Roadway Safety Data Program

TENNESSEE'S HORIZONTAL CURVE DATABASE

ROADWAY SAFETY DATA AND ANALYSIS

CASE STUDY

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ACRONYMS

AADT	Annual average daily traffic
CMF	Crash Modification Factor
GIS	Geographic Information System
GPS	Global Positioning System
HFST	High Friction Surface Treatment
HSM	Highway Safety Manual
LOS	Level of Service
LRS	Linear Referencing System
MPO	Metropolitan Planning Organization
RFP	Request for Proposal
RPO	Rural Planning Organization
SPF	Safety Performance Function
TDOT	Tennessee Department of Transportation
TRIMS	Tennessee Roadway Information Management System

EXECUTIVE SUMMARY

In 2012, The Tennessee Department of Transportation (TDOT) accomplished its initial data collection for its entire roadway network, which includes all interstates, state highways, arterials, collectors, and local roads. With these data, TDOT created a horizontal curve database with approximately 40,000 miles of roadways with curves, which is housed in the Tennessee Roadway Information Management System (TRIMS)—a client-server application that allows TDOT to capture, maintain, and view critical roadway data. TDOT uses the horizontal curve database to provide quick, data-derived answers to public concerns, make data-driven decisions, quantify potential benefits from both systemic and spot improvements, and compare curves with similar characteristics to help prioritize projects.

INTRODUCTION

The Tennessee Department of Transportation (TDOT) has spent almost two decades collecting data on their roadway network in an effort to have a complete inventory. In 2012, TDOT accomplished this task and completed the initial data collection for its entire roadway network, which includes all interstates, state highways, arterials, collectors, and local roads. While driving along the roadway network to collect center line data for their Linear Referencing System (LRS), on-board software recorded each horizontal curve on the system. TDOT compiled and stored the data in a horizontal curve database that is housed in the Tennessee Roadway Information Management System (TRIMS)—a client-server application that allows TDOT to capture, maintain, and view critical roadway data. The purpose of this case study is to describe the challenges and successes in developing and using the horizontal curve database in Tennessee.

BACKGROUND

TDOT used a vendor to collect roadway center line data in the late 1990s using a Global Positioning System (GPS) device. The vendor developed software that converted the GPS coordinates to horizontal alignment data. The software identified curves with a degree of curvature greater than two degrees. TDOT has conducted numerous update cycles using internal staff since the initial collection in 2012, and the entire roadway network is now stored in TRIMS.

OBJECTIVE

Tennessee strives to use the horizontal curve database to:

- Provide a high level of detail for all curves on the roadway network.
- Identify horizontal curves that have potential for safety improvement.
- Select and prioritize projects with more efficiency and, therefore, better allocate funds.
- Support before-after analysis to quantify the safety benefit once projects are completed.

AUDIENCE

This case study may be of interest to the following audiences:

- State Department of Transportation: Safety Engineering, Design, Planning, Maintenance, Geographic Information System (GIS), and Asset Management Units.

- Local and Regional: City and County Public Works/Engineering/Transportation Departments, Metropolitan Planning Organizations, and Regional Planning Commissions.
- Local Technical Assistance Programs.
- Consultants and private industries involved in safety.

THE HORIZONTAL CURVE DATABASE

The horizontal curve data for both local and State roads are stored within TRIMS. TDOT originally developed TRIMS in the 1970s. In the late 1990s, TDOT hired a vendor to convert it to an Oracle database, resulting in a complete replacement of the legacy system. At that time, TDOT converted to a GIS for location coding. TDOT is comfortable with the accuracy of the LRS center line data, which was used to derive the curve data. TRIMS provides users with a view of roadway data, traffic, bridges, crashes, railroad grade crossings, pavement conditions and photolog digital images. The photolog images are digital roadway photographs taken of all interstates and state routes.

Of the 96,000 miles of roadway inventory data in TRIMS, segments accounting for 40,000 miles include a curve with greater than two degrees of curvature. The raw data for horizontal curves come in as separate database tables and are then imported into TRIMS. The main attributes stored in the curve database are the beginning mile point of the curve, the ending mile point of the curve, the degree of curvature, and whether it curves to the right or left. There are multiple databases in TRIMS that can be linked to curve data. For example, there is a crash table, roadway geometrics table (number of lanes, access control, land use, terrain), maintenance features table (inventory of signs), roadway description table (shoulder type, pavement type, pavement width), and traffic table (average annual daily traffic [AADT], truck percentages).

Any authorized user in TDOT can access the horizontal curve database at any time and for any purpose. Parties accessing the database go through the client server TRIMS or through the E-TRIMS web application. Local agencies, including municipalities and Rural Planning Organizations (RPOs), also have access to the database.

Since the completion of data collection in 2012, TDOT estimates that five percent of the curve data need to be updated based on changes in the roadway since 2013. Therefore, TDOT updates their roadway inventory on a weekly basis, based on recent changes of roadway items through construction progress reports and notifications of local officials. As TDOT receives these new updates, an import process updates the data in TRIMS. TDOT is in the process of working with local officials to automatically receive notifications when new local roads are added. TDOT does not usually realign curves for safety projects, but rather implements other low-cost countermeasures—such as signing and pavement markings—because of the high cost

and many other projects vying for funding. After these low-cost countermeasures are installed, TDOT monitors the sites for crash reductions and can then quantify the safety effectiveness of the treatment.

APPLICATIONS OF THE HORIZONTAL CURVE DATA

The Project Safety Office within the Strategic Transportation Investments Division used the horizontal curve database to look for locations with four or more crashes with any degree of curvature to create the High Friction Surface Initiative. TDOT gathered the data for these locations to look at the superelevation and curvature of these sites, and then conducted meetings to review these sites for potential safety improvements. These meetings vary depending on the project, but involve necessary personnel (such as the Long Range Planning Division's E-TRIMS group, the Project Safety Office) when developing safety initiative concepts. The Project Safety Office also invites local agencies, RPOs/Metropolitan Planning Organizations (MPOs), and district personnel to attend meetings for any safety related projects. Once a project is approved, TDOT conducts site visits that involve members of the Traffic Engineering Office, Design Division, and Construction Division.

At the end of 2013, TDOT began using the horizontal curve database to locate sites where High Friction Surface Treatment (HFST) could be applied to reduce crashes. HFST is the application of small, durable aggregates to the existing surface using a polymer binder to restore and maintain the pavement friction. TDOT overlaid the curve data with crash data to create a statewide map of locations where both wet and dry lane departure crashes occurred on curves. TDOT does not monitor pavement friction at horizontal curves on a regular basis because of the lack of time, staff, and funds. The Project Safety Office reviewed the degree of curve, speed, and slope to determine sites that could most benefit from HFST. To date, TDOT has chosen approximately 40 sites to apply HFST. The locations were limited to state routes, but TDOT plans to expand the map to include local roads, pending funding availability and local interest.

At TDOT, every safety project includes an evaluation plan—meaning that TDOT identifies what data are needed in order to conduct an evaluation. TDOT participated in peer exchanges with other States and received feedback that many States would be interested in Tennessee's safety evaluation of HFST. They conferred with the Federal Highway Administration (FHWA) to determine how to develop Crash Modification Factors (CMFs) for HFST. In order to complete the analysis, TDOT is accumulating several years of post-treatment crash data. TDOT will develop multiple CMFs for HFST specific to different scenarios including wet and dry pavement conditions, varying degrees of superelevation, and for all crashes and separately for lane departure crashes.

RESULTS

It is still too soon to see crash reductions resulting from projects chosen using the database. The evaluations will begin once there are enough post-treatment data. However, TDOT has already seen significant cost savings because of the horizontal curve database. For example, contractors hired by TDOT are able to use the database and do not have to collect new data for their own projects. TDOT has also noticed cost reductions on contracts.

The horizontal curve database has utility in a variety of safety analyses. Besides identifying potential HFST implementations, TDOT is planning other improvements using the horizontal curve database. For example, there are a large number of rural two-lane roads without shoulders in Tennessee. Without shoulders, there may not be sufficient spacing for a vehicle to stay in the travel lane, even with a wide lane through a horizontal curve. TDOT has identified curve locations without shoulders and is evaluating the potential safety benefits from shoulder widening. TDOT is also looking at adding lane markings and rumble strips to improve safety at curves.

The horizontal curve database also results in better customer service. Nearly every day, TDOT receives queries from the public, press, or elected representatives concerning the safety of specific curves. Using the database, TDOT can supply the data to the concerned parties instantly. TDOT can immediately identify the degree of curvature, the speed limit, and if there are crashes associated with the geometry of the roadway from TRIMS. These data help TDOT answer queries in a fast and efficient manner.

TDOT does not use the horizontal curve database to choose projects for local agencies, but TDOT conducts a great deal of training for local agencies on how to use TRIMS. However, TDOT does share network screening results with local agencies; then, if the local agency is interested, TDOT helps them develop the project and, if needed, works alongside them throughout the project.

FUNDING

The effort to collect center line data in the 1990s was strictly for state routes, but TDOT eventually added the collection of arterials and collectors. This effort was funded through TDOT's ongoing maintenance contract with its vendor. Then, through a Request for Proposal (RFP) process, TDOT added data collection of the local roads over a five-year period, which was funded through regular State Planning and Research (SP&R) funds. Because the horizontal curve data were derived from the center line data and not its own independent project, it is difficult to estimate the total cost of generating the horizontal curve database.

Since the statewide data collection effort ended in 2012, TDOT has continued the database maintenance in-house using regular state funds in the GIS Mapping and Facilities Data Office of the Long Range Planning Division.

BENEFITS

TDOT identified the following benefits of a horizontal curve database:

- Providing quick data-derived answers to public concerns at problem locations to determine if locations warrant safety improvements.
- Using the database to make data-driven decisions leads to better use of TDOT funds.
- Quantifying potential benefits from *both* systemic and spot improvements.
- Comparing curves with similar characteristics to help prioritize projects.

BARRIERS AND HOW THEY WERE OVERCOME

TDOT underwent a major update to migrate to a Microsoft Windows 7 platform because the previous versions were on an older version of Visual Basic that would no longer be supported. TDOT hired a contractor to help with the migration. Since that effort, TDOT is solely responsible to conduct the data updates. Although TDOT is short several staff, most updates to the roadway inventory do not include changes in the alignment, the horizontal curve data do not fall out of date too rapidly and TDOT is generally able to keep up. If someone requests data in an area where an update has been done to roadway inventory, TDOT can process individual segment updates and produce the data needed, which, would then be added to the database.

LESSONS LEARNED

TDOT noted that a valuable aspect of developing a horizontal curve database is to ensure it is capable of linking with other databases. For example, a user is able to gather the posted speed limit and advisory speed from a certain curve then overlay data from the crash database showing crash types and severity. This allows TDOT to identify correlation between curve characteristics and overrepresented crash types (such as road departure crashes) at that location and to select appropriate countermeasures. It also allows TDOT to compare curves to one another to determine which have the most potential for safety improvements.

NEXT STEPS

TDOT plans to develop CMFs for HFST on curves once enough post-treatment data have been collected.

TDOT is considering the development of calibrated Safety Performance Functions (SPFs). They have adopted the Highway Safety Manual (HSM), but development is in the beginning stages at this point. TDOT is contacting other States to learn about the process of developing state-specific SPFs and expects another year before making a decision on what to pursue with respect to calibrated SPFs. TDOT is also in the process of developing a new Level of Service (LOS) database, which will then be linked to TRIMS.

TDOT is constantly seeking new ideas that will improve the safety and operations of the roadway network. From that desire to identify new ideas, TDOT observes what other States are doing, participates in peer exchanges, and looks for new material (e.g., reports, guidance, evaluations) published by FHWA and others.

AGENCY CHARACTERISTICS

ORGANIZATIONAL STRUCTURE

The Long Range Planning Division of TDOT supplies and maintains the data in the GIS. All areas within TDOT can access the horizontal curve database whenever and for any purpose. Parties accessing the database go through the client server TRIMS or through the E-TRIMS web application. Local agencies, such as municipalities and RPOs also have access to the database.

PERSONNEL

The Long Range Planning Division – GIS Mapping and Facilities Office are responsible for the maintenance of the databases. Specifically, the GIS, City and County Mapping and Roadway Inventory Data Collection Section are responsible for GIS and GPS highway maintenance and roadway inventory data collection. The GIS Facilities Data (TRIMS) Section is responsible for TRIMS data maintenance, TRIMS application development, and the photolog images.

REFERENCES

The following resources were consulted in development of this case study:

1) John Hicks and Brian Hurst. Telephone Interview. March 13, 2015
2) Tennessee Department of Transportation website: http://www.tdot.state.tn.us/. Last accessed May 8, 2015.

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