Accelerated Intersection Improvements Enhance Safety

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Paper prepared for presentation
at the Road Safety Session
of the 2014 Conference of the
Transportation Association of Canada
Montreal, Quebec

ABSTRACT

In 2007, the South Carolina Department of Transportation (SCDOT) Strategic Highway Safety Plan (SHSP) established a goal to reduce fatalities on South Carolina roads to fewer than 784 by 2010 – a 25 percent reduction from 2004. Following an extensive, five-year analysis of traffic crash data, intersections were among the nine identified target areas within the Serious Crash Type Emphasis Area. The South Carolina Intersection Safety Implementation Plan (ISIP) was created and indicated 44 percent of intersection crashes occurred at just 1.3 percent of the state's intersections, resulting in a list of 2,204 candidate sites.

SCDOT's systematic improvements at stop controlled and signalized intersections were primarily related to signing and pavement marking upgrades. In addition, signalized intersections were treated with low-cost improvements specifically related to traffic signals and associated infrastructure.

It was critically important to SCDOT to implement the improvements quickly and efficiently, so during the summer of 2009, SCDOT advertised a performance-based contract for intersection improvements. Through the SCDOT procurement process, the contract was awarded to 3M, a St. Paul, Minnesota-based company.

As the project implementation proceeded, 3M was responsible for installing ground-mounted signs and pavement markings at all intersections within the project areas. An additional deliverable included an update of the SCDOT asset management system. The benefits provided to the agency and the motoring public from this streamlined process were safer intersections in a shorter timeframe.

Crash and fatality reduction results are anticipated to show a very high cost-benefit ratio for this safety improvement project. Preliminary results already indicate positive improvements during the first year of the project. The SCDOT expects similar positive results across all the improved intersections based on these initial findings and national research data on similar intersection safety improvement practices.

Preliminary statistics are based on simple analysis calculations and are not yet validated using well known Empirical Bayes methods. However, at a cost of only about $4.2 million per year to improve over 700 intersections, it is very clear that the safety improvements implemented have a positive benefit-to-cost ratio, met expectations and—most importantly—have saved lives.

INTRODUCTION

From 2002 through 2006, traffic fatality rates for the state of South Carolina were among the highest in the nation. During this time, South Carolina's fatalities per 100 million vehicle miles of travel ranged from 2.0 to 2.2, compared to a U.S. average range of 1.4 to 1.5 (*1*, *2*). The total number of collisions exceeded 450,000, including over 5,200 fatalities and nearly 255,000 non-fatal injuries, with a resulting economic impact to the state of over $13 billion (*1*). In 2007, the number of traffic fatalities in South Carolina per 100,000 of population was 24.2, compared to the U.S. average of 13.7 and a "best state" number of 6.5 (*2*).

In 2007, the South Carolina Department of Transportation (SCDOT) Strategic Highway Safety Plan (SHSP) established a goal to reduce fatalities on South Carolina roads to fewer than 784 by 2010—a 25 percent reduction from 2004. Following an extensive, five-year analysis of traffic crash data, intersections were one of nine identified target areas within the Serious Crash Type Emphasis Area. As a result, the South Carolina Intersection Safety Implementation Plan (ISIP) was created. The first phase of improvements began in September of 2009 and improvements were completed in early 2013.

PROGRAM OBJECTIVES

The primary goal of the 2007 SCDOT SHSP was to reduce fatalities on South Carolina roads to fewer than 784 by 2010. A secondary goal was to lower the number of traffic-related injuries by three percent. An extensive, five-year analysis of traffic crash data identified five key Emphasis Areas and 24 specific targets to be addressed.

Within the Serious Crash Type Emphasis Area, intersections were one of nine identified target areas. As a result, the South Carolina Intersection Safety Implementation Plan (ISIP) was developed to address safety in six different categories of intersections; signalized, single-lane stop controlled, or multilane stop-controlled intersections in rural areas and signalized, single-lane stop controlled, or multilane stop-controlled intersections in urban areas.

The ISIP indicated that nearly half of intersection crashes occurred at just 1.3 percent of the state's intersections. Based on a per-intersection threshold of five or more crashes within a five-year period, a list of just over 2,200 candidate sites were selected for systematic improvements, including a variety of intersection types and locations.

METHOD

SCDOT followed the Federal Highway Administration (FHWA) Intersection Safety Implementation Plan process to develop their systematic plan. A streamlined installation process for making modifications using low-cost treatments in the form of updated signing, pavement markings and signal enhancements was established.

Typical Improvements at All Intersections

Signing

- Doubled up (left and right) signing
- Oversized signing with high-intensity fluorescent sheeting
- Advance Street Name signs on Intersection Warning signs
- Retroreflective sign post panels
- Solar-powered, sign-mounted beacons
- Replacement of additional safety related signs (i.e., Do Not Enter, One Way, etc.) within 152.4 meters (500 feet) of the intersection

Pavement Markings

- Properly placed stop bars, 1.2 to 1.4 meters (4 to8 foot) offset and perpendicular to the mainline)
- Dashed edge lines to delineate the mainline and turn bays, and establish points of conflicting traffic
- Lane arrows and word messages in accordance with standard drawings, general notes and specifications
- Addition of crosswalks

Signalized Intersections

- One signal head per lane
- Supplemental nearside sign heads
- Back plates with retroreflective borders
- 30.5 cm (12-inch) LED signal indications
- Pedestrian treatments such as push button indicators and pedestrian countdown signals

Systematic Intersection Improvement Contracting

It was critically important to SCDOT to implement improvements quickly and efficiency. Due to the magnitude of the project and the time it would take to complete, SCDOT chose not to use in-house maintenance staff on the project and a decision was made to outsource intersection improvements.

To address improvements to traffic signals, four separate low-bid contracts were let. SCDOT used a statewide, low-bid contract for signing and pavement marking enhancements. A single contract was chosen instead of several smaller contracts to ensure uniformity of implementation statewide, gain administrative efficiencies from a single contract, and realize lower pricing through economy of scale from a larger, statewide contract.

SCDOT developed a contract to implement the systematic approach proposed in the ISIP. The single, state-wide, three-year contract (renewable each year) was structured to treat approximately one-third of identified intersections each year for three years. Through SCDOT's procurement process, the contract was awarded to 3M, a St. Paul, Minnesota-based company.

Key Roles and Funding

Key roles to develop, fund and implement the ISIP included SCDOT Headquarters, SCDOT District Offices; the FHWA's Office of Safety, Resource Center and SC Division Office; 3M as the contractor and subcontractors. Consistency between the ISIP and the SHSP, and identification of the projects through a systematic, data-driven process, allowed the projects to be implemented using Federal Highway Safety Improvement Plan (HSIP) funds. Because certain safety improvements, such as signing and markings, are eligible for 100 percent Federal funding, SCDOT's three-year systematic intersection improvement project did not require any State matching funds (*3*).

IMPLEMENTION

Through the implementation process, a high degree of importance was placed on keeping intersection improvements uniform across the state. As a result, a high level of communication between stakeholders was necessary during construction, along with adherence to a consistent process as shown in Table 1. In addition, all stakeholders on the project emphasized that mutual flexibility was an important key to project success. The implementation success of the project cannot be overemphasized and is a key benefit of the project.

As the project implementation proceeded, SCDOT Headquarters released work orders to District Traffic Engineering Offices. 3M was responsible for installing ground-mounted signs and pavement markings at all intersections within the project areas, and SCDOT District personnel performed site inspections during installation. An additional deliverable included an update of the SCDOT asset management system.

Work orders were released in groups of 40 to 50 intersections bundled in a single work order. SCDOT anticipated approximately 45 work orders in total would be issued for the entire project over a three year period. Work order bundles typically included intersections within a single District to minimize and streamline coordination and approval with the particular District management.

The SCDOT Headquarters office out of Columbia, South Carolina created site specific drawings and details for each intersection during the pre-construction development of the work orders. During the second and third years of the contract, the process was refined to include development of the drawings by four independent consulting engineering firms. The drawings were provided to the contractor for distribution and implementation of the improvements by the team.

Prior to beginning any work, the contractor identified locations and placed construction stakes at the new intersections at proposed improvement locations for both traffic signs and pavement markings. Verification then occurred to insure that the specifications were met within the required contract document requirements. When discrepancies were identified, adjustments were made in the field and then documented for additional review and approval by DOT personnel. Changes were submitted to the District Traffic Engineer, who verified the revisions and made the recommendations to the SCDOT Headquarters office for final approval.

Once approvals were obtained, the Contractor met with the appropriate District Office to review the final construction plans and to begin the installation work. During construction, SCDOT District Inspectors monitored activity to approve work as it was completed and to create punch list items of final work tasks that needed to be addressed prior to final payment and close-out of the intersection improvements.

A final deliverable of each phase of the project was a field installation workbook that served as an "as-built" record of all improvement activity. In conjunction with this workbook, the Contractor developed a reconciliation spreadsheet to manage multiple subcontractor crews, and to document and verify the significant installed quantities for payment.

Project and Asset Management Methods

One very unique aspect of the project was a requirement within the contract for the Contractor to establish and maintain a project management website along with transfer of all asset inventory data associated with improvements to the South Carolina DOT HMMS asset management system as shown in Table 2. Due to the large scale, size and fast-track of the statewide program, as well as the complexity of the approval and documentation processes, the project management web site established by the contractor proved to be an invaluable coordination tool for the flow of various project components such as schedules, intersection schematic drawings, process flow charts, revisions and punch list items, and staking and construction preliminary and final plans. The site also served as a repository for all design and approval records and approvals for each intersection included in the project scope.

The project management web site allowed all stakeholders easy access to and coordination of all pertinent project information. Coordination between District and Central SCDOT offices was streamlined through the use of a 'paperless' review and approval process, using the web site. In addition, the contractor used the web site for all coordination activity between subcontractors and the engineering consulting firm involved on the project.

Once construction was complete at each intersection, the resulting database of new assets (primarily pavement markings and traffic signs) captured on the geographical portion of the web site was used to upload asset information to the SCDOT HMMS asset management system. All assets were located by the contractor using GPS coordinates to ensure a seamless transition to the SCDOT HMMS system. Building this requirement into the Statewide Safety Improvement contract allowed SCDOT to accomplish the important step of updating their HMMS asset management system without having to send a SCDOT field crew to each intersection to inventory the new improvements and features, which saved SCDOT significant resources and costs.

RESULTS

A simple, preliminary "before and after" analysis was conducted by SCDOT on 458 completed locations. A more rigorous study, utilizing Empirical Bayes methods will be conducted by the Federal Highway Administration. Results of this preliminary analysis were for ground mounted

signs and pavement markings only; signal equipment upgrade dates were not included. Detailed statistics are not yet available for all the improved intersections.

Benefits provided to SCDOT and the motoring public from this streamlined process were safer intersections in a shorter timeframe. Through traditional procurement and improvement methods, SCDOT had previously established a plan to upgrade approximately 100 intersections per year with low cost safety improvements. The proposed statewide project advertised in 2009 included an ambitious plan to upgrade over 2200 intersections in only a three year period, or about 730 intersections per year. The contracted plan resulted in project completion 204 months faster than if traditional methods were used. 3M, utilizing the project management web site and asset management reporting required in the contract, was able to complete the project on time. This streamlined delivery method of improving over 700 intersections per year can be attributed to preventing literally thousands of crashes in the accelerated time frame compared to traditional safety improvement methods.

SCDOT Leading Nationwide Safety Programs

Through the implementation and success of the intersection improvements, SCDOT is a national leader in the improvement of intersection safety. The SCDOT project established a benchmark of success of how to implement a statewide project of this scale and the project has garnered attention from across the United States. Representatives from SCDOT receive numerous requests for presentations and information sharing about the project and SCDOT personnel accommodate these requests as they are able to do so. Presentations have been made to the South Carolina Transportation Commission, the FHWA Office of Safety Focus Area Web Conference, and the Statewide Council of Governments Conference. Key contacts at SCDOT have participated in various web-conferences to share the best practice methods associated with the project. The project was also presented at the 2011 and 2012 Technical Advisory Committee Meetings of the Evaluations of Low Cost Safety Improvements Pooled Fund Study held in Washington, DC and attended by many of the state departments of transportation throughout the United States. In additional to the numerous presentations, representatives from SCDOT also routinely meet with other DOTs and consulting engineering firms on an ongoing basis.

CONCLUSION—FASTER IMPLEMENTATION RESULTS IN SAVED LIVES

One of the primary benefits of the unique, innovative delivery method associated with the project was the significant time savings to implement the safety improvements and therefore save additional lives. Through traditional construction improvement methods, the SCDOT Traffic Safety Office would typically identify high crash incident intersections and target these locations for low cost improvement strategies. Safety enhancements at these locations would be initiated through an Office Memorandum from the Director of Traffic Engineering to the corresponding District Engineering Administrator for the District where the intersection is located. The District Engineering Administrator would then forward the memorandum to the local maintenance office for implementation. Through this process, SCDOT typically improved safety at about 100 different intersection locations per year. Scaling this process to the Statewide Safety Improvement Program would result in a time line of approximately 20 years (based on completing about 100 intersections per year).

SCDOT realized that through a different approach that greatly streamlined the process, improvements would be made years ahead of traditional methods—an accomplishment that would result in saving hundreds of lives compared with a more typical approach of only 100 intersections improved per year. The end result is a project that improved the safety at over 2200 intersections across the State of South Carolina in a short, three-year period. In addition to the actual safety improvements and features installed at each intersection, the speed of delivery and implementation cannot be overemphasized as an important achievement of the project.

When a program is as important as the one on which SCDOT embarked, it is essential to review and statistically analyze results into the future. SCDOT will actively record and collect data on accidents and crashes at improved intersections for the next several years to further examine benefits of the safety enhancements. Data and statistics, as well as relating outcomes to best practices, will be shared at all levels within various other transportation agencies. Another key benefit of the condensed time frame to implement the improvements across 2,200 intersections in only three years is the uniformity of the improvements across a large sample size, significantly reducing external factors and variability that would occur if the improvements were constructed over many years. This will further enable SCDOT and the roadway industry to draw significant conclusions for future safety programs as the statistical analysis is advanced in coming years.

REFERENCES

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2. *Fatality Analysis Reporting System (FARS) Encyclopedia, NCSA Data Resource Website, http://www-fars.nhtsa.dot.gov*. 2007: National Highway Traffic Safety Administration, U.S. Department of Transportation, Washington D.C.
3. Hinton, D., Riddle, J., *South Carolina Case Study: Systematic Intersection Improvements, FHWA Safety Program*, FHWA-SA-12-021. 2012: Federal Highway Administration, U.S. Department of Transportation, Washington D.C.

TABLES

TABLE 1 Process Map – Tasks by Stakeholder

Order	Entity	Description
Step 1	SCDOT HQ	Post Work Order
Step 2	Contractor	Publish Work Order to Project Web Site
Step 2A	Subcontractor	Conduct Field Engineering Review & Stake Sign Locations
Step 3	Contractor	Prepare Intersection ID Document Labels
Step 3A	Subcontractor	Prepare Work Order Plan and Staking Review Document
Step 4	Subcontractor	Schedule District Work Order Planning Meeting – Communicate Review Requirements and Approval Process
Step 5	SCDOT	District Review & Edit Work Order Plan and Staking Document
Step 6	SCDOT	HQ Review & Approve or Deny Culmination of Field Engineering and District Edits Post Approved Final Work Definition Document
Step 7	Contractor	Build Sign Detail Sheet and Order Traffic Signs
Step 8	Subcontractor	Correct Sign Staking (as necessary)
Step 9	Contractor	Prepared Detailed Work List for Installation Crews
Step 10	Contractor	Produce and Distribute Field Workbooks
Step 11	Contractor	Publish Approved Work Order Diagrams to Project Web Site
Step 12	Contractor	Publish Work Schedule to All Parties and on Project Web Site
Step 13	Contractor	Mobilize Installation Contractors
Step 14	SCDOT HQ	Review and Approve Fields Corrections (Real-Time)
Step 14A	SCDOT District	Identify Potential Field Corrections
Step 14B	Subcontractor	Identify Potential Field Corrections
Step 15	SCDOT District	Inspect Work as it Occurs
Step 15A	Subcontractor	Inspect Work as it Occurs
Step 16	Contractor	Maintain Punch List and Publish to Project Web Site

TABLE 2 SCDOT Project Management Web Site Data Requirements

Pavement Markings	Traffic Signs
Road name/Highway # (intersections)	Road name/Highway # (intersections)
Work Order #	Work Order #
Quantities of material installed	GPS coordinates of each traffic sign location
Type of material used	Sign ID # (bar code of new signs)
Field Supervisor name	Sign ID # (bar code – removed signs/posts) Ex. Signs had ID # and posts have an Assembly #
Status of work – planned or complete	MUTCD code for each sign type
Start Date	Sign dimensions (width and height)
Finish Date	Sign face substrate
Date Evaluated	Post type/style
Evaluation results – durability and retroreflectivity (PDF file download option)	Date of sign installation
	Sheeting type
	Sign face direction
	Field Supervisor name
	Status of work – planned or complete
	Approval date – utility locates
	Start Date of Work Order
	Finish Date of Work Order