



## Charting a Course to 2040

SOUTH CAROLINA MULTIMODAL TRANSPORTATION PLAN

Technical Memorandum

# SAFETY AND SECURITY

Prepared for:



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# 1. INTRODUCTION

## 1.1 Background

Safety on the State Highway System is one of the top goals for SCDOT. South Carolina has continued to have one of the highest mileage death rates in the nation. In 2011, the National Highway Traffic Safety Administration (NHTSA) indicated South Carolina had the 3<sup>rd</sup> highest fatality rate in the nation. South Carolina has held the third highest fatality rate since 2006 even though the State's fatality rate has dropped from a high of 2.11 fatalities per 100 Million Vehicle Miles Traveled in 2006 to 1.70 in 2011. The national average fatality rate also dropped from 1.42 in 2006 to 1.10 in 2011.

The number of fatalities occurring on the State's roads began declining in 2007 from a total of 1,077 in that year to a low of 810 fatalities in 2010. However, the number has begun to increase with 828 fatalities occurring in 2011 and 863 occurring in 2012.

South Carolina also had the 5<sup>th</sup> highest pedestrian fatality rate and the 5<sup>th</sup> highest bike fatality rate in the nation in 2010. NHTSA recently released the 2011 bicycle and pedestrian fatality state rankings and South Carolina has moved up to the 2<sup>nd</sup> highest pedestrian fatality rate while still maintaining the 5<sup>th</sup> highest bike fatality rate.

The cost of vehicle crashes, injuries, and fatalities to society is staggering and greatly exceeds the funding dedicated to SCDOT for highway maintenance, operations, and improvements. In 2009, the South Carolina Department of Public Safety (SCDPS) estimated that the annual economic loss due to vehicle crashes, injuries, and fatalities was \$2.67 Billion. These statistics indicate the need to bring greater emphasize to safety in all aspects of highway planning.

## 1.2 SAFETEA-LU

In 2005, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users known as SAFETEA-LU was implemented requiring all states to have a Strategic Highway Safety Plan (SHSP). South Carolina's Strategic Highway Safety Plan: A Roadmap to Safety was developed in 2007 in compliance with SAFETEA-LU. This plan was a comprehensive safety plan with five key emphasis areas that had numerous safety strategies that required combined efforts from federal, state and local agencies to implement. SCDOT concentrated its efforts on those emphasis areas that were engineering related and to the specific counter measures that would address areas of highest fatalities. Those strategies included run off the road, horizontal curves, intersections, head-on crashes, secondary crashes on interstates and work zones. Strategies to address these type crashes included:

- Installation of two feet wide paved shoulders on many rural roads,
- Installation of rumble strip along the road edge,
- Installation of safety edge during resurfacing projects,



- Open Graded Friction Surface course on interstates to prevent hydroplaning,
- Additional warning signs on curves with select roadside clearing,
- Low cost intersection safety program that addressed crashes at 2200 intersections,
- Installation of cable barrier along narrow interstate medians,
- Implementation of advanced warning on interstates advising of incidents, and
- Implementation of a Highway Patrol work zone Safety Improvement Team (SIT).

These counter measures have reduced numerous crashes and the corresponding injuries and fatalities, as evidenced by the decline in fatal crashes beginning in 2007.

### 1.3 MAP-21

In July 2012, the President signed the Moving Ahead for Progress in the 21<sup>st</sup> Century Act known as MAP-21. This new surface transportation bill includes specific provisions related to the Highway Safety Improvement Program (HSIP) which is a core Federal-aid program with a goal of achieving a significant reduction in fatalities and serious injuries on all public roads. In order for a state to obligate HSIP funds, it must have a program under which the State:

- Develops, implements, and updates a strategic highway safety plan (SHSP) that identifies and analyzes highway safety problems and opportunities;
- Produces a program of projects or strategies to reduce identified safety problems; and
- Evaluates the SHSP on a regularly recurring basis.

#### 1.3.1 Highway Safety Improvement Projects

The term “highway safety improvement project” is defined in 23 U.S.C. 148(a)(4) as strategies, activities, and projects on a public road that are consistent with a state strategic highway safety plan and correct or improve a hazardous road location or feature or address a highway safety problem. A highway safety improvement project includes but is not limited to the following projects:

- Intersection safety improvement;
- Pavement or shoulder widening;
- Installation of rumble strips or another warning device;
- Installation of skid resistant surface;
- Improvement for pedestrian or bicyclist safety or safety of persons with disabilities;
- Construction and improvement of a railway-highway grade crossing safety feature;
- Conduct modal traffic enforcement activity at a railroad-highway crossing;
- Construction of a traffic calming feature;
- Elimination of a roadside hazard;



- Installation, replacement, and other highway signage and pavement markings improvements, or a project to maintain minimum levels of retroreflectivity;
- Installation of a priority control system for emergency vehicles at signalized intersections;
- Installation of a traffic control or other warning device at a location with high crash potential;
- Transportation safety planning;
- Collection, analysis, and improvement of safety data;
- Planning integrated interoperable emergency communications equipment, operational activities, or traffic enforcement activities related to work zone safety;
- Installation of guardrails, barriers, and crash attenuators;
- Installation or retrofitting structures or other measures to eliminate or reduce crashes involving vehicles and wildlife;
- Installation of yellow-green signs and signals at pedestrian and bicycle crossings and in school zones;
- Construction and operational improvements on high risk rural roads;
- Geometric improvements to a road for safety purposes that improve safety;
- Conduct road safety audit;
- Roadway safety infrastructure improvements consistent with the recommendations included in the Highway Design Handbook for Older Drivers and Pedestrians;
- Truck parking facilities eligible for funding under section 1401 of the MAP-21; and
- Systemic safety improvements.

Highway safety Improvement projects must be consistent with South Carolina's SHSP and identified on the basis of crash experience, crash potential, crash rate or other data-supported means.

### 1.3.2 Performance Measures

Based on MAP-21, the US Secretary of Transportation, in consultation with state departments of transportation, metropolitan planning organizations and other stakeholders, shall establish performance measures and standards. For the Highway Safety Improvement program, the Secretary will establish measures for states to use to assess serious injuries and fatalities per vehicle mile traveled and the number of serious injuries and fatalities to help meet the national goal of a significant reduction in serious injuries and fatalities. One year after the Secretary has established the performance measures; each state shall set performance targets to meet these measurers. States should then select safety improvement projects that will help meet their targets.



There are penalties for any state that has not met or made significant progress toward achieving its safety performance targets within two years of establishing the targets. The state would be required to:

- Dedicate its obligation authority equal to the apportionment for the Highway Safety Improvement Program to the state for the prior year to highway safety improvement projects until the Secretary determines that the state has made significant progress or met its targets, and
- Annually submit to DOT a safety implementation plan until the Secretary determines that the state has made significant progress or met its targets.

Based on FHWA's timeline on issuing the rules and guidance on MAP-21, it is anticipated that states will not be held accountable for performance measure target until the year 2016. However, SCDOT will continue to annually track safety performance measures and report the results.

The vision and goals that have been identified for the 2040 SC Multimodal Transportation Plan include the goal to improve the safety and security of the transportation system by implementing transportation improvements that reduce fatalities and serious injuries as well as enabling effective emergency management operations. The proposed objectives for this goal include:

- Reduce highway fatalities and serious injuries,
- Reduce bicycle and pedestrian fatalities and serious injuries,
- Reduce roadway departures,
- Reduce head on and across median crashes,
- Reduce preventable transit accidents, and
- Reduce rail grade crossing accidents.

SCDOT should identify and implement strategies to accomplish these objectives and monitor the progress for these strategies using the following potential measures:

- Number or rate of fatalities and serious injuries,
- Number or rate of bike/pedestrian fatalities and injuries,
- Number of roadway departure crashes involving fatality or injury,
- Number of head on or across median crashes,
- Number of transit accidents per 100,000 service vehicle miles, and
- Number of rail grade crossing accidents.

### 1.3.3 State Strategic Highway Safety Plan Updates

Under MAP-21, the US Secretary of Transportation has one year from the date of the adoption of MAP-21 to establish requirements for regularly recurring state updates of strategic highway safety plans. The Secretary shall ensure that states take into consideration, with respect to their updated plans:

- The findings of road safety audits;
- The locations of fatalities and serious injuries;



- The locations that do not have an empirical history of fatalities and serious injuries, but possess risk factors for potential crashes;
- Rural roads, including all public roads, commensurate with fatality data;
- Motor vehicle crashes that include fatalities or serious injuries to pedestrians and bicyclists;
- The costs-effectiveness of improvements;
- Improvements to rail-highway grade crossings; and
- Safety on all public roads and roads on tribal land.

Each state shall update their strategic highway safety plan in accordance with the requirements that the Secretary issues and shall submit their updated plan to the Secretary along with a detailed description of the process used to update the plan. If a state does not have an approved updated SHSP by August 1, 2014, the state shall not be eligible to receive any additional limitation pursuant to the redistribution of the limitation on obligations for Federal-aid highway and highway safety construction programs that occur after August 1 for each succeeding fiscal year until the fiscal year during which the plan is approved.



## 2. SOUTH CAROLINA STRATEGIC HIGHWAY SAFETY PLAN UPDATE

Prior to the adoption of MAP-21, SCDOT and the South Carolina Department of Public Safety (SCDPS) jointly began planning the SHSP update. Meetings were held to discuss the update process and to identify the major participants that would be responsible for updating the SHSP. As a result of the pending guidance from the US Secretary of Transportation concerning the process for updates to the SHSP, South Carolina is moving ahead with plans for updating the SHSP using *Strategic Highway Safety Plan MAP-21 Interim Guidance* issued by the FHWA Office of Safety on April 5, 2013.

### 2.1 Potential Goals for Updated Strategic Highway Safety Plan

In preparation for updating the Strategic Highway Safety Plan, SCDOT and SCDPS have prepared a document that identifies the elements of a SHSP for South Carolina. Using crash and other safety data, fifteen goals have been identified that can directly impact highway safety through engineering, enforcement, education, emergency medical services, policy, public health, and communications. These goals or ones similar will most likely be included in the updated South Carolina SHSP once that process is concluded. Since the goals were identified through safety data as having great potential for reducing crashes and the subsequent fatalities and serious injuries that occur in these crashes. The goals are:

- Goal 1:** Instituting graduated licensing for young drivers
- Drivers with less than a year of experience have the highest crash rate due to lack of driving experience and a tendency toward risk.
- Goal 2:** Ensure drivers are fully licensed and competent.
- A substantial number of drivers continue to drive after privileges have been suspended or revoked.
- Goal 3:** Sustaining proficiency in older drivers.
- Baby boomers are expected to notably swell this number.
- Goal 4:** Curb aggressive driving
- Incidents of this are increasing in the forms of speeding, rally lane changes, following too closely, and driving were prohibited.
- Goal 5:** Reduce impaired driving.
- Alcohol alone is involved in fatal crashes every half hour in the United States.
  - Two in every five Americans will be involved in an alcohol related crash in their lifetime.

**Goal 6:** Keeping drivers alert

- Fatal collision rate between 2:00 a.m. and 3:00 a.m. is ten times greater than the 8:00 a.m. to 9:00 a.m. period.
- More than half of the fatal collisions occur at night.

**Goal 7:** Increasing driver safety awareness

- 85 percent of the causation factors associated with crashes are attributed to the driver.
- Many drivers are unaware or have underestimated the risks associated with these unsafe driving behaviors.

**Goal 8:** Improve and sustain seatbelt usage.

- In 2012, 323 people dies as a result of not wearing a seatbelt.

**Goal 9:** Making walking and street crossing safer

- A pedestrian is killed about every hour on our nation's roadways.

**Goal 10:** Ensuring safer bicycle travel

- In nearly 75 percent of bicycle crashes, an error or some other factor related to the bicyclists' behavior was involved. One third of bike fatalities involved individuals who were between five and fifteen year olds.

**Goal 11:** Improving motorcycle safety and increasing motorcycle awareness

- In South Carolina, motorcyclists account for 10 percent of all motor vehicle fatalities and the average age for these fatalities is forty-five. Alcohol and speeding is often involved as is an inadequate level of awareness of motorcycles by other drivers on the road.

**Goal 12:** Making truck travel safer

- In South Carolina, in 2010 large trucks were involved in approximately 3,200 crashes. This resulted in fifty-two fatalities.

**Goal 13:** Keeping vehicles on the roadway and minimizing the consequences of leaving the road.

- 50 percent of South Carolina's traffic fatalities involve vehicles leaving the road and striking fixed objects such as trees (25 percent in South Carolina, yet only 8 percent nationally.)

**Goal 14:** Improving the design and operation of highway intersections

- About one in every four fatal crashes occurs at or near an intersection.

**Goal 15:** Reduce head-on and across-median crashes.

- One of the most severe types of crashes occurs when a vehicle shifts into an opposing flow lane and crashes head-on with an oncoming vehicle.

## 2.2 SCDOT Goals

Of the 15 goals identified, SCDOT would be the lead agency to implement the five goals that are engineering related (goals 9, 10, 13, 14, and 15). If the South Carolina SHSP adopts these goals as emphasis areas, SCDOT will identify strategies, activities, and projects that would correct or improve a hazardous location or feature related to the goals. Locations or activities identified will qualify for federal funding as a highway safety improvement project. Projects selected should lead to a reduction in fatalities and serious injuries in order to meet the 2040 LRTP and MAP-21 performance measures. Possible strategies for each of these five goals are discussed below.

### 2.2.1 Making Walking and Street Crossing Safer

According to NHTSA, over 500 pedestrian fatalities have occurred on South Carolina roads between 2007 and 2011. In 2010, the number of pedestrian fatalities was 90, which gave South Carolina the 5<sup>th</sup> highest fatality rate in the nation. Unfortunately, in 2011, the number of pedestrian fatalities increased to 113. NHTSA recently released the 2011 rates and as a result of the increase in fatalities, South Carolina had the 2<sup>nd</sup> highest pedestrian fatality rate in the nation. Therefore, addressing pedestrian fatalities in South Carolina is essential for any highway safety plan.

According to NHTSA's Uniform Guidelines for State Highway Safety Programs, each state should develop and implement a comprehensive highway safety program to achieve a significant reduction in traffic crashes, injuries, and fatalities. This safety program should include a comprehensive pedestrian safety program that promotes safe pedestrian practices and provides safe facilities for pedestrians. Highway and traffic engineering is a critical element of any motor vehicle crash reduction program, but is especially important for the safe movement of pedestrians. States should utilize national guidelines for constructing safe pedestrian facilities in all new transportation projects, and are required to follow all Federal regulations on accessibility.

South Carolina should ensure that the State and community pedestrian programs include a highway and traffic engineering component that is coordinated with enforcement and educational efforts. This engineering component should improve the safety of pedestrians through the design, construction, operation, and maintenance of engineering measures, such as:

- Pedestrian and school bus loading zone signals, signs and markings;
- Traffic-calming or other approaches for slowing traffic and improving safety;
- Sidewalk design;
- Pedestrian facilities such as sidewalks, crosswalks, curb ramps, and paths; and
- Accommodations for people with disabilities.

As SCDOT identifies pedestrian fatality locations, particular attention should be given to the above safety measures as projects are selected and developed.



### 2.2.2 Ensuring Safer Bicycle Travel

Between 2007 and 2011, there was an average of 15 bicycle fatalities per year in South Carolina which is approximately 2 percent of the total highway fatalities. Although this seems like a relatively low number, the number of fatalities per million population was 3.21. This was the 5<sup>th</sup> highest bicycle fatality rate in the nation in 2011. For this reason, South Carolina's highway safety program should include a comprehensive bicycle safety element that promotes safe bicycle practices, educates drivers to share the road safely with other road users, and provides safe facilities for bicyclists through a combination of policy, enforcement, communication, education, incentive, and engineering strategies.

Highway and traffic engineering is a critical element of any safety program addressing the safe movement of bicyclists. The engineering component should coordinate with enforcement and educational efforts to improve the safety of bicyclists through the design, construction, operation, and maintenance of engineering measures, such as:

- Bicycle signs and markings;
- Parking regulations;
- Traffic-calming or other approaches for slowing traffic and improving safety;
- On-road facilities (e.g., signed routes, marked lanes, wide curb lanes, paved shoulders); and
- Off-road bicycle facilities (trails and paths).

### 2.2.3 Keeping Vehicles on the Road

SCDOT reports that 50 percent of all traffic fatalities in South Carolina are the result of a vehicle leaving the road and striking an object or overturning. In order to reduce the fatalities and injuries resulting in vehicles leaving the road, AASHTO Strategic Highway Safety Plan recommends states adopt initiatives that would (1) keep vehicles from leaving the road, (2) reduce the potential of a vehicle from overturning or striking an object if it leaves the road and (3) minimize the severity of a crash. There are a number of strategies that can be implemented to address this issue, such as:

- Improve guidance through better pavement markings and delineation;
- Implement a targeted shoulder rumble strip program;
- Improve the design process to incorporate safety considerations into design decisions to include wider shoulders for vehicle recovery;
- Improve roadside maintenance practices to enhance safety;
- Improve the selection, installation and maintenance of road side safety hardware ( guardrails, concrete barriers and curb types);
- Implement a state effort to address hazardous trees to include providing proper roadside clear zones;
- Implement a policy to reduce the hazard from roadside utility poles;



- Improve ditches and backslopes to minimize vehicle rollover; and
- Implement guidelines for safe urban streetscape design.

#### 2.2.4 Improving the Design and Operation of Highway Intersections

According to the AASHTO Strategic Highway Safety Plan, approximately 25 percent of all fatal crashes occur at or near an intersection, of which one third of these are signalized. The majority of these crashes are left turn type or rear end type crashes. At signalized intersections, fatalities are predominantly caused by right angle collisions. Some strategies identified in the AASHTO SHSP to improve safety at intersections include the following:

- Use of automated methods to monitor and enforce intersection traffic control,
- Upgrading signalized intersection controls to provide coordinated timing to smooth traffic flow and decrease unnecessary stops, and
- Include more effective access management policies for nearby developments.

Other intersection safety improvements include the following:

- Establish proper yellow and red clearance intervals based on prevailing speeds and road geometrics,
- Low cost signing and marking improvements at targeted high crash intersections,
- Utilize roundabouts to replace cross type intersections with high crashes,
- Add left and right turn lanes on intersection approaches with high turning volumes,
- Restrict movements at high volume intersections utilizing super street concepts,
- Improve visibility at intersections by clearing sight triangles, and
- Restrict or eliminate parking on approaches to intersections.

#### 2.2.5 Reduce Head-on or Across Median Crashes

AASHTO SHSP describes the head-on crash as one of the most severe types of crashes often resulting in fatalities. Most of these crashes occur on rural two lane roads and interstates with narrow medians. *NCHRP Report 500 Volume 4: A Guide for Addressing Head-On Crashes* list the following strategies to prevent these type crashes:

- Install centerline rumble strips for two-lane roads;
- Install profiled thermoplastic strips for centerlines;
- Provide wider cross sections on two-lane roads;
- Provide center two-way, left-turn lanes for four- and two-lane roads;
- Reallocate total two-lane roadway width (lane and shoulder) to include a narrow “buffer median”;
- Use alternating passing lanes or four-lane sections at key locations; and
- Install median barriers for narrow-width medians on multilane roads.

Installing rumble strips and cable median barriers is the top strategy used to prevent head-on crashes in South Carolina and it has proven to be very successful. Continuing the use of these measures is recommended where needed.

## 2.3 Other Safety Initiatives

In addition to the five main goals discussed above, there are other safety initiatives that should also be considered in the SHSP. These include work zone safety, adoption of safety features and standards, and improved crash data collection. Each of these is discussed below.

### 2.3.1 Work Zone Safety

Work Zones are areas that require special attention in order to maintain safe and efficient flow of traffic. Work zones can alter the normal traffic flow requiring vehicles to merge into other lanes, shift alignment through the construction area, travel next to barrier walls, barricades and cones, and make other movements that can lead to vehicular crashes which can endanger the life of the motorists, as well as the workers in the work zone. It is and should always be a SCDOT goal to reduce the fatal and injury crashes and to enhance traffic operations and safety within work zones. Prior to 2006, an average of 18 fatalities occurred each year in South Carolina highway work zones. To address this issue, SCDOT teamed with SCDPS to establish the Safety Improvement Team (SIT) Program. This program consists of 24 experienced Highway Patrol Troopers who are devoted exclusively with speed enforcement in highway work zones. The teams devote full-time effort to strict enforcement of traffic laws in highway and utility construction and maintenance work zones as directed by SCDOT. This program is funded through the federal Highway Safety Improvement Program (HSIP) at a cost of approximately \$1.5 million per year. As a result of this enforcement, annual work zone fatalities have dropped by 50 percent in South Carolina.

It is recommended that this program continue to be supported by SCDOT and included in the update for the South Carolina SHSP.

### 2.3.2 Adoption of Safety Features and Design Standards

In recent years, SCDOT has begun to adopt new standards in traffic control devices and highway design and construction that incorporate safety features to reduce highway crashes and fatalities. These new standards have been shown to improve safety by reducing the number of crashes occurring and as a result, also reducing injuries and fatalities. The following are some proven safety countermeasures that the FHWA recommends states to use at the appropriate locations.

#### **Safety Edge**

Safety Edge is a process used during asphalt paving which provides a 30 degree sloped pavement edge at the shoulder. This eliminates the vertical drop off at the edge of a paved road which contributes to loss of control of a vehicle, resulting in severe crashes. Studies indicate this process can reduce crashes on two lane roads by 6 percent. This safety feature was adopted by SCDOT in 2010 and should continue to be used on all resurfacing projects.

### **Roundabouts**

The modern roundabout is a low speed circular intersection that has proven to be significantly safer than the two way stop intersection and the signalized intersection. Converting a two way stop intersection to a roundabout can result in an 82 percent reduction in severe crashes and a 44 percent reduction in overall crashes. Converting a signalized intersection to a roundabout can result in a 78 percent reduction in severe crashes and a 48 percent reduction in overall crashes. Use of roundabouts is recommended at locations with major safety or operational issues where the higher costs for the construction can be justified by the crash reduction or operational improvements.

### **Corridor Access Management**

Access management refers to the design, implementation, and control of the entry and exit points along a road. All at-grade intersections or driveways have multiple conflict points between vehicles, pedestrians, and bicycles. The number and type of conflict points influence the safety and capacity of the road. Reducing the number of conflict points by controlling the access allowed at various intersections and driveways can reduce crashes significantly.

It is recommended that SCDOT consider adopting corridor access management techniques on high volume, high crash urban arterials to include restricted movements for driveways, alternative designs for major intersections that eliminate turns, and use of raised medians along the corridor to control movements into and out of driveways. These techniques will reduce crashes along the road and will increase the capacity of the corridor.

### **Signal Backplates with Retroreflective Borders**

The visibility of a traffic signal head can be improved with the addition of a backplate with a retroreflective border. This type signal head is more visible and conspicuous in both daytime and nighttime conditions, which will reduce unintentional red-light running crashes. SCDOT began using this safety feature several years ago and FHWA has published an Intersection Safety Case Study on the success of the South Carolina initial program. Also, the Department included these devices at signalized intersections identified in a high crash intersection safety program. The Department now includes reflective strips on all backplates used at all locations where the National Manual on Uniform Traffic Control Devices recommends the use of signal backplates. It is recommended that SCDOT continue the use of the retroreflective backplates at all locations where signal backplates are warranted or where conditions indicate that the devices would be helpful for motorists' visibility.

### **Longitudinal Rumble Strips and Stripes**

Approximately 53 percent of fatal crashes in the nation are the result of roadway departure crashes. Rumble strips milled into the pavement or raised elements on the pavement will alert an inattentive driver that he has left the travel lane which will reduce run off the road crashes. Continuous rumble strips can be installed on many miles of roadway at a reasonable cost, which makes this safety feature particularly suitable for a systematic application. The application includes:

- Shoulder rumble strips installed on roads with paved shoulders,
- Edge line rumble strips installed on roads with no paved shoulder,

- Centerline rumble strips installed on or near the centerline of undivided roads, and
- Rumble stripes where pavement markings are placed directly over the rumble strip.

SCDOT has installed many miles of shoulder and edge line strips and stripes in a systematic approach to addressing run off the road crashes. It is recommended that this safety effort continue and that rumble strips or rumble stripes be installed on additional roads as funding allows. It is also recommended that the use of centerline rumble strips be expanded to roads where head on crashes are present or the potential exist due to narrow lanes or roads with severe or multiple horizontal curves.

#### **Enhanced Delineation and Friction for Horizontal Curves**

According to the FHWA, approximately 28 percent of all fatal crashes nationally occur on curves as a result of the change in the roadway alignment that creates a more demanding environment for the driver and vehicle. Navigating a curve is compounded at night or on wet pavement. It is essential that drivers are warned early enough to perceive the change in road alignment and to take proper action to negotiate the curve safely. Low cost safety treatments can include signing that is in advance of the curve and delineation through the curve. Installing chevron signs through the curve, installing fluorescent curve signs in advance of the curve, and using the combination curve and advisory speed signs are all treatments that can reduce the crashes occurring. In addition, using a microsurfacing pavement treatment will significantly reduce curve crashes, particularly on wet pavement. SCDOT is developing a process for identifying and treating problem curves. It is recommended that these type treatments be considered in a systematic program to reduce curve crashes. It is also recommended that roadside hazards located in curves, particularly trees be removed or shielded to reduce potential for serious or fatal crashes for vehicles that leave the roadway.

#### **Open Graded Friction Course (OGFC)**

Open Graded Friction Course (OGFC) is a porous hot mix asphalt concrete wearing course with high air voids content. OGFC is designed to allow water to drain through to an impermeable barrier and, following the cross slope of the roadway, drain into a side ditch. It has very good frictional properties and provides quick drainage. It also reduces hydroplaning, splash/spray from vehicles, headlight glare, and road noise. SCDOT has installed OGFC on some sections of asphalt interstates in recent years to reduce the spray from large vehicles. The Department completed studies in 2008 and 2012 to analyze the before and after crashes occurring on those sections of interstate where OGFC was installed. The results from these studies indicated a 28 percent reduction in wet crashes after the OGFC had been installed. Since the reduction in wet crashes is significant, it is recommended that SCDOT adopt OGFC as the standard for all asphalt interstate surfaces. It also recommended that SCDOT consider expanding OGFC to other type routes where hydroplaning or spray issues exist.

#### **Roadside Clear-Zones**

In the *South Carolina Traffic Fatality Report for 2012*, SCDOT reports that fatalities resulting from a vehicle striking a tree increased to 114, which was a 14 percent increase from 2011 and a 30 percent increase from 2010. Over 13 percent of all fatalities in 2012 were the result of crashes with trees. The FHWA reports that vehicle collisions with trees account for more than 4,000 fatalities and 100,000

injuries each year. In spite of these high numbers, efforts to remove trees adjacent to roads are often met with strenuous objections by local residents.

The AASHTO *Roadside Design Guide* discusses the forgiving roadside design principles that influence the design for shoulders, embankment slopes, and ditches. It defines the clear-zone concept which is an unobstructed, traversable roadside area designed to enable a driver to stop safely or regain control of a vehicle that has accidentally left the roadway. It is an effective strategy for prevention and mitigation of roadway departure crashes.

In South Carolina, many tree related crashes occur on portions of the interstate highways, where clear-zones were established years ago using a 30 foot standard dimension. The *Roadside Design Guide* suggests that the clear-zone on a 70 mph design road to be 30-34 feet where slopes are 1:6 or flatter, and 38-46 feet where the slopes are 1:5 to 1:4. On sections where the slope is 1:3 or steeper, fixed objects should not be present at the toe of the slope and a 10 foot recovery area should be provided at the toe of the slope. The guide also gives values for other design speeds based on traffic volumes, many of which appear to exceed the present clear-zones provided on South Carolina roads.

In view of the high fatalities occurring on South Carolina roadways, it is recommended that SCDOT begin a comprehensive review of the present clear-zones beginning on the interstate highways and continuing onto the primaries and any high volume, high speed secondary roads to access the need for increasing the clear-zones to reduce the fatalities resulting from vehicles leaving the roadway.

### 2.3.3 Improve Crash Data Collection

The quality of traffic safety records is critical to the planning, management, and evaluation of any successful state transportation safety program. This need has become even more pronounced in light of the safety performance measures required in the MAP-21 legislation. The South Carolina Traffic Records System consists of several state systems that contain information about collisions, roadways, drivers, vehicles, citations, court adjudications, and medical treatments for collision victims. The collision component is the central component of the traffic records system as it provides the data that is used in safety planning.

South Carolina's SHSP is a data-driven plan which relies heavily on the vehicle collision reports. In order for the State to be successful in identifying safety issues and implementing countermeasures to correct the safety problem, it must first have collision reports that are reported timely, accurately, and completely. Particularly important is the exact location of the collision. SCDOT uses the location of collisions to identify high crash areas and implements safety improvements at these locations. If the locations of collisions are coded wrong, SCDOT may incorrectly identify a location for a safety improvement project where a safety hazard does not exist. This could result in unnecessary allocation of limited safety resources.

In South Carolina, there is a Traffic Records Coordinating Committee (TRCC) whose mission is:

*“To provide multi-agency coordination of projects designed to create more timely, integrated, accurate, and accessible data and to use these data to realize our ultimately shared goal of reducing traffic fatalities and injuries in South Carolina.”*

The TRCC is composed of two groups, the Executive Group and the Working Group. The Executive Group consists of the Agency heads of the SCDPS, SCDOT, South Carolina Judicial Department (SCJD), South Carolina Department of Motor Vehicles (SCDMV), and South Carolina Health and Environmental Control (SCDHEC). The Working Group is a forum of employees in technical and managerial capacities in the South Carolina Traffic Records System. The TRCC has been working diligently over the past few years to improve the traffic records system. A number of projects have been implemented or are ongoing to improve the data collection and distribution. They have also completed a new strategic plan for data improvements.

On May 21, 2013, the TRCC Executive Group approved the South Carolina Traffic Records Strategic Plan (TRSP). This plan was an update to the original plan approved in June 2009. The SC TRSP provides a framework for identifying projects critical to improving the state’s traffic records systems. The TRSP also serves to integrate and coordinate each Agency’s activities to achieve the overall goal of reducing highway fatalities and serious injuries.

The TRSP has three specific goals and eighteen projects associated with these goals. The goals are:

- Goal 1 - Improve Data Collection Methods,
- Goal 2 – Implement Data Sharing projects and provide Enhanced Data Analysis, and
- Goal 3 – Improve Management and Coordination of Traffic Records Systems Improvement.

One major project underway is to improve on the collision data collection is the South Carolina Collision and Ticket Tracking System (SCCATTS). SCCATTS is a system being implemented by SCDPS to automate the collection of crash data by law enforcement. This system will improve accuracy and timeliness of crash data by capturing location information electronically through GPS equipped laptop computers in the vehicles of investigating officers. The project began in 2008 and as of May 2011, all South Carolina Highway Patrol troopers have been using the new system. In addition, local law enforcement personnel are also receiving this software along with training, thereby enabling them to begin using this product. As of April 2013, approximately 20 local agencies were using the software. SCDOT continues to collaborate with SCDPS on the development, funding, and implementation of this system.

This data collection system provides accurate and timely crash data. However, only 60 percent of all crash reports are collected electronically through SCCATTS and 40 percent of crash reports do not have the crash location by latitude and longitude. As a result, SCDOT reports that 15 percent of crashes cannot be located on the state road system due to inaccurate location information.

It is recommended that:

- The South Carolina Traffic Records Strategic Plan be incorporated into the South Carolina Strategic Highway Safety Plan update.
- All law enforcement agencies that are responsible for preparing traffic crash reports should be required to list the latitude and longitude coordinates of the crash site. A simple handheld GPS unit can provide these coordinates until such time that the agency adopts the SCCATTS system.
- All local law enforcement agencies that are responsible for preparing traffic crash reports should be required to use the SCCATTS system for crash reporting to increase accuracy and timeliness of the reports.

## 2.4 Implementation of Updated Strategic Highway Safety Plan

The goal of a strategic highway safety plan is to reduce fatalities, injuries and crashes. In order for a plan to be successful, implementation of the plan is essential. Using the FHWA *Strategic Highway Safety Plan Implementation Process Model* as a guide, South Carolina can assure that the objectives and strategies in the future updated Strategic Highway Safety Plan will be accomplished and as a result, the goal of reducing fatalities, injuries and crashes will be obtained. The following are the fundamental elements of implementation of the plan.

### 2.4.1 Leadership

A successful plan must have strong leadership to set direction for the various agencies and organizations involved in the implementation process. These leaders must be committed and motivated to see that the safety plan elements are implemented and that all staff involved in the plan are inspired to do their part in making the plan successful. The top leader for SCDOT must be the Secretary of Transportation since he/she is the only one who can direct the various areas in the agency such as engineering, mass transit and administration. Also, the Secretary would be the proper person to collaborate and coordinate efforts by other agencies in implementing those initiatives that would be accomplished by those agencies. Other leaders in the agency are necessary to carry out the plan implementation. These are individuals who have authority and access to resources and can motivate their employees to action. They must communicate the vision, goals and objectives of the plan and support the multidisciplinary efforts that are essential for those initiatives that cross agency lines.

### 2.4.2 Data Collection

The Strategic Highway Safety Plan is a data driven document that uses many types of information to identify the locations and causes of highway crashes. Easy access to these various forms of information is critical to assure the plan addresses the safety issues in the state and identifies the type of initiatives and objectives that will improve these safety conditions. The types of data such as crash data, roadway, vehicle and driver are housed in various agencies. Sharing of this data between those agencies that are stakeholders in the Safety Plan is essential for a successful plan outcome.

Information from the crash reports is the most important data used in the SHSP. The reports are initially prepared by the South Carolina Highway Patrol and some City and County Law Enforcement

agencies. All hard copies of the reports are housed at SCDMV and all electronic copies filed through SCCATTS are housed at SCDPS. SCDOT has an interagency agreement with SCDMV and SCDPS to access all crash records electronically. It is essential that the crash records system be kept up to date and that crash reports be accurate for all information especially the crash location. As indicated previously, expanding the SCCATTS electronic crash report system to all agencies involved in preparing crash reports is recommended.

### 2.4.3 Action Plans

When SHSP goals have been identified, an action plan should be developed to identify the steps that will be taken to meet each goal. The action plan should detail what type of countermeasures will correct the identified safety issue and at what locations these will be used. The plan will identify who will be responsible for implementing the improvements and what time period will be required to complete the task. A clearly detailed action plan will focus the resources where they are most needed and avoid spending limited funds on locations that will not provide the most safety improvement. Each action plan should also have an owner who is the individual responsible for seeing that the plan is implemented. This individual should report on the progress of the implementation on a periodic basis to assure that the improvements are being accomplished in a timely manner. Requiring periodic reports will emphasize to all stakeholders that this effort is a high priority and the success of the SHSP rest in the individuals assigned to the various action plans.

### 2.4.4 Integration into Other Transportation Plans

Safety should be an emphasis area in all transportation plans. The high state fatality rate and the high rate for bicycle fatalities and pedestrian fatalities are clear indications that more emphasis should be placed on selecting projects that address the safety needs in South Carolina. Act 114 of 2007 established changes in the South Carolina Code of Laws that require SCDOT to use a ranking process to select highway projects. SCDOT has established public safety as one criterion that generally has a ranking of 15 to 20 percent for the various road and intersection projects. Metropolitan Planning Organizations (MPO) and Council of Governments (COG) use a similar ranking process for ranking projects in their Transportation Improvement Programs (TIP). However, there is little emphasis in selecting projects that are strictly safety oriented in the MPO/COG TIPs or their corresponding Long Range Transportation Plans (LRTP). Selecting projects in the LRTP based only on capacity or development needs does not address the safety issues which occur in all MPO and COG areas. It is recommended that each MPO and COG utilize the goals from the South Carolina SHSP to select projects that emphasis safety improvements in their areas. MPO areas should consider projects that make pedestrian and bicycle trips safer. COG areas should consider projects that keep vehicles on the road and reduce head-on and across median crashes. Both areas should consider the design and operation of intersections. These are the type of strategies that SCDOT has identified as potential goals for the updated SHSP.

### 2.4.5 Marketing

Marketing is a term usually used to describe the process of communicating information on products or services that are available to customers or clients. However, marketing is a significant process in any public program that needs to be communicated to all stakeholders and any individual that is affected

by the success or failure of this program. Marketing a safety program for transportation in a state is critical since it affects almost all residents. It increases awareness of the safety issues on the transportation system and it educates the public and the key political leaders of the efforts that need to occur in order to be successful. This can include changes in laws to correct driver behavior, increased enforcement and additional funding for safety programs as well as persuade stakeholders and the public to support the goals and become involved in their implementation. It can also encourage collaboration among the various agencies and organizations that must work together to make the plan successful. One important marketing tool is using a brand to identify the effort. South Carolina has recently adopted “Toward Zero Deaths” as its safety brand. This brand helps the public understand the goal of transportation safety and to better understand why safety is so important. Previously, the use of “Highways or Dieways” was a highly successful brand used for many years in South Carolina and was adopted by many other states for their safety campaigns. The graphic television public announcements in this campaign greatly increased the public’s attention to highway safety by emphasizing the drivers’ responsibility for highway safety.

The following are marketing strategies recommended to increase safety awareness for transportation in South Carolina.

- Develop a statewide strategic marketing plan that addresses overall transportation safety.
- Keep all current safety stakeholders actively involved and seek to gain support of new stakeholders.
- Educate the public about the most serious transportation safety issues.
- Inform the public about the goals and objectives in the Strategic Highway Safety Plan.
- Use of the media and other means of communicating the safety messages should be coordinated among the safety partners.

#### 2.4.6 Monitoring and Evaluation

For any plan to be successful, continuous monitoring and evaluation is essential to assure that the plan’s goals are being met by the implementation of the safety initiatives. It is particularly important that the safety goals are successful since MAP-21 requires performance measures that must result in a reduction in fatalities and serious injuries or the state will face penalties as outlined previously in the *Performance Measures* section. Reporting on the progress should be done on a periodic basis to allow safety partners to assess safety initiatives and make adjustments as necessary to assure progress toward the goals. Collecting before and after crash data on those areas where safety initiatives are being employed is essential to assess the economics of the improvements. The type of data that should be collected includes the following:

- Costs of safety countermeasures;
- Benefits of the countermeasures;
- Incidents of crashes, injuries and fatalities before and after the improvements; and
- Expected crashes, injuries and fatalities without the safety improvement.



Key Monitoring and Evaluation Strategies should include the following:

- Establish a timeline for updating the Strategic Highway Safety Plan,
- Identify key data inputs and reporting cycles,
- Monitor the implementation of safety improvements and issue periodic progress reports for each emphasis area,
- Use a tracking tool to organize and manage the monitoring process and to formalize reporting,
- Collect baseline data prior to safety initiatives to compare with the data collected after the implementation,
- Define the performance objectives that will define success for each initiative, and
- Use the results of monitoring and evaluation to adjust the safety initiatives as necessary to obtain better results.



### 3. STATEWIDE SECURITY EFFORTS

In addition to safety, the security of motorists on South Carolina’s highways is critical especially during emergency events. Maintaining safe traffic flow and keeping roads open for motorists to evacuate from an unsafe area and to allow emergency response teams into the disaster areas is an essential part of any statewide safety and security plan. This requires the efforts of many state and local government agencies. The South Carolina Emergency Management Division (SCEMD) is tasked with the development and implementation of efforts to respond to emergencies and disasters both natural and man-made. According to their web site:

*“The mission of the South Carolina Emergency Management Division is to develop, coordinate and lead the state emergency management program, enabling effective preparation for, and efficient response to, emergencies and disasters in order to save lives, reduce human suffering and reduce property loss. To accomplish this mission, the South Carolina Emergency Management Division:*

- *Develops plans and procedures to ensure the highest levels of mitigation, preparedness, response and recovery.*
- *Maintains a comprehensive, risked-based, multi-hazard emergency management and training program.*
- *Coordinates federal, state and local resources for mitigation, preparedness, response and recovery operations.*

#### 3.1 South Carolina Emergency Operations Plan

The SCEMD web site defines the South Carolina Emergency Operations Plan (SCEOP) as “an all-hazard plan developed for use by state government departments and agencies to ensure a coordinated and effective response to natural, technological, or man-made disasters that may occur in South Carolina. The plan is organized to correspond to the four phases of emergency management: mitigation, preparedness, response, and recovery”.

The plan assigns emergency operations to the government agencies most appropriate to provide effective response. The plan has three major parts consisting of: the governor's Executive Order which assigns responsibilities to the various state and local agencies; the Basic Plan which outlines general policies and procedures that provide coordinated state and local operations; and the functional Annexes which outline the responsibilities of state agencies within the framework of Emergency Support Functions (ESFs).

## 3.2 Types of Disasters and Severe Weather Events in the Plan

The South Carolina Emergency Operations Plan establishes the policies and procedures by which the state will coordinate state and federal response to disasters impacting South Carolina. The plan addresses the various types of emergencies that are likely to occur in the state. Using a relative frequency, potential severity and available historic information, the state identified the following events that had the potential to occur in South Carolina and could result in the loss of life, injuries and the damage or loss of property. The hazardous events include:

- Hurricanes,
- Tornadoes,
- Floods,
- Earthquakes,
- Dam Failure,
- Severe Thunderstorms,
- Wildfires,
- Hazardous Materials,
- Terrorism,
- Drought,
- Nuclear Power Plants, and
- Severe Winter Weather.

## 3.3 Transportation Elements in Emergency Operations Plan

Most of the hazardous events can affect transportation in the state in varying degrees from a low impact in a small area to a major impact affecting most of the state. Some of these events such as major earthquakes and large dam failures are rare occurrences and impacts to the transportation infrastructure will mostly be affected by the damage that occurs during the event. Plans for addressing this are covered in the SCEOP. Other events such as tornadoes are of short duration and mostly in a confined area which does not allow for any transportation plans to be implemented prior to the event. All of the above events are addressed in the SCEOP and SCDOT has specific responsibilities listed in each plan that affects transportation. The most significant event that affects transportation is hurricanes. In the event of a major hurricane, the state may require the evacuation of the coastal areas and other low lying areas near the coast. The size and strength of the hurricane and the unpredictability of its direction of travel can result in large areas of the coast being evacuated which overloads the existing highway system.

## 3.4 Roles of SCDOT and SCDPS

The SCEOP divides the responsibilities of the varying functions into Emergency Support Functions known as ESF. Transportation is ESF-1 and the SCDOT is the responsible state agency serving as the Primary lead for this function. The SCDPS along with thirteen other agencies are assigned as Support for this function depending on the type of emergency event. The function of this support group is to provide for transportation assets and infrastructure essential to support all phases of emergency management and to provide public transportation to temporarily replace or augment services affected in a disaster area.



Emergency Traffic Management is ESF-16 and the Department of Public Safety is the responsible state agency serving as the Primary lead for this function. SCDOT and eight other agencies are assigned as Support for this function. The function of this support group is to provide for coordinated plans, policies and actions of state and local governments to insure the safe and orderly evacuation of populations affected by all hazards and the orderly re-entry into affected areas after the hazard no longer exists. Others missions include ensuring public safety to motorist during hazardous weather conditions, re-routing traffic to protect motorists/pedestrians from hazardous materials and restricting access from flood prone areas. SCDOT has a major role in ESF-16 by providing technical assistance and access to the DOT Intelligent Transportation System network and the assignment of a Senior Traffic Engineer to ESF 16 during activations. SCDOT also assists SCDPS in developing evacuation routes, designating predetermined traffic control points, monitors traffic flow, plans for ingress and egress of emergency vehicles during evacuations, develops and maintains plans for interstate and other major route lane reversals for hurricane evacuations and provides other functions necessary to traffic management.

### 3.5 Recommendations

The South Carolina Emergency Operations Plan is an all-encompassing document which is well planned and detailed for handling all transportation safety and security issues for major events. Some recommendations for revisions to the SCEOP and consideration of other security issues are listed below:

#### 3.5.1 Hurricane Evacuation

Utilize the recent FEMA report; *Vulnerability Analysis for South Carolina Hurricane Events*, to revise the evacuation plans to accommodate the higher clearance times required as a result of this study. The report identifies a much larger storm surge area for the coast during hurricanes and the larger evacuation area along with an increase in permanent population and higher tourist will require higher clearance times for evacuating this additional areas.

#### 3.5.2 Interstate Incident Clearance

Develop an Incident Action Plan for each area of all interstates to identify emergency response agencies that would respond to an incident in each area, to assign tasks for clearing the incident quickly and obtain more responsive Tower Service Operators for large vehicles. Also seek to obtain more hazardous clean up companies that can quickly respond to a hazmat incident. Set a goal of clearing all interstate incidents in 90 minutes.

#### 3.5.3 Significant Transportation Infrastructure

There are significant bridges on interstates and other major routes over large waterways which carry heavy traffic volumes. In the event of a failure of one of these major structures, whether by terrorism, accident or structure failure, establishing a detour for the heavy traffic volumes on these routes would be a significant problem due to lack of capacity on alternate routes or the significant distance for a detour. In some cases, there is no alternative route to detour traffic. SCDOT should review the possible detour alternatives for these areas and establish a plan of action for a short term and long



term detour. In the case where there is no detour route (US 278 onto Hilton Head Island), plans for establishing a temporary bridge or the use of a ferry should be considered. The following are some significant locations that are recommended to be considered for this review.

- I-95 over Lake Marion
- I-526 over the Ashley River
- I-526 over the Cooper River
- I-526 over the Wando River
- I-85 over Lake Hartwell
- I-95 over the Savannah River
- US 17 over the Cooper River (Ravenel Bridge)
- US 278 bridge onto Hilton Head Island



## 4. REFERENCES

- National Highway Traffic Safety Administration. *Traffic Safety Facts 2011*
- National Highway Traffic Safety Administration. *Traffic Safety Facts 2010*
- National Highway Traffic Safety Administration. *Traffic Safety Facts 2011, Bicyclists and Other Cyclists*
- South Carolina Department of Transportation. *The Roadmap to Safety, South Carolina's Strategic Highway Safety Plan. 2007*
- P.L. 112-141, The Moving Ahead for Progress in the 21<sup>st</sup> Century Act (MAP-21), 23 U.S.C. 148
- Federal Highway Administration, Office of Highway Safety. *Highway Safety Improvement Program (HSIP) MAP-21 Interim Guidance*. September 24, 2012
- Federal Highway Administration, Office of Highway Safety. *Strategic Highway Safety Plan (SHSP) Interim Guidance*. April 5, 2013
- South Carolina Department of Transportation, Traffic Engineering Office. *Elements of a Strategic Highway Safety Plan for South Carolina*. October 26, 2012.
- National Highway Traffic Safety Administration. *Traffic Safety Facts South Carolina 2007 – 2011*
- National Highway Traffic Safety Administration. *Uniform Guidelines for State Highway Safety Programs*. November 2006.
- American Association of State Highway and Transportation Officials. *AASHTO Strategic Highway Safety Plan*. 2004.
- National Cooperative Highway Research Program. *NCHRP Report 500, Volume 4: A Guide for Addressing Head-on Collisions*. 2003.
- Federal Highway Administration, Office of Highway Safety. *Proven Safety Countermeasures*. <http://safety.fhwa.dot.org>



Federal Highway Administration. *Intersection Safety Case Study: Retroreflective Borders on Traffic Signal Backplates, A South Carolina Success Story*. February, 2010.

South Carolina Department of Transportation, Traffic Engineering Office. *Open Graded Friction Course Study*. March 14, 2012.

American Association of State Highway and Transportation Officials. *Roadside Design Guide*, 4<sup>th</sup> Edition. 2011

Federal Highway Administration. *Highway Safety and Trees: The Delicate Balance*. 2006

Traffic Records Coordinating Committee. *South Carolina Strategic Plan for Traffic Records Improvements*. May 21, 2013.

Federal Highway Administration. *Strategic Highway Safety Plan Implementation Process Model*. June, 2010.

South Carolina Department of Transportation. *Engineering Directive Memorandums*. <http://www.scdot.org/doing/engineering.aspx>.

South Carolina Emergency Management Division. *The South Carolina Emergency Operations Plan*. February 2011. <http://www.scemd.org>.

Federal Emergency Management Agency. *Vulnerability Analysis for South Carolina Hurricane Events*. January 2012.