, in both cases the data were collected during typical 'rush hour' times, therefore the major differences would be due to seasonal change.

Though the same procedure was generally followed as in our regular fall data collection, there were a few differences:

1. The roads covered were slightly different than those covered in the fall. Less of a focus was placed on New Castle County's minor roads, and only major roadways were covered in this study. Also, for the roads that were covered in both fall and summer reports there are added control points for our research this season. For example, on SR 1, a control point was placed at every exit. This was done to make it easy to determine the travel time for a route which includes segments from several different roads which were covered in the study by simply adding the travel times for the segments used.

2. Instead of weekday morning and afternoon collection times as in the fall, the summer data was collected on Friday, Saturday and Sunday afternoons and on Saturday mornings.
3. The window of possible data collection times was much smaller for this study than for the fall. The fall time span is mid-September to Thanksgiving, which is ten weeks in length. For this project, data collection started the first week in July and ended the second week of August, totaling just six weeks. In the fall, data is collected at least twice daily for each of the five weekdays. This summer, data was collected a maximum of four separate occasions per weekend.
4. Due to the fact that many of the roads travel through more than one county, the roads were not separated by county as they are in the fall. This study focuses on the shores, long-distance beach traffic, not short-distance intra-county commuting.

While data collection using a GPS unit is a considerable advancement to manual data collection, the system is not flawless and some technical problems were faced. One downfall with the Aspen software used in the field is that this program has no signal to warn of low voltage in the batteries. When the batteries no longer have enough power to continue use, the system announces that the batteries are dead and the collection process is ended. When many runs were being done consecutively or in the case of those with extreme length, the batteries used to power the Trimble system ran out of power and information was stalled immediately. Also, lost connections with the satellite receivers created added difficulties. On a few separate runs, particularly those running EB/WB, due to trees and other obstacles over the road which blocks, connection with the GPS rover satellites was lost and information could not be collected.

Fortunately, any communication loss between the antennae and the satellites did not result in the missing of control points. Also, any segments in which information was lost were relatively short in length.

There are two recommendations for the future that should be considered. First, though there existed a significant degree of manual computation—which to a large degree—was eliminated, there is still an opportunity to fully automate the computation process. Finally, we noticed that some segments were long and not uniform in terms of speed limits. It would be much better to have fewer variations of speed limits within our segments.

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