Highway Safety Improvement Program Guidelines

August 2021

HSIP

Highway Safety Improvement Program

Data Driven Decisions

Protection of Data from Discovery & Admission into Evidence:

23 USC 148(h)(4) stipulates that data compiled or collected for the preparation of the HSIP Report "…shall not be subject to discovery or admitted into evidence in a Federal or state court proceeding or considered for other purposes in an action for damages arising from any occurrence at a location identified or addressed in such reports…" This information is also protected by 23 USC 409 (discovery and admission as evidence of certain reports and surveys).

For additional information about the Florida HSIP, please email or phone the contact below:

Lora Hollingsworth, PE
Chief Safety Officer
Florida Department of Transportation
605 Suwannee Street
Tallahassee, FL
Phone: (850) 414-3100
Email: Lora.Hollingsworth@dot.state.fl.us

Table of Contents

Abbreviations

2R	resurfacing or restoration
3R	resurfacing, restoration, and rehabilitation
AADT	annual average daily traffic
AASHTO	American Association of State Highway and Transportation Officials
ACF	average crash frequency
ARBM	All Roads Base Map
AVC	annualized value of costs
BCR	benefit-cost ratio
CAR	Crash Analysis Reporting system
CC	crash cost
CDIP	Crash Data Improvement Program
CFR	Code of Federal Regulations
CMF	crash modification factor
COTS	commercial-off-the-shelf
DSE	District Safety Engineer (as in FDOT DSE)
FLHSMV	Florida Department of Highway Safety and Motor Vehicles
EMS	emergency medical services
EPDO	equivalent property damage only
FARS	Fatality Analysis Reporting System
FAST Act	Fixing America's Surface Transportation Act
FDE	fundamental data elements (as in MIRE FDE)
FDOT	Florida Department of Transportation
FHWA	Federal Highway Administration
F.S.	Florida Statute
GIS	geographic information system
HPMS	Highway Performance Monitoring System
HRRR	High Risk Rural Roads
HRRRP	High Risk Rural Roads Program
HSIP	Highway Safety Improvement Program
HSM	Highway Safety Manual (published by AASHTO)
IHSDM	Interactive Highway Safety Design Model
ITS	intelligent transportation systems
ISATe	Interchange Safety Analysis Tool
KABCO	scale by the National Safety Council categorizing injury severity
LAP	locally administered project
LHS	local highway system
LRS	linear referencing system
LRSP	local road safety plan
MAP-21	Moving Ahead for Progress in the 21st Century
MIRE	Model Inventory of Roadway Elements
MPO	Metropolitan Planning Organization

NCHRP	National Cooperative Highway Research Program
NPV	net present value
ORT	Online Reporting Tool (for HSIP)
PBCAT	Pedestrian and Bicycle Crash Analysis Tool
PD&E	project development & environment
PDO	property-damage-only
PM	performance measure
PSI	potential for safety improvement
PVB	present value of benefits
PVC	present value of costs
RCI	Roadway Characteristics Inventory
RSA	road safety audit
SAFETEA-LU	Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users
SHS	State Highway System
SHSP	Strategic Highway Safety Plan
SPF	safety performance function
SSO	State Safety Office (as in FDOT SSO)
STIP	Statewide Transportation Improvement Program
TDA	Transportation Data and Analytics Office (as in FDOT TDA)
TEO	Traffic Engineering and Operations Office (as in FDOT TEO)
TPO	Transportation Planning Organization
TRCC	Traffic Records Coordinating Committee
USC	United States Code
VMT	vehicle miles traveled

Foreword

The purpose of this document is to provide information and guidelines to Florida Department of Transportation staff, local agencies, and other stakeholders involved with implementing the Highway Safety Improvement Program (HSIP) on all public roads in Florida. This document supersedes the Florida Department of Transportation (FDOT) HSIP Guideline (1991). This document does not address administration or expenditures of Section 130 railway-highway crossing funds, apart from the potential transfer of funds to the HSIP.

The FDOT State Safety Office (SSO), FDOT Districts, FDOT Turnpike Enterprise, and Federal Highway Administration (FHWA) Florida Division Office regularly review this document to ensure it reflects current practice. Updates may reflect changes in legislation, funding, program requirements, and standards of practice. Please contact the FDOT SSO to report any major errors in this manual. Amendments shall be made with concurrence from the FHWA Florida Division Office.

In addition to this document, FDOT develops and makes available many tools that analyze safety data and predict the benefits of safety improvement strategies. Reference to these tools has been incorporated in this document as well as links to information on how to apply those tools. Readers are encouraged to review other resources and seek technical assistance to help implement an effective HSIP in Florida.

1. HSIP Overview and Administration

Safety is the highest priority at Florida Department of Transportation (FDOT or "the Department"). The Highway Safety Improvement Program (HSIP) is FDOT's largest source of safety improvement funding. The HSIP is a state-administered, core Federal-aid program with the purpose of achieving a significant reduction in traffic fatalities and serious injuries on all public roads. The HSIP is a data-driven program and focuses on improvements to the safety performance of the road network.

The Florida Strategic Highway Safety Plan (SHSP), which outlines a vision of eliminating fatalities and reducing serious injuries on Florida's public roads, guides the HSIP. Twelve emphasis areas and six evolving emphasis areas are the primary focus for Florida's traffic safety improvement efforts. FDOT supports a broad range of programs aimed at eliminating fatal or serious injuries on Florida roadways.

The roles in administering and implementing the HSIP are as follows:

- The **FDOT State Safety Office** (SSO) manages the HSIP and evaluates the program's effectiveness. The SSO determines the eligibility of projects for funding approval and provides policies, tools, and guidelines to assist the Districts, Turnpike Enterprise, and local agencies with implementing the HSIP.
- The **FDOT Districts and Turnpike Enterprise** manage project funding and are responsible for delivering highway safety improvement projects. Each District has a District Safety Engineer (DSE) and supporting staff that identify, plan, design, and implement HSIP projects with support from the SSO. Each District also works with Metropolitan Planning Organizations (MPO), Transportation Planning Organizations (TPO), and local jurisdictions to assist them in improving safety within their District.
- The **Federal Highway Administration** (FHWA) assists with program strategy, oversees all Federal-aid expenditures, and assures the HSIP meets federal requirements. FHWA also offers technical assistance and training to FDOT and local agencies.
- Florida's **MPOs, TPOs, and local agencies** are integral to addressing the safety problems on all public roads. MPOs, TPOs, and local agencies coordinate with FDOT's Districts to identify and implement effective off-system highway safety improvement projects. Local agencies also develop and implement locally administered projects (LAPs) as well as Local Road Safety Plans (LRSP) to improve safety in their jurisdictions.
- **Partner organizations** serve as ambassadors of traffic safety and help promote the vision of *Driving Down Fatalities*. Partners include charities, community groups, universities, and professional associations responsible for supplemental programs that improve safety beyond road engineering, which helps achieve the HSIP's goals.
- **Community Traffic Safety Teams** (CTST) are multi-jurisdictional, with members from city, county, state, and occasionally federal agencies, as well as private industry representatives and local citizens. CTSTs integrate the 4E approach to safety (engineering, enforcement, education, and emergency services) to help solve local traffic safety problems and promote public awareness of traffic safety. Many effective HSIP projects are initiated through CTSTs.
- **Florida's road users are the most important stakeholder in the HSIP**. Each HSIP project aims to improve the safety and quality of life for road users. The HSIP is most effective when the public is

engaged in safety, provides feedback during the development of HSIP projects, and actively reports safety concerns to FDOT and local government agencies.

1.1 HSIP Background Information

The HSIP has been a part of the Federal-aid highway program since 1979. During 2005, the Safe, Accountable, Flexible, and Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) was signed into law, which established the HSIP as a core Federal-aid program with increased funding levels. With the signing of the Moving Ahead for Progress in the 21st Century (MAP-21) legislation in 2012, HSIP funding nearly doubled and there was more flexibility in types of eligible projects and activities. The Fixing America's Surface Transportation (FAST) Act of 2015 continued similar funding levels and introduced restrictions on the types of eligible safety improvement projects. FHWA regulates the development and implementation of the HSIP under Title 23 CFR 924, accompanied by general policy memorandums.

1.2 FDOT Organization and Safety Program Contacts

FDOT is decentralized with a Central Office and seven District Offices. The FDOT Organization Chart is available at this link. Table 1 lists the primary contacts for the HSIP. Please feel free to contact us for more information.

Table 1. Primary FDOT Contacts for HSIP

Office Contact Name	Phone Number	Website
FDOT State Safety Office Chief Safety Officer Lora Hollingsworth	(850) 414-3100	https://www.fdot.gov/safety/7-ContactUs/CO-StaffDirectory.shtm
FDOT State Safety Office State Safety Engineer Brenda Young	(850) 414- 4146	https://www.fdot.gov/safety/7-ContactUs/CO-StaffDirectory.shtm
FDOT State Safety Office Safety Data Coordinator Rupert Giroux	(850) 414-4072	https://www.fdot.gov/safety/7-ContactUs/CO-StaffDirectory.shtm
FDOT State Safety Office Crash Records and Research Administrator Ben Jacobs	(850) 414-4007	https://www.fdot.gov/safety/7-ContactUs/CO-StaffDirectory.shtm
FDOT Districts District Safety Engineers	See website.	http://www.fdot.gov/agencyresources/districts/

1.3 HSIP Delivery Overview

The SSO, Districts, and Turnpike Enterprise are responsible for managing the HSIP as well as providing strategy guidance, policies, and tools to local agencies and traffic safety partners responsible for administration and delivery of highway safety improvement projects.

The Department's HSIP focuses on highway safety improvement projects that are:

- Low cost (typically under $1,000,000).
- Shorter-term, with concept to construction in under three years.
- Implemented on a public road.
- Addressing a problem known to result in fatalities and serious injuries.

23 USC 148(c) indicates a focused, data-driven approach should be used for safety problem identification, countermeasure analysis, and resource allocation. Safety funds should be used on the most effective countermeasures at the locations with the greatest needs. The Department actively uses the AASHTO Highway Safety Manual (HSM) and other data-driven approaches discussed throughout this document.

The primary intent of the HSIP is to implement engineering safety improvements. However, HSIP project development should consider the 4E (i.e., education, enforcement, engineering, and emergency services) and 4I (i.e., innovation, insight into communities, information intelligence, and investments and policies) methodologies through the Safe System approach promoted by FHWA in FHWA-SA-20-018. Safety studies should consider the 4Es and 4Is when determining whether engineering is effectively improving safety at each location. Comprehensive strategies pairing HSIP engineering projects with complementary efforts from other disciplines is proven to increase the effectiveness of safety improvements. Figure 1 illustrates the various roles within the Florida HSIP.

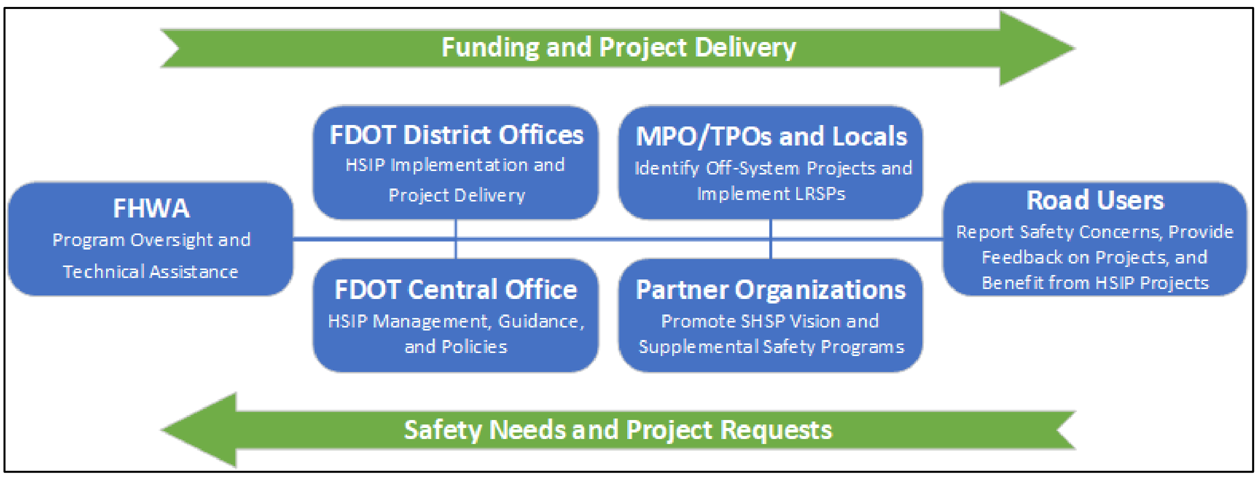

Figure 1. Stakeholders have different roles in delivering the Florida HSIP.

1.4 HSIP Eligibility

23 USC 148(a) provides a sample listing of eligible highway safety improvement project types. However, any project meeting all the following requirements is potentially eligible for funding in the HSIP.

- Implements safety infrastructure countermeasures or improves safety data collection, integration, and analysis such that HSIP stakeholders can better plan, implement, and evaluate highway safety improvement projects in the future.
- Consistent with an emphasis area, strategy, or activity identified in the Florida SHSP.
- Estimated benefit-cost ratio (BCR) of 1.0 or greater.

- Addresses a serious crash risk or safety problem identified through a data-driven process.
- Likely to result in a reduction of fatalities and serious injuries.

Non-eligible activities include education, public outreach, and enforcement (such as those previously allowed under MAP-21).

1.5 Strategic Highway Safety Plan

In compliance with 23 CFR 924.7, Florida maintains and updates an SHSP that identifies key highway safety emphasis areas and strategies. The Florida SHSP provides a framework for how Florida's traffic safety partners will move toward the vision of a fatality-free transportation system with the understanding that the death of any person is unacceptable. The Florida SHSP introduces a **Safe System** approach promoted by FHWA to address all elements of a safe transportation system in an integrated manner The SHSP lays the foundation for the Department's HSIP by identifying major contributing factors to fatal and serious injury crashes as well as strategies aimed at reducing or preventing serious crashes.

1.5.1 Updating the Strategic Highway Safety Plan

The Department updates the SHSP at least every five years in coordination with statewide, regional, and local safety partners. The Florida SHSP focuses on 12 emphasis areas and 6 evolving emphasis areas. Together these emphasis areas reflect ongoing and emerging statewide highway safety issues. The strategies related to each emphasis area are multidisciplinary and align with the Safe System approach using the 4E and 4I methodologies.

The SHSP is important to the HSIP as it establishes FDOT priorities for investments in safety. As discussed in the previous section, Federal law requires any expenditure of HSIP funds to be consistent with priorities established in the SHSP. For this reason, it is important to consider the SHSP in the HSIP process and account for future HSIP needs when updating the SHSP.

1.5.2 Local Road Safety Plans

Many counties in Florida develop and implement a Local Road Safety Plan (LRSP). These plans should be consistent with the Florida SHSP and focus on specific, high-priority emphasis areas and strategies for local road safety. HSIP funds can be used to develop LRSPs, which are a proven safety countermeasure presented in FHWA-SA-17-069.

LRSPs support strategic safety management on off-system roads through the identification, analysis, and prioritization of roadway safety opportunities and improvements on the local system. For example, local areas with a large proportion of rural roads may use data to show a focus on reducing fatal and serious injury run-off-road crashes. Counties and other local agencies should consider developing and implementing LRSPs to:

- Define local safety priorities.
- Prioritize safety investments on off-system public roadways.
- Communicate safety improvement opportunities to stakeholders.
- Apply for HSIP funding.

LRSP development mimics the SHSP development process but focuses on local issues and needs. LRSPs should have a prioritized list of issues, risks, actions, and improvements that can be used to reduce fatalities and serious injuries on off-system roads. FHWA publishes *Developing Safety Plans: A Manual for Local Road Owners* (FHWA-SA-12-017) which outlines the LRSP development process and contains an LRSP template.

1.6 HSIP Reporting

Federal legislation requires each State to submit an HSIP report. Collectively, all State HSIP reports inform Congress regarding progress to reduce fatalities and serious injuries nationally. The SSO submits an HSIP annual report to FHWA by August 31 each year using the HSIP online reporting tool (ORT). HSIP reporting in Florida is a collaborative process involving crash data, traffic data, roadway data, project data, financial data, and the efforts of multiple offices. The Crash Reduction Analysis System Hub (CRASH) application analyzes data and produces outputs that facilitate HSIP reporting. The HSIP report helps ensure program implementation occurs as intended to achieve the SHSP purpose. More information is available on the HSIP ORT website.

1.7 HSIP Funding

The HSIP is a state-administered, federal-aid highway program with the purpose of reducing traffic fatalities and serious injuries on all public roads. Funding is apportioned to Florida per FAST Act formulas explained on the FHWA website. In recent years, Florida has received over $100M annually for the HSIP.

Prioritized lists of safety needs are maintained by each FDOT District. Proposed HSIP projects are authorized and funded through procedures outlined later in this guide and in the FDOT Work Program Instructions, which are accessible through online (Work Program Instructions (fdot.gov)).

1.7.1 Applying HSIP Funds to Non-HSIP Projects

Safety improvements or features routinely included in broader Federal-aid projects (such as guardrail) should be funded from the same source funds as the broader project whenever possible. HSIP funds are primarily reserved for standalone safety projects, targeting serious safety problems as cost-effectively as possible.

However, when it would yield efficiencies in funding due to construction mobilization, work force management, or other factors, Districts may consider using HSIP funds to add safety countermeasures or hardware to non-HSIP projects. When applying HSIP funds to non-HSIP projects, HSIP funding should be limited to countermeasures that meet HSIP eligibility requirements and are expected to reduce fatalities and serious injuries.

1.7.2 Funding Obligation and Availability

All apportioned funds should be obligated to the combination of projects with the highest estimated reduction in fatalities and serious injuries that meets all program requirements.

According to FHWA-PL-17-011, HSIP funds laps after four years. If FDOT obligates fewer HSIP funds than the amount apportioned in a given year, the unobligated balance builds and can eventually lead to the funds lapsing. Lapsing funds are redistributed amongst other states in August each year. It is important that the Department maintain an active HSIP program and a backlog of needs to prevent funds from lapsing.

1.7.3 Federal Share for HSIP Projects

Per 23 CFR 924.11, HSIP projects are funded with 90% Federal share of apportioned funds and 10% state match. Some exceptions may be funded at 100% Federal share as listed in 23 USC 120(c)(1).

1.7.4 Transferability of Apportioned Funding

Per 23 USC 126, the Department may transfer up to 50% of its apportionment (as referenced in FHWA-PL-17-011) to the HSIP from the National Highway Performance Program (NHPP), Congestion Management and Air Quality Improvement Program (CMAQ), National Highway Freight Program (NHFP), Surface Transportation Block Grant (STBG)—except from the portion sub allocated to areas by population, and Transportation Alternatives Program (TA)—but only from the portion available for use anywhere in Florida. Up to 100% of the Railway-Highway Grade Crossings Program (RCHP) apportionment may be transferred to the HSIP if the Department demonstrates to FHWA that it has met all needs for installation of protective devices at railway-highway crossings.

FDOT may also transfer apportionments out of HSIP to the NHPP, NHFP, STBG, CMAQ, or TA. However, this should only be done if HSIP funding would otherwise lapse. The HSIP supports safety, which is the top priority at FDOT.

For ease of administration, the law also allows the Department to request that FHWA transfer funds among entities to fund eligible projects (e.g., between FHWA and the Federal Transit Administration, and from one State to another or to FHWA). In these instances, the transferred funds are still used for the original purpose; they are just administered by a different entity. The Department may use this allowance to fund pooled fund studies and other initiatives.

1.8 HSIP Special Rules

The FAST Act includes two special rules for the HSIP as part of 23 USC 148(g) to emphasize High Risk Rural Roads (HRRR) as well as older drivers and pedestrians. More recently, FHWA established the Safety Performance Management Measures and HSIP Final rules, which affect the administration of the HSIP. The following subsections discuss these rules and penalties associated with them.

1.8.1 Special Rule for High Risk Rural Roads

The HRRR Special Rule (as discussed by FHWA online) defines HRRRs to include any rural major, minor collector, or rural local road with significant safety risks. The Special Rule emphasizes the overrepresented fatalities and serious injuries on these roadways. The Department has not formally defined the "significant safety risks" for HRRRs in Florida on which penalty funds could be spent.

The *Highway Safety Improvement Program MAP-21 High Risk Rural Roads Guidance* issued by FHWA in 2012 states that if the fatality rate increases across these three functional classifications in the most recent two-year period, then FDOT must set aside $9,445,004 of its HSIP funding for HRRR improvements in the next fiscal year. FHWA uses five-year rolling average fatality rates based on FARS and HPMS data to assess HRRR rule applicability. The Department is not responsible for assessing its performance for this Special Rule.

If the HRRR Special Rule applies in any year, FHWA will notify FDOT to begin programming HRRR projects. FDOT SSO will then outline a plan to spend the penalty funds in the HSIP Annual Report. It is imperative to spend all HRRR penalty funds in the first year they apply. FHWA Memorandum 113017 states that If funds set aside as part of the HRRR Special Rule are not spent the next immediate fiscal year, then remaining funds are returned to FHWA and subject to redistribution. The balance must be spent in the next year with formula obligation limitation. Having some projects on HRRRs annually in the HSIP will minimize changes to the program should this Special Rule apply.

1.8.2 Special Rule for Older Drivers and Pedestrians

The Older Drivers and Pedestrians Special Rule (as presented by FHWA online) defines older drivers and pedestrians as road users over the age of 65. If fatalities and serious injuries per capita for this demographic increase over the recent two-year period, Florida is required to include strategies in the SHSP to address the increases in those rates.

Each year, the SSO determines if the Special Rule applies by checking whether the five-year rolling average rate of older driver and pedestrian fatal and serious injury crashes increased across the most recent 2-year period. To calculate the rates required for this rule, the annual number of fatal and serious injury crashes involving drivers and pedestrians 65 years of age and older from the Fatality Analysis Reporting System (FARS) supported by NHTSA is divided by the number of people 65 years of age or older per 1000 total population (provided by *Section 148: Older Drivers and Pedestrians Special Rule Final Guidance* from FHWA) These annual rates are then averaged over the appropriate five-year windows. For example, the 2018 HSIP Annual Report compares rates between 2010-2014 and 2012-2016.

Florida's latest SHSP already includes an Aging Road User emphasis area. If this Special Rule applies in the future, the Department will consider strategies within the existing emphasis area to better target older driver and pedestrian crashes. If future versions of the SHSP do not include an Aging Road Users emphasis area and this Special Rule applies to Florida, the FAST Act requires it be reintroduced in the next version of the SHSP. The Safe Mobility for Life Coalition is one of Florida's continuing strategies to improve the safety of older road users. The *Handbook for Designing Roadways for the Aging Population* (FHWA-SA-14-015) also includes strategies targeting older road users.

1.8.3 Safety Performance Management Measures Final Rule

The *National Performance Management Measures: Highway Safety Improvement Program*, a rule by FHWA regarding safety performance measures, established the following five performance measures for the HSIP, effective April 14, 2016.

1. Number of fatalities.
2. Rate of fatalities per 100 million vehicle miles traveled (VMT).
3. Number of serious injuries.
4. Rate of serious injuries per 100 million VMT.
5. Number of non-motorized fatalities and non-motorized serious injuries.

Florida targets zero fatalities and serious injuries on all public roads in Florida, hence the target is zero for the five measures. FDOT SSO reports on these measures as five-year rolling averages in the HSIP Annual Report. MPOs may target zero or establish their own targets. FDOT performance measures and targets for HSIP shall be identical to those in the Highway Safety Plan (HSP). More information is available on the HSIP Rulemaking website.

Annually, FHWA determines whether Florida meets the targets or performs better than baseline for at least four of the five measures. If Florida fails to do so, then the Department must reserve a large portion of HSIP obligation authority only for HSIP (i.e., it cannot be transferred out) and submit an annual implementation plan with actions the Department will take to meet targets in the future. FDOT continues to improve its planning and programming decision making and support tools to yield the greatest possible improvements in safety performance.

1.8.4 HSIP Final Rule

The HSIP Final Rule, effective April 14, 2016, updates the existing HSIP requirements under 23 CFR 924 to be consistent with MAP-21 and the FAST Act and clarifies existing program requirements. There are no established penalties associated with this rule.

Specifically, the HSIP Final Rule added the following requirements:

1. The SHSP must be updated at least once every five years.
2. The HSIP Annual Report is due August 31st. The SSO must use the HSIP ORT to submit the report, as discussed previously. The Annual Report must include a description of progress toward achieving safety performance targets.
3. Florida must collect and use the Model Inventory of Roadway Elements (MIRE) fundamental data elements (FDE) on all public roads to support enhanced safety analysis by September 30, 2026. By the FHWA *Guidance on State Safety Data Systems*, MIRE FDE are a subset of roadway data elements representing the minimum data to conduct advanced safety analysis, which includes basic geometric and location data to assign a facility type plus its annual average daily traffic (AADT).

More information is available on the HSIP Rulemaking website.

2. Safety Data and Analysis Tools

Per 23 CFR 924, highway safety improvement projects in the HSIP must be data-driven. Safety data is the basis for safety analysis and safety improvement project development. When extensive data are available for roadways and crashes, decision making to advance safety is more effective. If analysis methods are not appropriate to available data elements, the reliability of data-driven analysis decreases and may result in less effective projects. Analysts should use analysis methods that are appropriate for the roadway and crash data available.

The Department and our partners maintain and continually improve safety data sets consisting of crash, roadway, traffic, and completed project data to support the HSIP. Various tools and software analyze safety data to better inform project planning, design, resource allocation, and effectiveness evaluations. Many of these tools are necessary to facilitate the calculations required in advanced safety analysis.

FDOT SSO recommends using the most appropriate analysis methods available when identifying and planning HSIP projects. The most appropriate methods vary by location due to roadway type and data availability. The FDOT Safety Engineering website is a resource sharing information about crash data, safety analysis, countermeasures, reference material, training, and other resources.

2.1 Crash Data

Crash data are the basis of safety analysis. A roadway's safety performance is determined primarily by the frequency, severity, and type of crashes occurring on them. Crashes are reported by law enforcement or self-reported by drivers to the Florida Department of Highway Safety and Motor Vehicles (FLHSMV). Any crash with over $500 in damage is considered reportable. In Florida, crashes are reported with a long-form or short-form version of the crash report. Long-form reports are required for injury crashes, commercial vehicle crashes, towaway crashes, and other scenarios. All other crashes may be reported with the short-form version, which contains the same information except the narrative and diagram portions. Appendix A: Crash Data Collection Process includes more information.

FDOT maintains the Crash Analysis and Reporting (CAR) database, which contains long-form and short-form crash records from FLHSMV. FDOT SSO verifies geolocations of long-form records and connects them to roadway data from the Roadway Characteristics Inventory (RCI). CAR system crash data is accessible by several means. Public access is available through the FDOT Open Data Hub and the public version of SSOGis (State Safety Office Geographic Interface Software). Controlled access to CAR system crash data is available through CAR Online and the access-controlled version of SSOGis.

The Department strongly recommends using crash data with verified geolocations for HSIP network screening and economic justification analyses. Verified geolocations shall come from FDOT systems, staff, or consultants. The Department also recommends using at least three to five years of crash data under consistent site conditions in safety analysis. The FDOT Safety Engineering website provides information about accessing crash data.

Property Damage Only (PDO) crashes have a larger influence on congestion than on safety and are not a major consideration in the HSIP. However, PDO crashes should be accounted for to the extent possible. Many reportable PDO crashes are recorded via the short form and do not have verified geolocations in

FDOT crash data systems. Other PDO crashes are not reported at all and do not reach FLHSMV, the official repository for crash reports for the State of Florida.

Florida Signal Four Analytics (S4A) is an interactive, web-based system that supports crash mapping and analysis needs. crash data system maintained by the University of Florida GeoPlan Center and supported by the Florida Traffic Records Coordinating Committee (TRCC). S4A crash data can be used as a supplementary reference for crash data. S4A shows all crash records (long and short form) from FLHSMV, which can help verify crash patterns. S4A automates geolocation and supplements missing geolocations with verified-location data from the FDOT CAR database. Engineering applications and processes should use location-verified crash data from the FDOT CAR database.

2.2 Roadway and Traffic Data

Roadway and traffic data are available on the State Highway System (SHS) and off-system sections required for the FHWA Highway Performance Monitoring System (HPMS) within RCI. The FDOT linear referencing system (LRS) is a route-milepost based system. The Department maintains roughly 10% of public roadway mileage in Florida. HPMS data are required for roads above local functional classification. Some local roads are also in HPMS as sample sections. Altogether, the data in the RCI account for approximately 30% of public road mileage and the locations of over 60% of fatalities. The All Roads Base Map (ARBM) seamlessly links the LRS and linear geometry of state-maintained roadways with local roads. The ARBM and tools based on the ARBM, like the Florida All Roads Intersections and Segments (FLARIS) geo-datasets, are accessible behind the FDOT firewall. Roadway data from the RCI, HPMS, and HERE data are conflated into one basemap. FDOT roadway-characteristic data is available in the FDOT Open Data Hub.

Data availability varies for roads and intersections. State road segments have the most data, including location, classification, cross section, traffic volume, and other segment descriptors; intersections have less, but include traffic control, functional classification, area type, and traffic volumes. Local road segments and intersections have less data, and usually have no traffic volumes. Ramp and ramp terminal data are even more limited.

2.3 Crash Reduction Analysis System Hub

The FDOT Crash Reduction Analysis System Hub (CRASH) is a web-based application developed mainly for the selection and evaluation of improvement projects for highway safety. Specifically, it has the following five functions:

- Perform benefit-cost analysis of safety improvement project.
- Perform before-and-after analysis to evaluate the effectiveness of safety programs.
- Serve as a central storage location for safety improvement projects.
- Update crash reduction factors (CRFs) using implemented safety improvement projects and crash records.
- Generate standard reports for annual HSIP reporting.

Access to the CRASH system is restricted to authorized personnel only. Contact SSO for more information.

2.4 FHWA HSIP Manual

The FHWA HSIP Manual (FHWA-SA-09-029) was published in 2009 and describes the HSIP roadway safety management process. The manual includes many data-driven, strategic approaches to analyzing and delivering safety projects. While the FHWA HSIP Manual is a good reference for basic information and analysis methods when data are limited at a location, the SSO recommends more progressive data-driven analyses like those in the Highway Safety Manual (HSM). Progressive analyses are particularly recommended if appropriate data is available on the SHS or other public roadways.

2.5 AASHTO Highway Safety Manual

The Highway Safety Manual (HSM) provides statistical tools which can be used from the Systems Planning Process through Operations and Maintenance. Benefits from using these tools include safety, operational, and financial benefits. FDOT encourages transportation planners, engineers, and other decision-makers to implement this manual on FDOT projects whenever possible. MIRE FDE, crash data, and SPFs are needed to apply most HSM methods.

FDOT supports research to configure and customize the HSM methods to Florida's roadways. The SSO maintains an HSM Implementation website with more information, and Integrating the HSM into the Highway Project Development Process (FHWA-SA-11-50) by FHWA is another resource. The Department also promotes the use of analysis software that implement HSM methods. Examples include AASHTOWare Safety Analyst, AASHTOWare Safety by Numetric, and Interactive Highway Safety Design Model (IHSDM). and tools related to SAFE STRIDES 2 Zero. Please note that AASHTOWare Safety Analyst is due to sunset by June 30, 2022. SSO also recommends the SPF Tool and other applications that support SAFE STRIDES 2 Zero. Districts may use spreadsheets or other analysis tools to apply HSM and other data-driven safety analysis methods. Reference documents about applying and implementing HSM recommendations are available through the SSO Safety Engineering website (Publications and Manuals (fdot.gov)).

The FDOT HSM User's Guide provides an abbreviated overview for practitioners of the HSM. The intent is to provide guidance on the application of the HSM. The *FDOT HSM User's Guide* contains information on the following topics.

- HSM Terms and Concepts
- HSM Predictive Method
- Selecting an Appropriate CMF or CRF
- Applying Countermeasure CMFs

2.5.1 Overview of Predictive and Performance-Based Safety Analysis

The HSM provides methods for predictive and performance-based safety analysis. The number of crashes occurring over time is the fundamental indicator of a roadway's "safety." However, by solely looking at the crash history of one location (i.e., frequency, type, and severity), it is difficult to determine if that site is performing relatively well or relatively poorly. Performance-based analyses compare a site to many others with similar geometric and operational characteristics to determine how it is performing and indicate factors contributing to differences in performance.

The simplest way to conduct performance-based analysis is to compare a site's crash frequency or rate to the average for similar sites. A more reliable, predictive method is to use safety performance functions

(SPF). SPFs are statistical models that better account for the randomness of crash occurrence, changes in traffic volumes, and other biases to estimate a long-term average predicted crash frequency performance threshold. The empirical Bayes (EB) method estimates a more reliable estimate of a site's crash frequency.

Crash modification factors (CMF) are another predictive tool to estimate the effectiveness of countermeasures in changing a location's crash frequency, type, and severity. CMFs are an important tool in estimating the benefits of proposed HSIP projects and determining funding eligibility. The FDOT Safety Engineering website, FDOT HSM User's Guide and the FHWA CMF Clearinghouse are good resources for finding and selecting appropriate CMFs for analysis.

Performance-based analyses provide a better indication of the potential to improve safety at a location. However, the results of analyses using only crash history and those incorporating predictive methods are not directly comparable. The *FDOT HSM User's Guide* and *HSM Chapter 3: Fundamentals* further explain these concepts.

2.5.2 SAFE STRIDES 2 Zero Program

State Traffic Roadway and Intersection Data Evaluation System (STRIDES) 2 Zero is a program to evaluate roadway safety and mobility for SHS intersections and roadway segments. STRIDES 2 Zero uses predictive and performance-based safety analysis as discussed in Section 2.5.1 for network screening. Furthermore, it evaluates the effectiveness of implemented countermeasures.

System Analysis and Forecasting Evaluation (SAFE) follows HSM procedures for network screening and is the first program developed under the STRIDES 2 Zero initiative. SAFE is a network screening program for SHS roadways utilizing Department and external data to increase the accuracy of crash predictions. SAFE also supports business decisions by analyzing changes to the SHS using Return on Investment (ROI) analysis.

The FDOT Traffic Engineering and Operations (TEO) office spearheads the SAFE STRIDES 2 Zero Program. The methodology of the SAFE STRIDES 2 Zero Program addresses intersection safety on the SHS through the following steps:

- Group intersections by context classification, traffic control type and number of legs;
- Develop safety performance functions (SPF) with collected intersection and crash data;
- Evaluate intersection safety performance using state-of-the-art crash predictive models;
- Calculate highly reliable excess expected crash frequency with Empirical Bayesian (EB) method;
- Identify candidate intersections with high potential for safety improvements and their sisters; and
- Propose engineering countermeasures for candidate intersections and rank them by benefit-cost ratio (BCR).

Currently, the program is focused on signalized intersections on state highway systems. In the near future, it will expand to include both unsignalized intersections and roadway segments.

2.5.3 Interactive Highway Safety Design Model and HSM Spreadsheets

The Interactive Highway Safety Design Model (ISHDM) software suite and HSM Spreadsheets automate the predictive methods in HSM Part C. The Part C predictive methods are typically not used in the planning of HSIP projects. These methods are more detailed and are applicable in the design process once projects are selected and authorized. The Department partners with universities to calibrate the HSM models to Florida's roadways. Applicable calibration factors should be applied whenever possible.

2.5.4 AASHTOWare

The AASHTOWare Safety Analyst software suite automates the roadway safety management process in HSM Part B. Safety Analyst includes the following modules, which generally follow the HSIP roadway safety management process.

- Network screening.
- Diagnosis and countermeasure selection.
- Economic appraisal and project prioritization.
- Safety effectiveness evaluation.
- Systemic analysis.

To conduct these analyses, Safety Analyst requires basic roadway, traffic, and crash data for each road, along with a consistent LRS and milepost system to link data—essentially the MIRE FDE plus crash data. AASHTO intends to sunset AASHTOWare Safety Analyst on June 30, 2022. AASHTOWare Safety by Numetric, Inc is a Software as a Service (SaaS) platform which replaces Safety Analyst and offers analytics for segments, intersections, and trends.

2.6 Pedestrian and Bicycle Crash Analysis Tool

The Pedestrian and Bicycle Crash Analysis Tool (PBCAT) is a software tool that assists users with crash-typing pedestrian and bicycle crashes. Crash-typing is a method of categorizing crashes of similar circumstances and collision types. PBCAT helps users assign accurate crash types that reflect the nature of the collision, rather than just noting that the crash involved a collision with a pedestrian or bicyclist. Characterizing crash types helps to understand the underlying crash contributing factors. Lists, images, and codes of PBCAT's crash types can be found on the PBCAT website.

Crash typology alone is not enough. Besides PBCAT, the PEDBIKESAFE website hosts PEDSAFE and BIKESAFE which provide lists of multidisciplinary countermeasures relating to crash types. PEDSAFE and BIKESAFE also recommend when countermeasures may be appropriate. Users can conduct crash-typing, relate crashes to roadway locations, and identify appropriate countermeasures to address overrepresented crash types. SSO partnered with Signal Four Analytics to include bicyclist and pedestrian crash type data within the S4A system.

3. HSIP Strategy Considerations

The SSO is responsible for strategic guidance statewide in cooperation with the Districts and Turnpike Enterprise for the HSIP. Those responsible for administration and delivery of highway safety improvement projects (District Offices, the Turnpike Enterprise, and local agencies) should consider the strategies outlined in the following sections. These approaches have been shown to enhance HSIP quality and effectiveness based on best practices from other state DOTs and national research.

3.1 Implementing Different Types of HSIP Projects

The Department implements highway safety improvement projects in four ways, outlined below and in the following sections.

- **Systemic projects** focus on mitigating highly prevalent crash types or contributing factors in the SHSP that result in large numbers of fatalities and serious injuries across the network. The Department tries to address these issues as cost-efficiently as possible. Typically, systemic countermeasures are lower-unit cost and implemented at many locations with moderate-to-high potential for safety improvement in the target crash types across a corridor or region (within a standalone project). Systemic projects also include addressing these high priority crash types by adding cost-effective countermeasures to existing 3R, Work Program, or other non-HSIP projects. This is an efficient way to implement systemic safety improvements because it leverages the mobilization and other fixed costs of existing projects.
- **Hotspot projects** focus on the roadway segments, corridors, intersections, or ramps with highest overall potential for safety improvement across the network. The Department tries to address these poorly performing locations with the HSIP if an improvement project is feasible and cost-effective. Hotspot projects should address serious crash patterns and other risks demonstrated by site-specific crash experience as well as geometric and operational characteristics.
- **Policy-based projects** are improvements to bring roadway design or operational features up to a standard. Policy-based countermeasures (also called nominal or systematic) often aim to reduce liability as well as crash risk, such as updating old roadside hardware to current designs or meeting sign retro-reflectivity standards. Typically, policy-based improvements are implemented at all appropriate locations but may be prioritized by site-specific or regional safety performance.
- **Data and analysis projects** enhance the delivery of the HSIP by advancing planning, implementation, and evaluation methods. The Department realizes comprehensive data and modern analytics can improve decision making and increase the effectiveness of resulting projects. However, data and analysis improvements take away from construction funding, so these projects should be strategic with a clear goal to help reduce fatalities and serious injuries.

The SSO suggests District Offices and the Turnpike Enterprise incorporate a combination of these types of projects within the HSIP. Each type addresses serious crash risks and safety problems in a different way, creating a diversified portfolio of investments in safety improvements. However, the HSIP does not have to include projects of each type every year. Districts should use discretion to address their safety concerns with projects that provide the greatest opportunity to reduce fatalities and serious injuries.

Typically, hotspot projects are higher cost and effectiveness than systemic projects on a site-by-site basis. Hotspot projects allow a higher level of investment because higher crash frequencies and traffic volumes have a higher potential for benefits and therefore can justify higher costs. However, less than 10% of sites have much higher crash frequencies than others, as shown in Figure 2—a typical network screening of intersections ranked by fatal and injury crash frequency. Hotspot projects are typically not appropriate at locations with relatively low potential for improvement because tailored projects with a high attention to site-specific analysis are not always warranted.

Systemic projects and policy-based improvements with widespread implementation often achieve greater benefits for the same level of investment and are applicable to more sites. These types of projects have a greater opportunity to maximize the effectiveness of investments and affect statewide fatalities and serious injuries.

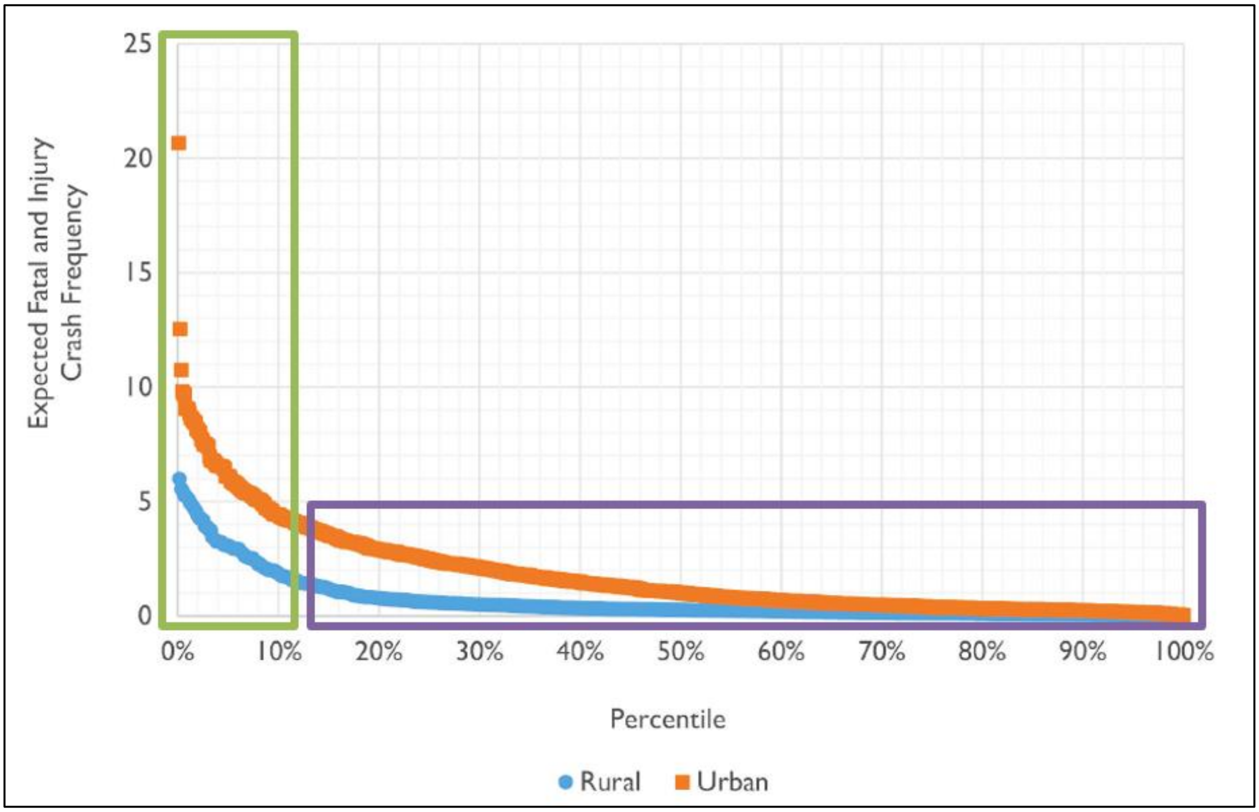

Figure 2. Typical network screening results and potential for projects.

Figure 2 illustrates a suggested application of hotspot and systemic projects to sites across the network. Sites in the **green, vertical box are good candidates for hotspot projects** while sites in the **purple, horizontal box are candidates for systemic improvements**. However, any project type can be applied to any site based on the safety needs of each District.

3.2 Accounting for Data Availability and Quality

FDOT endeavors to use the most appropriate methods when analyzing each safety performance at locations and the effectiveness of proposed projects. FDOT is working to acquire more data for statistical analyses recommended by the HSM. Ideally, all projects would be analyzed on a consistent basis using the same methods. However, the best data and tools are not available for every roadway. Some off-system roads lack inventory data and traffic volumes. Short-form crashes are included in the CAR database but not included in crash analyses in the CAR system. FDOT is currently working to include short-form data in analyses, FLHSMV requires the submission of traffic crash reports to the central crash database (CRSCAN) within 10 days of the incident and over 80% of traffic crash records are uploaded accordingly. FLHSMV and local partners are working to improve timeliness and accuracy of crash reports.

FDOT SSO supports several data systems, tools, and methodologies to assess safety on all public roads in Florida. In addition to some distribution-based statistical analysis tools, FDOT SSO supports Empirical Bayes (EB) methods (also referred to as predictive methods) where possible for Florida roads. The Transportation Data and Analytics (TDA) Office from FDOT manages a statewide non-motorist counter program to address a gap in pedestrian and bicycle traffic volume data.

Predictive statistical methods and traditional statistical methods have different advantages and disadvantages. They also have different assumptions regarding the underlying data. If the underlying data violates any assumptions, the analysis may draw false conclusions. The Department recommends using EB methods whenever possible. District Offices and the Turnpike Enterprise should consider the following factors when implementing HSIP projects to better account for data availability and quality.

- **SHS roadways** represents approximately 10% of roads (12,000 miles), with 55% of total daily vehicle miles traveled (DVMT) and 60% of Florida's fatalities. The Department also has the most reliable data on the SHS. Most of these roads can be analyzed with predictive methods, and they have potential for greater spending and benefit due to higher crash frequencies on average.
    - Projects proposed on the SHS are usually more reliable investments than off-system projects. Crash patterns tend to be more pronounced on the SHS, and improvements have a higher chance of success due to more concentrated traffic volumes and exposure paired with better analysis methods.
    - **Systemic projects** are the most cost-efficient approach to addressing statewide fatalities and serious injuries as well as the emphasis areas in the SHSP.
    - **Hotspot projects** should address locations with the highest crash frequency or highest potential for safety improvement. Since hotspot projects only cover a small portion of the network and are relatively costly, they should be reserved for improving only the worst performing locations.
    - **Policy-based improvements** are appropriate on SHS roadways and can help fill program budgets with scalable countermeasure implementation.
    - **Data and analysis improvements** for SHS should be reserved for strategic improvements that add analysis capabilities, improve HSIP management, or meet legislative data requirements.
- **Off-system roadways** represent 90% of public road mileage, with 45% of DVMT and 40% of Florida's fatalities. Many of these roads lack data to apply the HSM and other advanced analysis methods. Violations of data assumptions lead to less reliable analysis compared to SHS roadways.

However, with 40% of fatalities, off-system roads are a critical concern and require more strategic improvement.

- Projects on off-system roads are typically less reliable investments than SHS projects. Fatalities and serious injuries as well as DVMT are dispersed across many more miles. High crash frequencies may not repeat at the same rate, even with no improvement.
- **Systemic projects** are typically more cost-effective than other project types on off-system roadways. Systemic project planning should use the available data to the extent possible when identifying target crash types, risk factors, appropriate countermeasures, and implementation sites.
- **Policy-based improvement** is a good approach for off-system roads. Since crashes are dispersed, improving deficiencies or adding safety features to all roads is a good approach to risk management. However, these improvements can get costly across the off-system network and should focus on low-cost countermeasures in regions with pronounced infrastructure needs or relatively high fatalities and serious injuries.
- **Data and analysis improvements** are an important consideration that will allow the Department to better target improvements to off-system roads in the future.
- **Hotspot projects** on off-system roads should be limited to high-volume sites experiencing serious crash risks with clear opportunities for improvement. With so many off-system miles, hotspot projects on off-system roadways are not a cost-effective way to address statewide fatalities and serious injuries.

3.3 Economic Analysis of Proposed Projects

Economic analysis helps assure that the Department does not invest more funds into safety projects than the anticipated benefits those projects will bring to road users. Each project in the HSIP should be economically justified, such that the benefit-cost ratio (BCR) is greater than 1.0 and the net present value (NPV) is positive, as explained below. District Offices and the Turnpike Enterprise may set higher thresholds for the HSIP projects they implement at their discretion.

BCR – The ratio of present value benefits (PVB) to present value costs (PVC), as shown in Equation *(1)*. A BCR greater than 1.0 indicates that benefits exceed costs, and therefore a project is economically justified. The BCR in this context is the same as the return on investment (ROI), but ROI is more commonly used when evaluating projects. Generally, higher BCRs are desirable. BCR is unitless.

$$BCR = \frac{PVB}{PVC} \quad (1)$$

NPV – The difference between PVB and PVC, as shown in Equation *(2)*. NPV is also sometimes called net benefits or net present worth. A positive NPV indicates that benefits exceed costs, and the project is economically justified. Generally, higher NPVs are desirable. NPV is in units of dollars.

$$NPV = PVB - PVC \quad (2)$$

When a project is not economically justified, the following options are available.

1. Consider whether the cost could be reduced (e.g., by eliminating non-safety project components or identifying cheaper construction methods) or the benefits could be increased (e.g., by adding more cost-efficient supplemental countermeasures).
2. Consider whether other countermeasures of higher or lower cost could be justified instead of the proposed unjustified alternative. Higher or lower cost countermeasures could be justified if they provide more crash reduction per dollar spent than the unjustified alternative. Confirm whether the newly considered countermeasures are acceptable to stakeholders.

3.3.1 Estimating HSIP Project Costs

Project costs should include preliminary engineering, right-of-way, construction, and maintenance and be expressed in present value to normalize projects with different service lives. Maintenance should include costs expected to be incurred beyond those required to maintain existing facilities over the service life of the project, either annually or in intervals when significant maintenance will be necessary. Often project features or design aspects that do not directly improve safety (e.g., utility realignment, drainage) are required to facilitate safety countermeasure implementation. These aspects should also be accounted for in project costs.

When HSIP funds are used to supplement non-HSIP projects, only the HSIP portion of project costs should be accounted for in the safety-related economic analysis. Portions of projects funded and maintained by other fiscal means should be accounted for in other programming decisions. Economic analysis should indicate whether the additional safety features provided by HSIP will meet the requirements and advance the goals of the HSIP.

3.3.2 Estimating Project Benefits

The Department uses at least three methods to estimate a highway safety improvement project's effect on crash frequency, explained below in order of reliability. The SSO recommends using the most reliable method available for each project.

1. Apply HSM predictive method to estimate the expected average crash frequency of the existing and proposed conditions. The project benefit is the difference in crash frequency multiplied by crash costs.
2. Apply HSM predictive method to estimate the expected average crash frequency of the existing condition and apply an appropriate CMF to estimate the safety performance under proposed conditions.
3. Estimate the average crash frequency of the existing condition using five years of observed crash frequency (more or fewer years may be necessary to represent current conditions). Apply an appropriate CMF to estimate the safety performance under proposed conditions.

Project benefits are determined by multiplying the change in annual average crash frequency by crash costs, and then converting the result to present value. The SSO selects and updates crash costs. The FDOT Design Manual (FDM) lists the FDOT crash costs, which are replicated below in Table 2. When using HSM analysis methods, crash costs by severity are appropriate. When using observed crash frequency methods, or when the severity of past or future crashes is not reliable or well-known, weighted crash costs are appropriate. The final row in Table 2 indicates the weighted average crash cost.

Table 2. Florida crash costs by severity.

Crash Severity	Crash Cost
Fatal (K)	$10,560,000
Severe Injury (A)	$599,040
Moderate Injury (B)	$162,240
Minor Injury (C)	$100,800
PDO (O)	$7,600
Weighted Average (K/A/B/C/O)	$151,677

When the expected benefits of safety projects are unknown (e.g., a CMF is not available), then the DSE should conservatively estimate of the project's effectiveness based on related research (e.g., effect of countermeasure on safety surrogates or human behavior), comparison to similar countermeasures, or consensus decision based on past crash history and patterns. When crash data are unreliable, projects may not warrant funding or should be very low cost.

It is unrealistic to account for all potential benefits—including safety, mobility, asset condition, environment, etc.—in economic analysis of all HSIP projects. Most projects improve, do not affect, or have only minor impacts in these areas. Not considering benefits in these areas is generally a conservative approach. For fairness and to reduce preliminary engineering costs, HSIP analysis should focus on safety benefits of HSIP projects. However, if major negative impacts to mobility, environment, or other factors are expected as the result of an HSIP project, those impacts should be quantified and accounted for to the extent possible as they may be a controlling factor in economic justification.

When HSIP funds are used to supplement non-HSIP projects, only the aspects funded by HSIP should be considered in determining project benefits (whether they improve safety or not).

3.3.4 Project Budget Setting

Economic analysis can also be used to set budgets during early stages of exploring proposed projects and selecting final countermeasures. When selecting countermeasures to meet a given BCR, analysis can indicate an allowable budget at different levels of crash reduction (i.e., CMFs). Equation *(3)* reworks the BCR equation to solve for the annualized value of costs (AVC). Analysts can estimate the AVC from the equation based on the desired BCR, CMF for the proposed countermeasure, and historical or expected annual crash frequency. Analysts can subtract estimated annual maintenance costs and convert the difference to a present value. This value represents the maximum budget for preliminary engineering, right-of-way, and construction to assure a cost-effective project.

$$AVC = \left(\frac{Estimated\ Annual\ Crash\ Frequency \times (1 - CMF) \times (Crash\ Cost)}{BCR}\right) \quad (3)$$

Alternatively, if a budget and desired BCR are known, then analysts can use Equation *(3)* equation to calculate the maximum allowable CMF (i.e., minimum crash reduction). This alternative method could be used to filter economically justified countermeasures. In other words, only certain countermeasures will fit within the budget and have enough crash reduction to be justified at the given BCR.

3.3.5 Adding Contingencies to Improve Project Success Rate

Due to limitations of predictive methods and data-driven safety analysis, the SSO recommends adding at least one form of contingency during economic analysis to assure resulting projects are economically beneficial. The following contingency methods are available for consideration when planning and prioritizing projects. Contingencies help maximize the effectiveness of the HSIP and minimize the risk of projects being unsuccessful.

- **Minimum BCR thresholds higher than 1.0** increase the chance that projects achieve at least a BCR of 1.0 after accounting for the confidence interval of CMFs and other factors that affect project outcomes. BCR thresholds of 1.5 or 2.0 are example minimum thresholds.
- **Contingency on project costs** can account for potential cost or scope overruns during design, right-of-way acquisition, construction. Additionally, maintenance costs for some projects can be difficult to estimate and may be a controlling factor in economic justification. Increasing present value cost estimates by 20% is an example of a cost contingency.
- **Conservative estimates of safety effectiveness** can account for uncertainties in CMF estimates. Each CMF value represents an average crash reduction with some confidence interval based on a standard error. Using a more conservative CMF value can improve the chances that projects are beneficial. Using the upper 95% confidence limit of the CMF based on the associated standard error is an example of a conservative estimate of the safety effectiveness.

3.4 Prioritizing Proposed Projects

The effectiveness of the HSIP is assessed by the benefits it achieves per dollar spent and in terms of reduced fatalities and serious injuries. The objective of project prioritization is to maximize the net benefits of the program, such that the HSIP achieves the maximum possible reduction in fatalities and serious injuries within available budget.

The Department receives a set apportionment of HSIP funds each year. With a fixed program budget (i.e., total costs), the most cost-effective program will also be the most efficient and effective overall, having the highest possible BCR and NPV. However, to achieve the most effective program, individual projects should be prioritized by their BCR, and not by NPV. This concept is explained in this section.

3.4.1 Recommended Prioritization Method

District Offices and the Turnpike Enterprise should consider using BCR as the initial prioritization factor and adjusting the ranking order as necessary to deliver a successful program. In some cases, prioritization by BCR may be unacceptable in practice when stakeholders demand a more effective project or intangible factors impact prioritization.

BCR prioritization can favor lower cost projects that make low or modest reductions in crash frequency or severity. More expensive hotspot projects providing large crash reductions at a few sites tend to be less cost-effective than many lower-cost, more efficient projects. The SSO recognizes practical concerns that the Department can only handle so many projects each year and may find efficiencies in construction mobilization, workforce management, and other factors by consolidating funding in fewer projects.

3.4.2 Hypothetical Prioritization Explanation

Table 3 shows the monetary benefits, costs, NPV, and BCR for 10 hypothetical projects. All these projects are economically justified with BCR greater than 1.0 and a positive NPV. By selecting the best projects within a budget after prioritizing by BCR and NPV, the relative effectiveness of these prioritization measures should be apparent.

This exercise could be completed with any set of projects to demonstrate the relative effectiveness and recommended prioritization. The goal of prioritization is to maximize the BCR and NPV of the overall program.

Table 3. Economic information for 10 hypothetical safety projects.

Project #	Project Benefits	Project Costs	NPV	BCR
Project 1	$900,000	$300,000	$600,000	3.0
Project 2	$500,000	$250,000	$250,000	2.0
Project 3	$680,000	$200,000	$475,000	3.4
Project 4	$1,000,000	$400,000	$600,000	2.5
Project 5	$150,000	$75,000	$75,000	2.0
Project 6	$600,000	$100,000	$500,000	6.0
Project 7	$400,000	$100,000	$300,000	4.0
Project 8	$250,000	$100,000	$150,000	2.5
Project 9	$250,000	$50,000	$200,000	5.0
Project 10	$150,000	$50,000	$100,000	3.0

For this example, suppose the safety program budget is $800,000. Program 1 will be the best projects ranked by BCR, and Program 2 will be the best projects ranked by NPV. Projects for each program are selected from the top of the list until the budget is filled. Table 4 lists the project priority ranking by BCR. Table 5 lists the project priority ranking by NPV. Rows are shaded gray for projects that do not fit within the budget.

Table 4. BCR ranking of example projects for Program 1.

Project #	Benefits	Costs	NPV	BCR
Project 6	$600,000	$100,000	$500,000	**6.0**
Project 9	$250,000	$50,000	$200,000	**5.0**
Project 7	$400,000	$100,000	$300,000	**4.0**
Project 3	$680,000	$200,000	$475,000	**3.4**
Project 1	$900,000	$300,000	$600,000	**3.0**
Project 10	$150,000	$50,000	$100,000	**3.0**
Project 4	*$1,000,000*	*$400,000*	*$600,000*	***2.5***
Project 8	*$250,000*	*$100,000*	*$150,000*	***2.5***
Project 2	*$500,000*	*$250,000*	*$250,000*	***2.0***
Project 5	*$150,000*	*$75,000*	*$75,000*	***2.0***

Table 5. NPV ranking of example projects for Program 2.

Project #	Benefits	Costs	NPV	BCR
Project 1	$900,000	$300,000	**$600,000**	3.0
Project 4	$1,000,000	$400,000	**$600,000**	2.5
Project 6	$600,000	$100,000	**$500,000**	6.0
Project 3	*$680,000*	*$200,000*	***$475,000***	*3.4*
Project 7	*$400,000*	*$100,000*	***$300,000***	*4.0*
Project 2	*$500,000*	*$250,000*	***$250,000***	*2.0*
Project 9	*$250,000*	*$50,000*	***$200,000***	*5.0*
Project 8	*$250,000*	*$100,000*	***$150,000***	*2.5*
Project 10	*$150,000*	*$50,000*	***$100,000***	*3.0*
Project 5	*$150,000*	*$75,000*	***$75,000***	*2.0*

The economic measures for programmed projects in Table 4 and Table 5, representing Program 1 and Program 2, respectively, are compared in Table 6. Table 6 shows that Program 1 provides the most efficient program (i.e., greatest benefits within a fixed cost). **When BCR is used as the project ranking measure, the BCR and NPV of the program is higher than if NPV is used directly as the project ranking measure.**

Table 6. Program 1 and Program 2 economic comparison.

Economic Measure	BCR Program	NPV Program
Total Benefits	$2,980,000	$2,500,000
Total Costs	$800,000	$800,000
NPV	$2,180,000	$1,700,000
BCR	3.73	3.13

3.5 Planning Pedestrian and Bicycle Safety Improvements

Traditional safety analysis methods have mostly been developed for analysis of single- or multiple-vehicle crashes. Pedestrian and bicyclist crashes are different in type, frequency, and density than vehicular crashes and can benefit from other analysis methods that are better geared toward pedestrian and bicycle crashes. Specifically, it is important to characterize the collision type of pedestrian and bicycle crashes and to consider areawide improvements for neighborhoods or regions with high crash frequency in addition to linear road segments and intersections.

The systemic approach also has a lot of potential to improve pedestrian and bicycle safety. The data-driven systemic analysis methods described in the previous sections are all applicable to pedestrian and bicycle safety but may not have the same level of reliability due to maturity of the methods and limitations in data for non-motorized road users.

Funding for pedestrian and bicycle safety improvements is addressed in the Funding Projects for Non-Motorized Users section of this document.

4. HSIP Process and Project Development

The HSIP Delivery Overview section of this guide introduces the intent of the program and stakeholder roles. The HSIP is intended to implement low-cost, quickly-delivered engineering safety improvements across Florida's public roads to reduce traffic fatalities and serious injuries. The HSIP process consists of planning, implementing, and evaluating highway safety improvement projects.

The Department recognizes that accurate, fair, and reliable analysis of all roadway locations requires appropriate data. Districts rely on MPOs, TPOs, local agencies, and citizen requests to identify priority issues and initiate effective safety projects. The SSO recommends using the most reliable analysis methods available in the HSIP process.

In general, HSIP projects follow the roadway safety management process shown in Figure 3. The goal of network screening (Step 1) is to identify the sites that have the highest potential for safety improvement. Analysts diagnose (Step 2) the safety concerns at sites identified in the network screening to determine correctable crash patterns and contributing factors. Once a site's data-driven safety problems are understood, Districts select appropriate countermeasures with input from local stakeholders (Step 3). Unfortunately, HSIP cannot address all highway safety problems in Florida. Economic appraisal (Step 4) and project prioritization (Step 5) determine eligibility and relative ranking of proposed projects to select projects that maximize the effectiveness of the program within the available budget. Safety effectiveness evaluation (Step 6) evaluates the program and projects to track performance and inform future decisions.

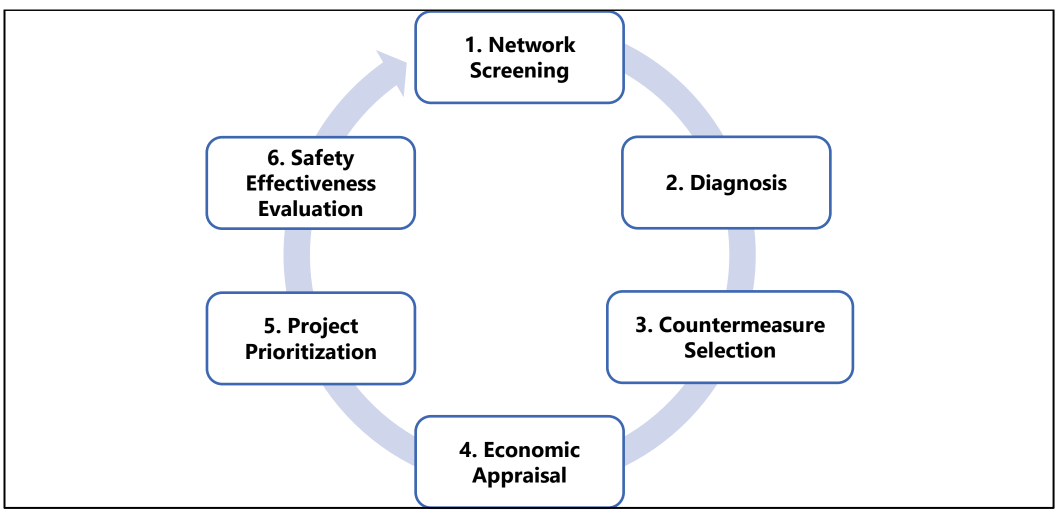

Figure 3. Roadway safety management process.

The SSO is responsible for managing the HSIP as well as providing strategy guidance, policies, and tools for implementation. District Offices, the Turnpike Enterprise, and local agencies are responsible for administration and delivery of highway safety improvement projects within their jurisdiction. Figure 4 shows the general workflow for project programming across stakeholder agencies.

The HSIP process originates with the SSO developing and updating the SHSP, along with safety stakeholders across Florida. The SSO conducts a statewide crash analysis to identify emphasis areas for the HSIP and other safety programs that address traffic fatalities and serious injuries. The following process outlines the typical responsibilities at each step of the HSIP process in Florida. Later sections of this document provide insight into analyses completed at each step and intricacies in procedures.

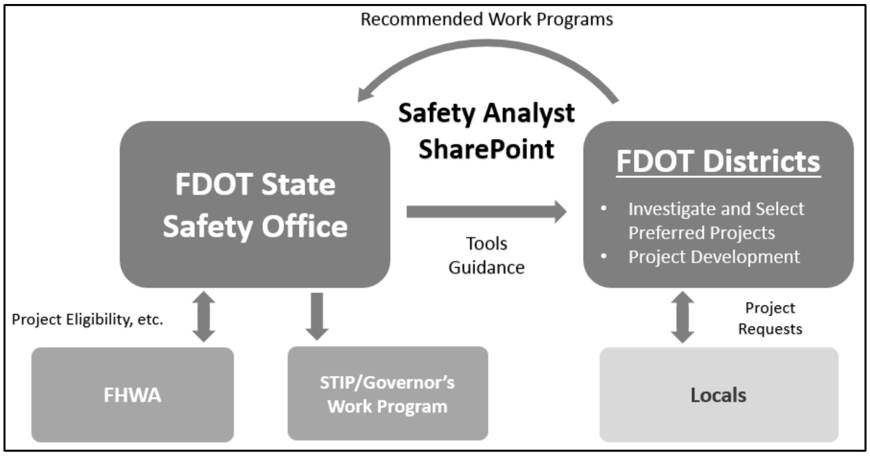

Figure 4. HSIP process workflow.

1. SSO conducts network screening annually and provides results to Districts.
2. SSO, Districts, and Turnpike Enterprise review screening results and reconcile with current work programs. Consider local agency and citizen requests for safety improvements.
3. Districts select hotspot sites for further investigation as well as plan systemic and policy-based safety improvement projects.
4. Districts diagnose safety problems and select preferred countermeasures for proposed projects, considering insights from stakeholders including local agencies and the public.
5. Districts analyze projects' economic justification and adjust selected alternatives accordingly.
6. Districts submit HSIP applications to SSO and work with SSO to prioritize projects within the available HSIP budget.
7. SSO provides prioritized projects to FHWA Florida Division for concurrence and authorization.
8. The Department incorporates selected projects into Governor's Work Program and STIP.
9. Districts develop and implement HSIP projects.
10. SSO evaluates the program and projects post-construction to assess their effectiveness.
11. SSO compiles evaluation results into guidance and procedures for future decision making.

The following sections discuss the FDOT HSIP process including project identification, planning and alternatives development, eligibility determination, prioritization, implementation, and evaluation.

4.1 Project Identification

Each District Office and the Turnpike Enterprise is responsible for identifying effective highway safety improvement projects that address their safety needs and maximize the opportunity to advance safety in Florida. Districts should take a Districtwide approach to identifying beneficial improvement projects, including a mix of hotspot and systemic improvements, on SHS and off-system roads.

The Implementing Different Types of HSIP Projects and Accounting for Data Availability and Quality sections of this guide discuss the Department's strategies for implementing projects on SHS and off-system roads to address different types of safety problems. HSIP projects are typically identified through one of the mechanisms discussed in the following sections.

4.1.1 Network Screening for Locations with Potential for Safety Improvement

The goal of network screening is to identify sites worth investigating further. Annually the SSO will provide Districts and the Turnpike Enterprise with an initial statewide network screening as a starting point for hotspot project identification (on the SSO SharePoint site). District Offices and the Turnpike Enterprise may elect to conduct their own network screening analyses to determine locations with high potential for safety improvement with respect to specific crash types and contributing factors of regional significance. Districts are not required to select sites from network screening—other methods for project identification are acceptable.

When HSM methods are applicable, the SSO recommends using the peak searching method based on expected fatal and injury crash frequency in network screening. TEO recommends using SAFE STRIDES 2 Zero for signalized intersections on the SHS. When HSM methods are not applicable, simple queries or GIS analysis based on observed fatal and injury crash frequency is a reasonable alternative. Up to five consecutive years of roadway and crash data reflecting current conditions should be used in screening. If there are major changes to a site over time, then the network screening should use the most recent years of data that correspond to current conditions. For example, if an intersection was converted from stop-control to signalized within the study period, then the network screening should only include data from years under the current condition (signalized). Within each method, analysts can screen certain crash types and severities using various performance measures. For more information on these methods, see *HSM Chapter 4: Network Screening* or the Safety Analyst Module 1 White Paper.

Regardless of screening method, the SSO recommends ranking rural and urban sites as well as segments and intersections in separate lists. Combining these lists may favor certain types of sites. However, Districts should use an approach that suits their ability to diagnose safety problems and develop effective projects for their jurisdiction.

Districts should consider the following factors when reviewing network screening results:

- Whether the safety concern illustrated in screening is valid (e.g., data were correct, there is an apparent safety issue, etc.). If not, assess whether there is a less significant safety concern that is worth addressing.
- The highest ranked sites may have projects that are already planned or in progress. If so, consider if additional emphasis on safety is warranted and feasible.
- Some locations may have had previous planning studies or corridor studies noting safety concerns or potential future preferred safety improvements. If so, consider using these results as a starting point for the current diagnosis.

- Preferred improvements may be out of scope for HSIP (e.g., full interchange reconstruction). Consider how the project could be funded and whether short-term improvements may be a good starting point.
- Omit sites recently improved and continue to monitor those locations.
- Visualizing and mapping network screening results (e.g., heat map) can also help identify regions or corridors where a systemic safety project could be warranted to efficiently address common safety problems.

Network screening typically produces hotspot projects. However, the results are just as applicable to systemic and policy-based projects as well as reviewing the safety performance of the road network. Please notify the SSO if network screening analysis indicates significant issues in safety data causing incorrect rankings or difficulty interpreting the results.

4.1.2 Systemic Safety Analysis

Systemic projects target predominant crash types occurring across the network rather than focusing on the unique concerns facing individual sites. FDOT tries to address common issues and crash types that cause fatalities and serious injuries as cost-effectively as possible to maximize the benefits of the HSIP. Typically, systemic countermeasures are lower-unit cost and implemented at many locations with potential for safety improvement in the target crash types across a corridor or region.

The first steps in the systemic process are to identify focus crash types and focus facility types. The SHSP is a good place to start as it identifies emphasis areas (i.e., focus crash types) related to fatalities and serious injuries. Focus facility types are typically those facilities where focus crash types are most prevalent or overrepresented. Ideally, the system diagnosis should be limited to the network that is considered for a project (e.g., all public roads, state system, one or more regions or Districts). The next step is to identify and confirm potential risk factors, which could include crash-related, operational, and geometric characteristics associated with the locations where the targeted crash types occur. Systemic projects can cost-effectively address these factors on the facility types where they are most prevalent to make a substantial impact on statewide safety performance. Once there is an understanding of the underlying risk factors, it is appropriate to develop a list or package of appropriate countermeasures to apply when specific risk factors are present. The SHSP is also a good place to start for potential countermeasures of interest as it identifies strategies for each emphasis area; however, other new or innovative countermeasures may be appropriate.

Districts should settle on one or more countermeasures that target the factors contributing to focus crash types on focus facility types. Network screening or risk factor analysis can help indicate where implementing the selected countermeasures would have a high chance of success. Network-wide crash type distributions or crash tree diagrams can help to determine priority risk factors and appropriate countermeasures. Appendix B: Systemic Safety Analysis Approaches contains more detailed information about planning systemic projects.

4.1.3 Policy-Based Safety Improvements

Policy-based projects typically bring roadway design or operational features up to a standard. Typically, these types of improvements are implemented at all appropriate locations but may be prioritized by site-specific or regional safety performance. Policy-based improvements should implement countermeasures that mitigate serious crash risks presented by existing infrastructure or proven countermeasures shown to cost-effectively reduce fatalities and serious injuries, such as FHWA's Proven Safety Countermeasures.

Policy-based projects are a good approach when site-specific crash data are not available or reliable, since implementation is more dependent on existing infrastructure and not on a site's safety performance. Because a detailed safety analysis or economic analysis may not be possible with very limited data, each site should be reviewed to determine whether the location could potentially benefit from one of these countermeasures and whether implementation is feasible within site constraints.

If highly effective countermeasures are adopted in Department standards, they should be implemented through regular non-HSIP projects to the extent possible. The intent of policy-based HSIP projects is to address serious safety concerns in existing infrastructure and facilitate widespread implementation of effective or low-cost strategies targeting areas in the SHSP.

4.1.4 Investigations into Fatality Locations

Districts investigate locations where fatal crashes occur. These locations may not show up in network screening, especially if the fatality has not been reported and entered into the CAR database. Districts can consider safety projects at fatality locations. However, one fatality does not necessarily indicate a correctable crash pattern conducive to engineering improvement. Districts should consider whether improvements are warranted at fatality locations or whether a systemic or policy-based project could address the underlying factors contributing to the fatality across many sites.

4.1.5 Local Road Safety Plans, Local Agency Requests, and Citizen Requests

Another source of HSIP projects is from LRSPs or requests originating from local agencies and citizens. LRSPs often indicate specific projects, countermeasures, or strategies of interest to local stakeholders. Districts can approach local agencies to make them aware of a safety issue, and local agencies can request projects from the District (which may not have shown up on the network screening list due to lower PSI or data issues). All local agency and citizen requests should be reviewed to assure the locations are appropriate candidates for the HSIP, demonstrate a data-driven opportunity for safety improvement, and determine if cost-effective improvements are feasible.

4.1.6 Community Traffic Safety Teams

The CTST program was developed to undertake safety-related projects and activities, serve as a resource to all communities and local government agencies, reduce the number of serious and fatal injury crashes that occur on Florida roadways, and assist in reaching Zero Fatalities.

Districts decide how to best address issues in their communities, including selection and implementation of safety improvement strategies. Most are responsible for planning, developing, maintaining, and operating the local system roads within their municipality. Since a large portion of crashes occur on local roadways, it is important that Districts engage in local safety improvement initiatives.

MPOs working with their District office can apply for HSIP funds on local roads in their jurisdiction. District Offices can help local agencies and partners understand requirements, criteria, and processes involved in HSIP projects. Local governments also work with stakeholders who share safety interests (police, emergency medical services (EMS), schools) to develop projects that address local safety needs.

4.1.7 Supplement Other Planned Projects

There are many opportunities to include safety countermeasures or features in existing 3R, FDOT Work Program, or other planned projects. The SSO recommends Districts regularly consider opportunities to add safety countermeasures to planned projects outside of the HSIP when there is a data-driven and obvious need to improve safety. An annual review of work programs may be an effective way to identify potential projects. These types of improvements add HSIP funds to other projects to efficiently improve safety where work is already planned, minimizing mobilization costs and impacts on operations. The Applying HSIP Funds to Non-HSIP Projects and Economic Analysis of Proposed Projects sections of this document further discusses how to handle these types of improvements.

4.1.8 Other Safety-Related Studies

Other planning and engineering studies from various sources often incorporate a safety review that identifies potential safety improvements to the studied locations. These studies rely on data-driven analysis or anecdotal information to assess safety concerns. Districts may elect to initiate HSIP projects from these types of studies after verifying the presence of a data-driven need. All projects must meet HSIP eligibility requirements and maximize the opportunity to reduce fatalities and serious injuries in Florida.

4.2 Project Planning and Alternatives Development

After selecting sites, and if not already decided, analysts should identify predominant crash types or contributing factors and develop a list of potential mitigation measures. Project planning and alternatives development procedures can vary depending on the type of project. The scope of planning analyses should reflect the scope of the project and magnitude of the safety problem. A lower-volume site needing an obvious, low-cost fix does not require weeks of study.

Understanding the underlying issues that contribute to high frequency or severity of crashes is critical to mitigating highway safety problems. Projects that do not address the factors that contribute to serious crashes at a site may be a waste of funding, even if analysis shows it should be beneficial. Diagnosis and countermeasure selection should consider site-specific contextual factors that may not be represented in predictive models or CMFs. Many intangible factors contribute to the success or failure of safety improvement projects.

4.2.1 Diagnosis

Districts and the Turnpike Enterprise can use various analysis tools to create crash summaries, develop collision diagrams, and conduct statistical tests for crash proportions to facilitate data-driven diagnosis. Other diagnosis tools include time trends, Haddon matrices, and diagnostic scenarios. The FHWA guide, *Reliability of Safety Management Methods: Diagnosis* (see FHWA-SA-16-038), discusses these various diagnostic tools in greater detail and their effectiveness in accurately diagnosing site-specific safety concerns.

RSAs and field reviews can provide context to the data and bring to light problems not displayed in the data. When there is a specific, notable roadway-related deficiency at the location of interest, detailed statistical diagnosis procedures may not be necessary. At sites where stakeholder input or judgment indicates that the factors contributing to the safety issues are not fully known or are unknown, more involved methods should be considered.

For each hotspot project, diagnosis should result in clearly defined safety concerns at each site related to the geometry, operations, hardware, or crash types that occur. For systemic and policy-based projects, diagnosis may not be necessary or confirm that sites are good candidates for improvement and the countermeasures are feasible. This focused approach will generally lead to the selection of targeted, effective, and defensible countermeasures to mitigate specific safety issues.

4.2.2 Countermeasure Selection

The objective of countermeasure selection is to choose countermeasures that will address the concerns identified in site diagnosis. Rather than selecting a preferred countermeasure at this point, analysts should compile a list of potentially applicable countermeasures for economic appraisal and prioritization (unless there is only one clear or acceptable solution).

The best practice is to start by considering low-cost countermeasures and then move to higher-cost options when lower-cost countermeasures are not desirable or appropriate for the site of interest. Table 7 is an example of how to organize potential countermeasures. Stakeholders could determine the most appropriate alternative of one or more countermeasures that meet HSIP requirements.

Table 7. Example table organizing potential countermeasures.

Possible Countermeasures	Lower Cost	Moderate Cost	Higher Cost
Short Term			
Medium Term			
Long Term			

There are several tools available to analysts to help select appropriate countermeasures, including:

- National Cooperative Highway Research Program (NCHRP) Report 500 Series
- FHWA's Proven Countermeasures
- FHWA's Reliability of Safety Management Methods: Countermeasure Selection
- This basic matrix linking crash patterns, contributing factors, and potential countermeasures.
- Safety Analyst recommends potential countermeasures based on answers to diagnostic questions.

CMFs can also assist in countermeasure selection. When CMFs are available by crash type, often the crash types can indicate specific target crashes identified in research that the countermeasure can address. However, analysts should consider the effect on total crashes as well to understand how other crash types may be affected. If these tools are not applicable to a site, then judgment and experience as well as other stakeholder input can be valuable tools to recommend and select applicable countermeasures.

Refer to Appendix C: Crash Modification Factors and Countermeasure List for FDOT's standard list of countermeasures and CMFs.

4.2.3 Road Safety Audits

RSAs are formal safety performance evaluations of an existing or future road or intersection by an independent, multidisciplinary team. RSAs are a valuable tool to evaluate road safety issues and to identify opportunities for improvement with stakeholders of various perspectives and experiences. Local stakeholders often have intimate knowledge of the location and can speak to anecdotal safety concerns as well as data-driven ones. Non-local stakeholders can provide a fresh perspective and share additional experiences. The FHWA RSA process is defined by the following eight steps.

1. Identify Project or Existing Road to be Audited.
2. Select an RSA Team.
3. Conduct a Pre-audit Meeting to Review Project Information and Drawings.
4. Conduct Review of Project Data and Conduct Field Review.
5. Conduct Audit Analysis and Prepare Report of Findings.
6. Present Audit Findings to Project Owner/Design Team.
7. Prepare Formal Response.
8. Incorporate Findings into the Project when Appropriate.

Most RSAs do not reach the stage of selecting the final countermeasures. The RSA process usually results in a list of safety concerns and potential countermeasures, but selection of preferred alternatives is usually left to project managers and designers. For more information, visit the FHWA RSA website.

4.3 Project Eligibility Determination

Any project meeting all the following requirements is potentially eligible for funding in the HSIP. However, there are some exceptions in which projects may not be required to have a BCR. The SSO, District Offices, Turnpike Enterprise, and FHWA Florida Division are all responsible for assuring HSIP eligibility is met.

- Implements safety infrastructure countermeasures or improves safety data collection, integration, and analysis such that HSIP stakeholders can better plan, implement, and evaluate highway safety improvement projects in the future.
- Consistent with an emphasis area, strategy, or activity identified in the Florida SHSP.
- Estimated benefit-cost ratio (BCR) of 1.0 or greater.
- Addresses a serious crash risk or safety problem identified through a data-driven process.
- Likely to result in a reduction of fatalities and serious injuries.

Districts should compile HSIP project applications for submittal to SSO over the SSO SharePoint site. Once the application deadline has passed, SSO reviews and determines eligibility of proposed projects. SSO also confers with FHWA Florida Division regarding project eligibility. The Districts and Turnpike Enterprise manage selection, prioritization and budget of eligible projects.

4.3.1 Economic Analysis

Economic analysis compares the relative benefits and costs of proposed countermeasures. Safety benefits are calculated as the dollar value of the estimated lives saved and injuries prevented as well as property damage avoided (e.g., based on a CMF and average crash costs). It is important that Districts include a list of assumptions in economic analyses when preparing HSIP project applications (i.e., costs, service life, other information). Project costs include preliminary engineering, right-of-way acquisitions, construction, and maintenance costs as well as other costs incurred as a result of implementing the countermeasure.

Although network screening should be based on fatal and injury crashes for one or more crash types, economic analysis should be based on all crash types and severities if possible (accounting for data limitations). It is important to consider all crashes in economic analysis to gauge the full impacts of the project. The Economic Analysis of Proposed Projects section of this document discusses procedures for determining economic eligibility.

Data for PDO crashes is inconsistent across the network in Florida. When PDO crashes are not expected to increase, conducting benefit-cost analysis without PDOs is conservative. If PDO crashes are expected to increase, it may be worthwhile to further investigate the PDO crash data or estimate PDOs based on a typical severity distribution. Either approach is acceptable for HSIP projects.

Spreadsheets, CRASH, and Safety Analyst are all viable tools for estimating economic eligibility with BCR or NPV. The Districts and Turnpike Enterprise should require fair assessment of similar competing projects across Florida. For example, service life estimates, CMFs, and other assumptions and factors should be consistent to the extent possible, so projects are not unfairly favored.

Some projects are not required to have economic analysis with justification. Strategic data and analysis improvement projects are necessary and will likely bring enough safety benefits over many program years to justify their costs. In some cases, it may be impossible or infeasible to accurately estimate project costs or benefits (e.g., policy-based improvements with no CMFs available). At the discretion of the DSE, SSO, and FHWA, such projects can be approved if projects address a serious strategic safety concern, the costs are minimal and present no major investment risk, or project's benefits are clearly higher than the costs. For example, trimming back vegetation to improve sight distance is typically very low cost, and economic analysis for this type of improvement may be excessive and unnecessary.

4.3.2 Selecting CMFs

Analysts should use Florida-specific CMFs when available, listed in Appendix C: Crash Modification Factors and Countermeasure List. When Florida-specific CMFs are not available, analysts may choose from the HSM, CMF Clearinghouse, research reports, or other appropriate sources. The SSO or FHWA can help identify appropriate CMFs. CMFs should come from reputable sources with appropriate study design. CMFs should be applicable to the project location's facility type, traffic volume range, and reflect conditions as close to Florida's roads as possible.

In the absence of appropriate CMFs, estimates of countermeasure effectiveness may be derived considering the project site's crash history, CMFs for similar countermeasures, expert insights, and engineering judgment. The assumptions involved in a project's economic analysis, including the selection of CMF values, should be documented for future reference.

4.3.3 Funding Projects for Non-Motorized Road Users

Pedestrian and bicycle safety improvement projects may not always reduce crash frequency due to associated increases in mobility and volume when adding infrastructure for non-motorized users. However, pedestrian and bicycle projects should aim to reduce crash rate and severity by providing safer infrastructure and greater conspicuity. Pedestrian and bicycle projects may be approved in the HSIP without a BCR or with BCR under 1.0 with the understanding that providing safe mobility to non-motorized users is a priority.

4.4 Project Prioritization

FDOT SSO will assess if projects are eligible for funding. District Offices and the Turnpike Enterprise will prioritize eligible, economically justified projects to determine the combination of projects that provides the maximum opportunity to improve safety with available budgets. SSO will support DSEs as the Districts prioritize projects within the available program budget.

BCR is the default prioritization measure, which indicates proposed projects' relative cost-effectiveness as demonstrated in the Hypothetical Prioritization Explanation section of this document. In some cases, the Department or the public may desire an alternative with higher benefits than the one with the greatest BCR. The most cost-effective alternative may provide a marginal reduction in crashes, which may not be acceptable at the site. **NPV indicates the projects or alternatives that provide the greatest benefits, regardless of cost.** NPV and BCR can be used in combination to pick an eligible alternative that meets the needs of all stakeholders while still advancing the goals of the HSIP. Choosing a more expensive alternative with higher NPV and lower BCR may reduce the overall effectiveness of the program if those extra funds could be used more efficiently elsewhere. However, it is important for HSIP projects to meet the needs of road users and sufficiently address serious highway safety problems.

High priority projects should be implemented when ready to deliver safety benefits to road users sooner. However, proposed projects may not be implemented in sequential order of priority due to varying amounts of time required to plan and develop project designs, acquire right-of-way, and other factors. The highest ranked projects fitting in the HSIP budget are selected for inclusion in the STIP. Projects will generally be funded in accordance with the prioritized list, funding availability, and with SSO's approval.

4.4.1 Adjusting for Intangible Factors

An initial BCR ranking may need to be adjusted to account for other factors. The following criteria are examples of considerations when adjusting prioritized projects and selecting projects for the STIP.

- Other planned projects at the location: To assist with the identification of overlapping safety needs at the same location on the State Highway System and enable alignment with other planned projects, the Department's Safety Needs List Dashboard displays safety needs identified by Central Office and the Districts and as well as other projects programmed in the Work Program. Projects could be given a higher priority when other projects are planned at the location (for safety improvement or otherwise) when the projects could, for example, save on mobilization and materials costs if constructed together. Projects may be given a lower priority if other projects are planned at the location and the proposed safety improvement is redundant or the other project should be evaluated before further improvements are made.
- Funding equity: It is neither practical nor a good investment strategy to use all HSIP funds in one region of Florida—all regions experience traffic fatalities and serious injuries. The Department will adjust priorities as necessary to distribute available funding among Districts.
- Right-of-way needs and acquisition: Projects requiring right-of-way acquisition could be given slightly lower priority than similar projects with no right-of-way needs.
- Environmental impacts and mitigation: Projects with substantial environmental impacts could be given slightly lower priority than similar projects with no environmental impacts.
- Project readiness: Projects could be scheduled sooner if they are "shovel-ready" while other projects are in development and design stages.
- Familiarity with the countermeasure's design, construction, and safety effects: Unfamiliarity may trigger a slightly lower priority compared to countermeasures that engineers and contractors are more comfortable with. Alternatively, unfamiliar countermeasures could be given a higher priority to pilot their implementation and begin wider use of the countermeasures.

- Public requests for improvement projects: Public requests or expectation for a project could trigger a higher priority compared to other projects; however, a data-driven approach to project prioritization is typically more reliable.
- Public acceptance and political influence: Projects with favorable public perception could be given higher priority. The Department also acknowledges some safety projects can be highly political and may be prioritized accordingly; however, a data-driven approach to project prioritization is typically more reliable.

The Department recommends assessing any need to reprioritize project ranking based on these or other factors (with justification), integrating safety improvement priority with other important criteria. The Districts should communicate any adjustments to project priority to other project stakeholders and partner offices. Several of these factors affect the timing of projects. Any adjustments should be based on quantitative measures, if possible. Subjective changes to the priority ranking are assessed by the Districts, as several of these considerations can be difficult to quantify and compare to other factors.

4.4.2 Listing Unfunded Safety Needs

District Offices and the Turnpike Enterprise should maintain a listing of unfunded safety needs and potential projects across all public roads in their District. Each potential project should indicate preferred alternatives with economic appraisal. At least annually, these unfunded needs should be reprioritized to include all new potential projects, regardless of funding source, so the highest priority needs are clear at any time.

4.5 Project Authorization, Design, and Implementation

Once proposed projects are prioritized, authorized, and programmed, District Offices move forward with design and construction. Although implementation of HSIP projects is no different than projects programmed and constructed in other programs, there are opportunities to improve safety during design and other stages discussed in the following sections.

4.5.1 Design and Construction

Once projects have been prioritized and programmed (i.e., included in the Governor's Work Program and STIP), projects move into the design and construction phases. District Offices, the Turnpike Enterprise, and occasionally local agencies are responsible for project administration and the project development process, including project development and environment (PD&E), traffic operations, and roadway design. FDOT's project development process is explained in further detail in the FDOT PD&E Manual. There are opportunities to incorporate safety analysis throughout the project development process.

This section offers some ways to apply predictive methods throughout project development. The most basic application of the predictive method is to quantify the expected safety performance of an existing facility or proposed design alternative. SPFs, SPF calibration factors, and CMFs allow analysts to estimate the safety performance of finite design details including geometric and operational characteristics.

- Planning Studies: Determine how safety can be a factor in the purpose and need statement of a project, coordinate results from network screening to see if any existing projects will touch locations with below average safety performance, and apply planning-level CMFs to quickly estimate relative benefits of projects.

- Alternatives Analysis: Use various levels of the predictive approach depending on the scale and scope of the project to compare alternatives, understand the aspects of each alternative that perform better or worse than others, and select a preferred alternative considering its quantitative safety impacts.
- Design Decisions and Exceptions: Use CMFs and predictive methods to determine optimal design criteria and justify design decisions and exceptions. Determine whether suggestions from a value engineering study will eliminate safety features that were integrated in the previous steps. If there are changes to the design, there is a need to understand the safety implications.
- Construction: Use CMFs or predictive methods to inform work zone configuration and traffic control. Consider the safety impacts of change orders. The construction manager should not unilaterally make a change to a project without understanding the potential safety impacts.
- Operations and Maintenance: Use CMFs and predictive methods to consider safety impacts of operational improvements. Analyze and assess the impacts and justification for maintenance activities such as sign replacement programs, and schedule and budget for those efforts appropriately.

Throughout these stages, District Offices may need to coordinate with local agencies or private developers (e.g., for permitting or during construction). Local agencies responsible for locally administered projects (LAP) should coordinate with the Department on major projects.

4.6 Project Effectiveness Evaluation

Evaluation is the final step of the HSIP process. The Department evaluated the effectiveness of projects, countermeasures, and programs post-construction as well as program management factors including percent of apportioned funds obligated to HSIP projects. Evaluation informs future decision making in earlier stages of project development.

Project and countermeasure evaluations provide a better understanding of how effective specific countermeasure types are at certain sites, often with the goal of determining the amount of crash reduction that countermeasures provide on Florida roads. If a project is not economically beneficial once built (and possibly a detriment to road users), it is important to better understand the factors contributing to that result.

Program evaluations assess the effectiveness of the entire HSIP to monitor performance and suggest changes to policy or strategy. At the program level, there is a need to understand the most effective strategies and efforts to inform program-wide decisions. Evaluating the effectiveness of safety improvements provides insights into the efficacy of prior investments and can inform future investment decisions.

4.6.1 Project Tracking

Evaluation requires the tracking of individual projects to facilitate later evaluations. Project tracking is not exclusive to HSIP evaluation efforts, and it is important to consider how the safety effects of all projects can be evaluated to enhance the Department’s understanding of how projects improve safety regardless of the funding source. The SSO, in cooperation with the Districts, should compile an annual list of implemented project and countermeasure data to facilitate on-demand evaluation and reporting.

The data items needed for comprehensive project and countermeasure evaluations are listed below. Districts should provide this data to SSO via spreadsheets, CRASH, or the SSO SharePoint. SSO compiles the data from all Districts for evaluation. Safety Analyst requires specific project and countermeasure data to facilitate on-demand evaluation, which are listed in the Safety Analyst Data Import Reference.

- Project location.
- Construction dates.
- Countermeasure type and details.
- Project cost.
- Crash data.
- Traffic volume data.
- Funding source and amount(s).
- Relation to SHSP emphasis areas and safety programs.
- Information from pre-construction safety performance analyses (e.g. project type, BCR, NPV).
- Photos to verify pre- and post-construction conditions, as needed.

Figure 5, from the FHW *HSIP Evaluation Guide* (see FHWA-SA-17-039), shows the many stages and opportunities for project tracking within project development.

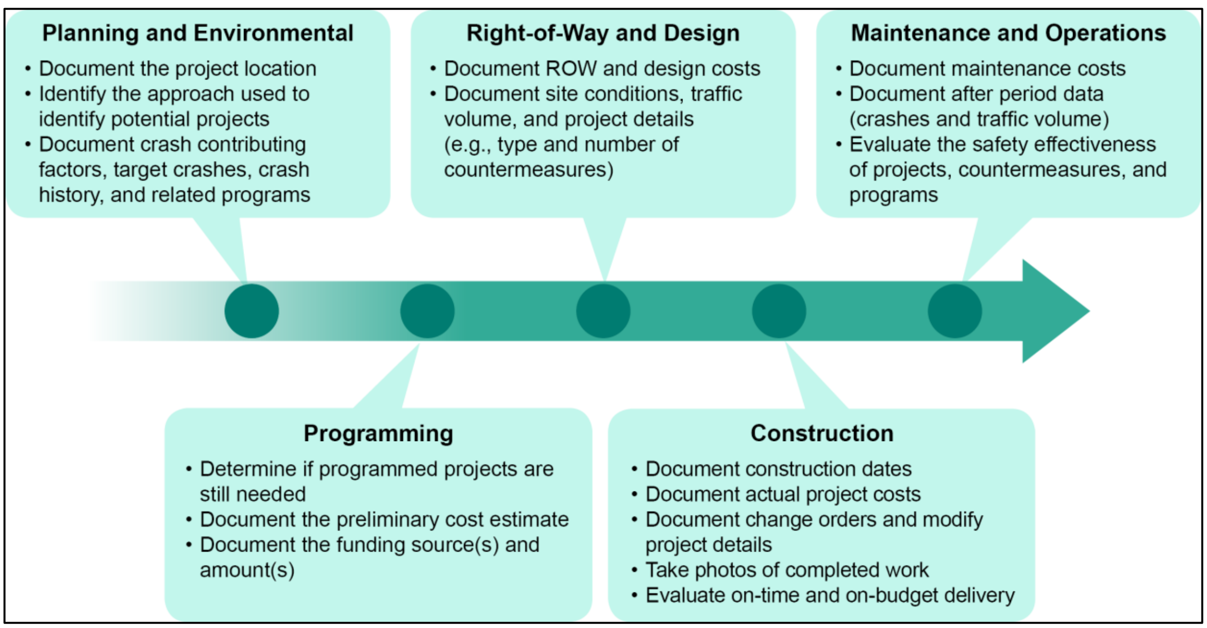

Figure 5. Project tracking opportunities in relation to the project development process.

4.6.2 Project and Countermeasure Evaluations

When SPFs and sufficient data are available, the SSO recommends using the Empirical Bayes (EB) before-after project-level and countermeasure-level evaluation method as presented in the HSM. The empirical Bayes method is considered more reliable than the simple before-after method in the presence of regression to the mean, changes in traffic volume, and other parameters best characterized as a time series.

Safety Analyst allows analysts to conduct empirical Bayes before-after evaluations for projects imported into the Safety Analyst data set, which includes project-level and countermeasure-level evaluations using data for overall construction projects and the implemented countermeasures within each project. FDOT SSO worked with safety partners on tools that implement statistical analyses recommended by the HSM.

When HSM methods are not applicable, simple before-after analysis with traffic volume correction and shift in proportions methods are appropriate for quick project evaluations. Before-after analyses are appropriate if the assumptions for the statistical analyses are met. It is helpful to focus on target crashes for project evaluations, assessing whether there is a change in target crashes after the project. The If the presence of changing traffic volumes or regression-to-the-mean are detected, using the simple before-after method may not be reliable for countermeasure evaluations.

Refer to the FHWA *HSIP Evaluation Guide* (see FHWA-SA-17-039) for procedures to complete these calculations for before-after analyses, plus spreadsheet templates and instructions.

4.6.3 Overall Program Effectiveness

The HSIP is a program of highway safety infrastructure improvements with the goal to reduce fatalities and serious injuries on all public roads. Within the HSIP, there are subprograms focused on emphasis areas such as lane departure, intersections, pedestrians, and bicycles. Other subprograms may be defined by approaches used to identify and treat locations (e.g., site-specific, systemic, and projects addressing a specific crash type).

There are two types of program-level performance measures for evaluation: crash-based and activity-based. Crash-based measures are the primary means of evaluating the HSIP, as the program intends to reduce fatal and serious injury crashes. Activity-based measures indicate progress to stakeholders and helps to identify and address inefficiencies in the program and processes.

Per 23 CFR 490.207, FDOT is required to track the following five performance measures for the HSIP based on the five-year rolling averages (submitted to FHWA annually in the HSIP report). These do not directly measure the HSIP's effectiveness but are important to track Florida's progress in improving road safety.

- Number of fatalities.
- Rate of fatalities per 100 million VMT.
- Number of serious injuries.
- Rate of serious injuries per 100 million VMT.
- Number of non-motorized fatalities and non-motorized serious injuries.

The following are crash-based performance measures which require project evaluations be conducted prior to the program/subprogram. The first two (lives saved, economic measures) are the most direct indicators of effectiveness of HSIP in meeting the objectives (reducing fatal and serious injury crashes).

- Lives saved (or crashes or injuries prevented).
- NPV and BCR.
- Number of projects with reduction in target crashes.
- Difference in effectiveness on target and total crashes.

- Percent change in crashes versus absolute number of crashes.
- Effectiveness of older versus newer projects.
- Effectiveness of HSIP-funded projects versus non-HSIP projects.
- Effectiveness of projects by region.

The following are examples of activity-based performance measures.

- Number of projects implemented.
- Timeliness of project implementation.
- Comparison of estimated project cost versus actual project cost.
- Proportion of program funds allocated.

For procedures to calculate these measures, and more discussion of pros and cons of each, reference the FHWA *HSIP Evaluation Guide* (see FHWA-SA-17-039).

Revision History

Revision	Description	Initials	Date
-	Initial release.	RRG	2019-05-30
A	Changed references to manual; revised title; minor edits	RRG	2019-10-14
B	Some content revisions; District management of HSIP	RRG	2020-01-24
C	Revised HSIP project management content	RRG	2020-01-30
D	Formatting; added SAFE STRIDES 2 Zero	RRG	2020-05-18
E	Update Appx C (CMFs, countermeasures); minor edits	RRG	2020-08-06
F	Updates from 2021 SHSP; updated links; minor edits	RRG	2021-08-09

Appendix A: Crash Data Collection Process

Crash data are collected by law enforcement agencies and incorporated in a statewide repository at the Florida Department of Highway Safety and Motor Vehicles (FLHSMV) called CRSCAN. The FLHSMV distributes a final snapshot of crash dataset for the year. For long-form crash records on state-maintained roads, FDOT geolocates crash records assigning LRS coordinates. These LRS coordinates are used to discern roadway characteristics from RCI for each crash record. For long-form crash records not on state-maintained roads, FDOT geolocates crash records with GIS coordinates and LRS coordinates that do not correspond to roadway data in the RCI. Location verification is conducted on all long-form crash records received by FDOT. Signal Four Analytics (S4A) geolocates long-form and short-form crash records using an automated process. Geolocations from FDOT are used to supplement locations for crash records that cannot be geolocated by the S4A automated process. S4A crash data are a reasonable supplement in HSIP improvement justification. Crash records with location verification from the CAR database are recommended for HSIP improvement justification. The following figure shows the general data processing workflow between agencies.

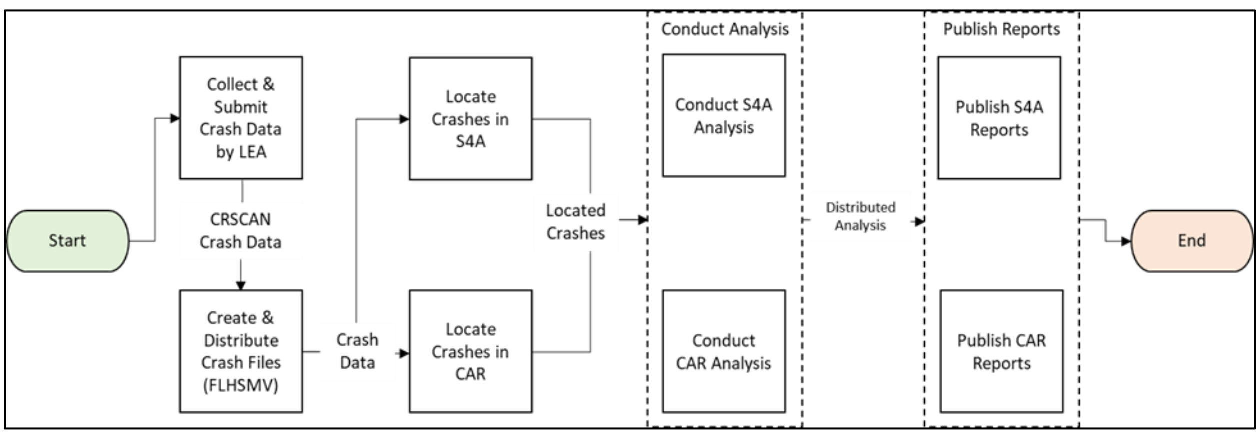

Figure 6. Crash data processing workflow.

There are two methodologies for completing the Florida Traffic Crash Report form. F.S. 316.066 allows law enforcement to provide either a long- or short-form version of the crash report. F.S. 316.066 requires a long form report for any crash meeting the following criteria:

- Resulted in death, personal injury, or indication of complaints of pain and discomfort by any parties or passengers involved in the crash.
- Involved a violation of section 316.061(1) or section 316.193.
- Rendered vehicle inoperable to degree that required wrecker to remove it from scene of crash.
- Involved commercial motor vehicle.

For all other crashes, agencies must submit the short form report or provide a driver self-report form. The short form does not require the narrative and diagram portions of the long-form. The short form includes:

- Crash date, time, and location.
- Description of the vehicles involved.
- Names and addresses of parties involved, including all drivers and passengers, and the identification of the vehicle in which each was a driver or a passenger.
- Names and addresses of witnesses.
- Name, badge number, and law enforcement agency of the officer investigating the crash.
- Insurance companies for the respective parties involved in the crash.

Many reportable PDO crashes recorded via short form (or not reported at all) do not make it into the FLHSMV database or CAR. Additionally, there is inconsistency between law enforcement agencies regarding the use of short form and long form—some always use long form report and others use the short form when the long form is required.

During FHWA’s crash data improvement program (CDIP) review in 2011, it was estimated 30-50 percent of PDOs are not submitted to the state, and FLHSMV does not capture data for roughly half of crashes. FLHSMV receives about 500,000 crashes annually (roughly one-third of which are submitted electronically), and PDOs typically account for about 75 percent of a state’s crashes. Furthermore, the ratio of PDOs is likely under-estimated given the low reportable threshold of $500 in Florida. Under-reporting of PDO crashes may significantly affect crash analyses based on total crash counts.

Appendix B: Systemic Safety Analysis Approaches

The three methods below should be considered for planning systemic projects in Florida. Analysts should select the best method for the available data and appropriate scope of the analysis.

- Systemic SPF-based method.
- Safety Analyst method.
- Simple risk factor-based method.

B.1 Systemic SPF-Based Method

The systemic SPF-based method, developed by University of Florida, implements the systemic approach for intersections and horizontal curves currently, and will be expanded to other types of sites or crash types in the future. A review of crash risk in Florida's Union, Hendry, and Gadsden counties led to the selection of focus facility types and associated fatal and injury crash types (e.g., rear end and left turn for intersections, run off road and rollover for curves). Systemic SPFs relate frequencies of various crash types to risk factors.

Depending upon the relative magnitudes of the historical crashes and the expected crash risk, as determined by the systemic SPFs, an appropriate approach can be chosen based on Table 8.

Table 8. Approaches by historical crash frequency and predicted risk.

Magnitude of Historical Crashes	High Crash Risk (Determined from SPF)	Low Crash Risk (Determined from SPF)
Many Historical Crashes	Common risk factors could be a reason for the problem at this location. A review of historical crashes at this site coupled with site visits and local knowledge can determine whether this needs to be treated as a spot or systemic problem	The risk factors may be site-specific. Consider spot analysis to find the best solution
Few Historical Crashes	Even though crashes have not happened, the risk of future crashes is evident. Since the SPFs do not control for typical countermeasures such as signage, striping etc., conduct site visits and use local knowledge to determine if the location warrants any countermeasure	Low priority location for safety improvement

B.2 Safety Analyst Method

Safety Analyst also includes a systemic analysis module, which incorporates HSM methods for planning systemic projects. The SSO recommends conducting a system diagnosis prior to using Safety Analyst, since the software starts at selecting a countermeasure. Systemic countermeasures should target a focus crash type or contributing factor identified with a data-driven approach. More information is available within the software or in the online user manual.

B.3 Simple Risk Factor-Based Method

When SPFs, crash data, or traffic data are unavailable, a simple risk factor-based approach is appropriate. This approach follows a similar approach to the Safety Analyst method, substituting other risk factors in the place of SPFs to determine risk. The approach is outlined in the following three steps. The FHWA Systemic Safety Project Selection Tool provides more information on this approach and each step.

1. Identify focus crash types, facility types, and risk factors: Focus crash types typically reflect prevalent severe crash types for a given jurisdiction, which may be determined from SHSP emphasis areas or a system diagnosis, as described earlier. Focus facility types include the locations where the target crash types are most prevalent (e.g., rural, two-lane, undivided segments or urban, four-leg, signalized intersections), which may be determined by querying the crash database or from previous research. Risk factors are site-specific attributes common across locations with the focus crash type(s) and associated with an increased risk of the focus crashes. Risk factors may include site-specific crash history (if available), geometric characteristics, and operational attributes. For example, sharp horizontal curves are a common feature associated with roadway departure crashes.
2. Screen and prioritize candidate locations: Using risk factors as a guide, identify sites on the focus facility types with these specific geometric and operational characteristics as candidate locations. To prioritize candidate locations, analysts assign a level of risk to each site based on the site-specific geometric and operational characteristics and crash history. Analysts can also apply thresholds or weights to each risk factor to reduce the list of sites based on available resources and program objectives. The weighted score, determined by presence and value of each risk factor, determines the site's relative risk and implementation priority.
3. Select countermeasures: Given the list of risk factors for the focus crash type(s), select targeted countermeasures to address or mitigate the specific risk factors at the specific locations across the network. Refer to the *Countermeasure Selection* section earlier in this document for more information on this step.

Appendix C: Crash Modification Factors and Countermeasure List

1. Source of Crash Data: The Department of Highway Safety and Motor Vehicles (DHSMV) is the official custodian of the crash reports. The numbers that DHSMV reports are the official numbers. The Florida Department of Transportation (FDOT) Safety Office maintains its own database with crash data obtained from DHSMV, and conducts analyses based on this data for internal FDOT purposes.

2. Use Restrictions: The information on the Traffic Safety Web Portal has been compiled from information collected for the purpose of identifying, evaluating or planning safety enhancements. It is used to develop highway safety construction improvements projects which may be implemented utilizing Federal Aid Highway funds. Any document displaying this notice shall be used only for the purposes deemed appropriate by the Florida Department of Transportation. See Title 23, United States Code, Section 409.

3. Crash Reduction Factors Parameters - ID: 1273, From Year: Any Year, To Year: Any Year, Before Month: 36, Min. Before Month: 12, After Month: 36, Min. After Month: 12

Crash Reduction Factors (as of 7/14/2020)

Florida Department of Transportation

ID	Improvement	Project Count	Total	Fatal	Injury	PDO	Urban	Rural	Night	Day	Rear-End	Angle	Left-Turn	Right-Turn	Sideswipe	Fixed-Object	Head-On	Pedestrian	Ran-Off-Road	Wet Surface
1	New signal at channelized intersection	54	17 Yes	36 No	23 Yes	9 Yes	19 Yes	6 No	20 Yes	17 Yes	-56 Yes	50 Yes	34 Yes	26 No	-9 No	1 No	31 Yes	-70 Yes	-27 No	15 Yes
2	New signal at non-channelized intersection	18	11 Yes	60 Yes	15 Yes	7 No	11 Yes	7 No	22 Yes	7 No	-22 Yes	22 Yes	43 Yes	10 No	-1 No	68 Yes	-38 No	39 No	33 No	7 No
3	Add signal and channelization	25	15 Yes	15 No	21 Yes	9 Yes	16 Yes	13 Yes	-35 Yes	25 Yes	-14 Yes	45 Yes	44 Yes	18 No	-24 Yes	18 No	26 No	41 No	54 Yes	28 Yes
4	Modify signal at channelized intersection	57	14 Yes	5 No	27 Yes	5 Yes	14 Yes		1 No	18 Yes	-5 Yes	12 Yes	16 Yes	-16 Yes	-8 Yes	-42 Yes	24 Yes	11 No	-7 No	28 Yes
5	Modify signal at non-channelized intersection	16	-6 Yes	-5 No	14 Yes	-19 Yes	-3 No	-57 Yes	-11 Yes	-5 Yes	-1 No	-24 Yes	-5 No	-82 Yes	-71 Yes	8 No	25 Yes	-14 No	43 Yes	22 Yes
6	Modify both signal and channelization	25	10 Yes	44 No	22 Yes	-5 No	10 Yes	-41 Yes	-4 No	13 Yes	-8 Yes	19 Yes	54 Yes	-48 Yes	-15 No	-24 No	-24 No	5 No	-61 Yes	14 Yes
7	Modify signal and add channelization	14	22 Yes	-219 Yes	30 Yes	18 Yes	22 Yes	20 No	8 No	26 Yes	17 Yes	25 Yes	40 Yes	8 No	-40 Yes	-34 No	-46 Yes	7 No	-77 No	6 No
8	Remove signal	0																		
9	Add flashing warning signal (signalization)	4	-2 No	100 Yes	-37 Yes	28 No		-2 No	59 Yes	-22 No	80 Yes	-30 No	-117 Yes	100 No	-63 No	100 No			100 No	46 No
10	Interconnect traffic signals	1	28 Yes		27 Yes	29 Yes	28 Yes		10 No	33 Yes	-3 No	-220 Yes		-59 No	-76 Yes	-54 No	56 No	100 No		42 Yes

11	New LT channelization w/ LT phase (signalized)	17	36 Yes	-5 No	36 Yes	36 Yes	38 Yes	13 Yes	23 Yes	41 Yes	45 Yes	31 Yes	40 Yes	24 Yes	33 Yes	4 No	27 No	19 No	25 No	32 Yes
12	New LT channelization w/o LT phase (signalized)	11	28 Yes	75 Yes	35 Yes	18 Yes	33 Yes	-27 Yes	33 Yes	26 Yes	19 Yes	48 Yes	62 Yes	45 Yes	30 Yes	-17 No	34 No	37 No	-29 No	29 Yes
13	New LT channelization (nonsignalized intersection)	66	4 Yes	32 Yes	7 Yes	-1 No	-3 No	19 Yes	-16 Yes	8 Yes	3 No	9 Yes	16 Yes	39 Yes	3 No	10 No	6 No	10 No	0 No	12 Yes
14	Modify intersection at signalized intersection	59	2 No	-12 No	11 Yes	-5 Yes	1 No	78 Yes	-4 Yes	4 Yes	-9 Yes	0 No	10 Yes	-56 Yes	-27 Yes	13 Yes	11 No	16 Yes	10 No	11 Yes
15	Modify intersection at non-signalized intersection	14	9 Yes	30 No	22 Yes	0 No	9 Yes	43 Yes	2 No	9 Yes	14 Yes	14 Yes	12 No	37 Yes	-2 No	30 No	0 No	22 No	0 No	26 Yes
16	Modify channelization and add signal	2	22 Yes		21 Yes	22 Yes	22 Yes		-131 Yes	18 Yes	11 No	16 No	39 Yes	33 No	-6 No	53 Yes	-68 No	16 No	-26 No	5 No
17	Increase storage lane	22	23 Yes	-16 No	22 Yes	24 Yes	28 Yes	-12 Yes	9 Yes	28 Yes	10 Yes	35 Yes	31 Yes	23 Yes	4 No	-5 No	-9 No	35 Yes	-22 No	22 Yes
18	Add turn bay	16	40 Yes	49 No	41 Yes	38 Yes	41 Yes	5 No	38 Yes	42 Yes	42 Yes	59 Yes	49 Yes	-24 No	35 Yes	-10 No	86 Yes	-136 Yes	49 No	38 Yes
19	Add right turn	13	-1 No	-1 No	0 No	-2 No	-9 Yes	25 Yes	4 No	-9 Yes	16 Yes	-11 No	-35 Yes	-142 Yes	-18 No	-18 No	-62 No	-1 No	80 Yes	9 No
20	Add LT (T-intersection)	7	43 Yes	7 No	61 Yes	21 No	32 Yes	51 Yes	-44 Yes	60 Yes	48 Yes	61 Yes	74 Yes	-178 Yes	7 No	-54 Yes	100 Yes		69 Yes	-2 No
21	Add LT (Y-intersection)	1	42 Yes	-118 Yes	53 Yes	31 Yes	42 Yes		24 Yes	56 Yes	52 Yes	48 Yes	84 Yes	46 No	17 No	32 Yes	69 Yes	-118 Yes	27 No	64 Yes
22	Add 2nd LT lane in same direction as existing	28	15 Yes	1 No	22 Yes	10 Yes	13 Yes	93 Yes	7 Yes	16 Yes	6 Yes	35 Yes	29 Yes	33 Yes	-5 No	-6 No	-30 Yes	14 No	1 No	23 Yes
23	Guardrail at bridges end	2	-5 No	-16 No	-16 Yes	2 No	-5 No		1 No	1 No	16 Yes	64 Yes			16 No	37 Yes	61 No		-102 Yes	15 No
24	Guardrail at steep embankments	3	-7 No	-3 No	3 No	-19 No	-3 No	-19 No	-68 Yes	2 No	29 No	-158 Yes	-55 No		57 Yes	-40 Yes	100 No		40 No	-9 No
25	Guardrail at steep embankments with curve	1	-256 Yes		-78 No			-256 Yes		-167 Yes					100 No					11 No

26	Guardrail at roadside obstacles (piers, sign posts, poles, etc.)	2	13 No		38 Yes	-18 No	13 No		31 No	16 No	-25 No	-14 No			-14 No	7 No	100 Yes	-52 No	-52 No	47 Yes
27	Guardrail end treatments	1	8 No		23 No	1 No	8 No		34 No	19 No	-98 Yes	100 Yes			-147 Yes	1 No				13 No
28	Guardrail relocation	0																		
29	Guardrail removal	0																		
30	Add painted median	2	43 Yes	78 Yes	43 Yes	40 Yes		43 Yes	-273 Yes	25 No	33 No	14 No	68 Yes	66 Yes	62 Yes	-44 No	57 No	83 Yes	-15 No	39 Yes
31	Add raised median	30	11 Yes	25 Yes	15 Yes	7 Yes	11 Yes	77 Yes	12 Yes	11 Yes	-3 No	23 Yes	29 Yes	-27 Yes	-2 No	3 No	34 Yes	15 Yes	-19 No	20 Yes
32	Increase median width	4	-2 No	-12 No	0 No	-3 No	-10 Yes	100 Yes	-19 Yes	3 No	3 No	-43 Yes	5 No	3 No	-28 Yes	30 Yes	-699 Yes	-224 Yes	60 Yes	45 Yes
33	Add two-way LT lanes	15	40 Yes	34 No	45 Yes	37 Yes	38 Yes	45 Yes	32 Yes	43 Yes	55 Yes	33 Yes	37 Yes	32 Yes	35 Yes	44 Yes	25 No	-41 No	34 No	29 Yes
34	Install concrete median barrier	1	-37 Yes	56 Yes	-27 Yes	-46 Yes	-37 Yes		-71 Yes	-36 Yes	-46 Yes	-407 Yes	56 Yes	94 Yes	29 Yes	-112 Yes	9 No	-58 Yes	-73 Yes	-48 Yes
35	Install double sided guardrail on wider median	15	-15 Yes	8 No	-2 No	-30 Yes	-25 Yes	8 Yes	-9 Yes	-17 Yes	-2 No	32 Yes	0 No		11 Yes	-33 Yes	38 No	-20 No	34 Yes	-54 Yes
36	Install attenuator type (IBC) barrier	0																		
37	Upgrade to concrete median barrier	1	100 Yes	100 No	100 Yes	100 Yes	100 Yes		100 Yes	100 Yes	100 Yes	100 Yes		100 Yes	100 Yes	100 Yes	100 No		100 No	100 Yes
38	Upgrade to attenuator barrier	0																		
39	Pavement deslicking	4	-3 No	-30 No	-13 Yes	2 No	-2 No	-20 Yes	-34 Yes	3 No	17 Yes	-24 Yes	-7 No	8 No	-43 Yes	8 No	-399 Yes	35 Yes	-127 Yes	30 Yes
40	Skid Hazard overlay	120	-6 Yes	-52 Yes	-4 Yes	-7 Yes	-6 Yes	-15 Yes	-11 Yes	-4 Yes	0 No	-31 Yes	-6 Yes	-2 No	-15 Yes	-9 Yes	-21 Yes	-20 Yes	3 No	17 Yes

41	Pavement grooving	0																		
42	Eliminate parking	4	12 Yes	100 Yes	11 Yes	12 Yes	12 Yes		8 No	13 Yes	2 No	29 Yes	32 Yes	46 Yes	25 Yes	9 No	13 No	63 Yes		26 Yes
43	Change two-way operation to one-way	0																		
44	Prohibit turns	2	-190 Yes	100 No	-99 Yes	-309 Yes	-190 Yes		-43 No	-360 Yes	-178 Yes	-19 No				-19 No	100 No	-19 No		-99 Yes
45	Modify speed limit (increase or decrease)	1	52 Yes	56 No	50 Yes	53 Yes		52 Yes		54 Yes	-18 No	75 Yes	85 Yes		71 No	56 No			100 No	78 Yes
46	Delineation of right edge lines	0																		
47	Delineation of painted median edge lines	1	-76 Yes		-18 No	-155 Yes	-76 Yes		-65 Yes	-85 Yes	-85 Yes	7 No	-85 No		31 No	-410 Yes				
48	Centerline striping	0																		
49	Delineation of no passing stripes	0																		
50	Delineation of reflectorized guide markers	0																		
51	Delineation of reflectorized raised pavement markers (center line)	1	10 No	23 No	11 No	5 No		21 Yes	16 No	3 No	7 No	7 No	-62 No	100 No	81 Yes	-32 No	38 No	100 Yes	25 No	7 No
52	Delineation of general pavement markings (stop bar, ped. crossing, code 46-51)	0																		
53	Delineation of guide posts on curves	0																		
54	Intersection delineation	0																		
55	Curve warning Signing	2	35 Yes		6 No	49 Yes	44 Yes	-306 Yes	56 Yes	21 No	72 Yes	-2 No	32 No		49 No	49 No	-2 No			19 No

56	Chevrons Signing	2	19 Yes		29 Yes	14 No	18 Yes	43 No	23 No	8 No	-5 No	48 No	100 No		-16 No	34 Yes	100 No	100 No	50 No	9 No
57	All-way stops Signing	0																		
58	Overhead directional (where to turn) Signing	3	-7 No	100 No	-9 No	-5 No	-7 No		-17 Yes	-4 No	-15 Yes	16 No	9 No	41 No	14 No	-21 No	-383 Yes	-45 No		-11 No
59	Roadside directional (where to turn) Signing	0																		
60	Overhead lane designation Signing	1	35 No		7 No	44 No	35 No		7 No	69 Yes	100 No	38 No			30 No					7 No
61	Minor leg stop control Signing	0																		
62	Yield sign	0																		
63	Advanced warning signs	1	60 No		60 No			60 No		60 No			100 No							
64	Intersection directional or warning signs	0																		
65	New roadway segment lighting	77	11 Yes	21 Yes	14 Yes	7 Yes	11 Yes	12 Yes	22 Yes	5 Yes	10 Yes	4 Yes	24 Yes	12 Yes	9 Yes	-6 No	14 Yes	36 Yes	21 Yes	11 Yes
66	Upgrade roadway segment lighting	15	8 Yes	12 No	4 Yes	12 Yes	8 Yes	86 Yes	16 Yes	2 No	0 No	-22 Yes	11 Yes	27 Yes	33 Yes	36 Yes	-40 Yes	-1 No	27 Yes	23 Yes
67	New lighting at intersection	22	-11 Yes	39 Yes	-3 No	-17 Yes	-10 Yes	-19 Yes	9 Yes	-22 Yes	-25 Yes	-55 Yes	-52 Yes	-103 Yes	-33 Yes	46 Yes	-42 Yes	3 No	61 Yes	24 Yes
68	Upgrade lighting at intersection	13	76 Yes	30 No	77 Yes	76 Yes	77 Yes	-7 No	73 Yes	77 Yes	80 Yes	76 Yes	73 Yes	79 Yes	66 Yes	60 Yes	68 Yes	72 Yes	67 Yes	67 Yes
70	Bridge approach lighting	1	9 No		-5 No	21 No		9 No		32 No	-42 No				62 No	37 No			-26 No	24 No
71	Underpass lighting	0																		

72	Intersection flashers four leg red-yellow	2	-59 No			100 Yes		-59 No		36 No		-91 No	52 No							
73	Intersection flashers three leg red-yellow	0																		
74	Intersection flashers four way red	0																		
75	Unknown	2	-157 Yes	36 No	-71 No			100 Yes	-29 No	-179 Yes		36 No								-61 No
76	Advanced warning flashers (curve & intersection)	4	-292 Yes	100 No	-68 Yes	-491 Yes	-302 Yes	100 Yes	-189 Yes	-349 Yes	-176 Yes	-257 Yes			-212 Yes	-155 Yes			100 No	-512 Yes
77	Install flashing warning signal (flashing beacon)	7	-51 Yes	-134 Yes	-70 Yes	-38 Yes	-90 Yes	18 No	-132 Yes	-30 Yes	-110 Yes	-65 Yes	11 No	22 No	-6 No	-87 Yes	69 No	-40 No	25 No	-46 Yes
78	Obstacle Removal/Hazard Mitigation	5	25 Yes	28 No	37 Yes	5 No	26 Yes	19 Yes	33 Yes	19 Yes	22 Yes	37 Yes	44 Yes	14 No	4 No	26 Yes	6 No	-38 Yes	61 Yes	28 Yes
79	Relocate obstacle 30 feet from road	0																		
80	Convert to breakaway	0																		
81	Cushion attenuators	0																		
82	Install guardrail	11	-36 Yes	40 Yes	-15 Yes	-61 Yes	-47 Yes	4 No	-38 Yes	-34 Yes	-8 No	3 No	3 No	100 No	-21 Yes	-73 Yes	-46 Yes	44 No	17 Yes	-51 Yes
83	Upgrade substandard bridgerail	1	25 No		100 Yes	-125 Yes	25 No		100 No	-12 No						-12 No				
84	Realignment	4	50 Yes	46 No	41 Yes	61 Yes	41 Yes	100 Yes	27 No	54 Yes	42 Yes	70 Yes	-29 No		23 No	-43 No	-437 Yes	100 Yes	100 No	8 No
85	Superelevation	3	29 No	100 No	-7 No	41 No		29 No	70 Yes	-33 No	-300 Yes	100 Yes	100 No	100 No		100 Yes	-167 Yes		100 Yes	100 Yes
86	Modify/Close median openings	56	6 Yes	15 No	15 Yes	-4 Yes	5 Yes	57 Yes	-5 Yes	9 Yes	-13 Yes	12 Yes	16 Yes	-62 Yes	-30 Yes	-29 Yes	-81 Yes	-37 Yes	3 No	12 Yes

87	Relocate drives	0																		
88	Curtail turning movements	0																		
89	Increase radii at intersection	2	38 Yes	100 Yes	16 No	58 No		57 Yes	21 No	44 Yes	-5 No	48 Yes	-5 No					100 No		-109 No
90	Widen travel way	4	-28 Yes	-8 No	-17 No	-35 Yes	-67 Yes	-2 No	-73 Yes	-19 Yes	-6 No	-134 Yes	-168 Yes	-270 Yes	-44 Yes	-44 No	64 Yes	-8 No	-143 Yes	-38 Yes
91	Widen shoulder	5	-4 No	22 No	5 No	-11 Yes	-7 Yes	20 Yes	2 No	-2 No	-56 Yes	-5 No	-288 Yes	-553 Yes	-112 Yes	-22 Yes	-63 No	7 No	-32 No	-3 No
92	Add 4 foot shoulders (bike lane)	1	6 No		15 No	3 No	6 No		-95 Yes	17 Yes	-15 No	-37 Yes	57 Yes	59 Yes	51 Yes	-173 Yes			67 Yes	-18 No
93	Construct grade separation	0																		
94	Widen bridge (min. of 6 feet)	6	-20 Yes	-112 No	-17 No	-20 Yes	-52 Yes	47 Yes	-21 No	-27 Yes	-32 Yes	3 No	29 No	100 Yes	-9 No	8 No	-6 No	-6 No	47 No	-43 Yes
95	Reconstruct road & shoulders	11	-13 Yes	-127 Yes	-13 Yes	-12 Yes	-25 Yes	65 Yes	-43 Yes	-5 No	-8 Yes	-56 Yes	-11 Yes	2 No	-13 Yes	-37 Yes	-80 Yes	-35 Yes	-46 Yes	6 No
96	Reconstruct curve	3	42 Yes	100 No	53 Yes	43 Yes	40 Yes	54 Yes	28 Yes	53 Yes	23 Yes	27 No	58 Yes	100 Yes	78 Yes	48 Yes	100 Yes	17 No	64 Yes	27 No
97	Construct interchange	2	31 Yes	72 No	24 Yes	35 Yes	22 Yes	100 Yes	24 Yes	44 Yes	39 Yes	22 No			44 Yes	25 No		16 No	53 Yes	41 Yes
98	Lengthen accel/decel lanes	4	50 Yes	-97 No	54 Yes	49 Yes	45 Yes	61 Yes	38 Yes	54 Yes	58 Yes	52 Yes	58 Yes	86 Yes	21 No	21 No	67 No		56 Yes	62 Yes
99	Extend drop lane	0																		
100	Install rumble strips	12	21 Yes	27 No	21 Yes	21 Yes	19 Yes	22 Yes	32 Yes	13 Yes	12 No	28 Yes	27 Yes	3 No	58 Yes	33 Yes	25 No	3 No	49 Yes	6 No
101	Flatten side slopes	0																		

102	Install Accel/Decel lane	3	6 No	100 Yes	-9 No	-2 No		6 No	31 No	-4 No	32 No	22 No	-118 Yes		46 No	100 No		100 No	64 Yes	-118 Yes
103	Upgrade signal and add pedestrian feature	18	-6 Yes	10 No	15 Yes	-21 Yes	-6 Yes		-7 Yes	-8 Yes	-9 Yes	-9 Yes	21 Yes	3 No	-1 No	25 Yes	-63 Yes	9 No	64 Yes	-3 No
104	Sight distance improvements	3	25 No	-93 No	38 Yes	10 No	24 No	25 No	61 Yes	4 No	13 No	49 Yes	81 Yes		52 No	4 No				4 No
105	Minor structures replaced or improved for safety	4	-7 No	-22 No	-3 No	-12 No	-7 No		6 No	-14 Yes	-34 Yes	-56 Yes	-71 Yes	-132 Yes	-13 No	6 No	52 Yes	-12 No	30 No	-61 Yes
106	Lanes added to travel way	5	11 Yes	47 No	21 Yes	-3 No	11 Yes		24 Yes	6 No	-20 Yes	46 Yes	74 Yes	12 No	-44 Yes	10 No	-193 Yes	-164 Yes	26 No	-8 No
107	Upgraded guardrail	3	-53 Yes	-67 Yes	-35 Yes	-98 Yes	-60 Yes	-43 Yes	-48 Yes	-63 Yes	-132 Yes	-30 Yes	-174 Yes	-317 Yes	6 No	-41 Yes	-734 Yes	67 Yes	1 No	-21 Yes
108	Sidewalk construction	25	2 No	-12 No	3 No	1 No	4 Yes	-37 Yes	12 Yes	-4 Yes	5 Yes	-9 Yes	-15 Yes	-6 No	-4 No	-5 No	6 No	-15 No	-36 Yes	6 No
109	Over/Under passes for pedestrians and/or bicycles	3	-90 Yes		-66 Yes	-132 Yes	-90 Yes		-194 Yes	-54 Yes	-58 Yes	-140 Yes	-1582 Yes		-60 No	-1102 Yes	-261 Yes			-37 No
110	Fencing or other pedestrian barriers	2	-4 No	100 Yes	11 No	-43 Yes	-4 No		-61 Yes	4 No	3 No	10 No	27 No	100 No	-107 Yes	-12 No	3 No	-45 No		1 No
111	Ramps on existing curbs	0																		
112	New bikeway/multi-use path construction	4	-28 Yes	-42 No	-23 Yes	-34 Yes	-28 Yes	-34 Yes	-31 Yes	-23 Yes	-56 Yes	-79 Yes	-339 Yes	-392 Yes	-111 Yes	-43 Yes	-53 Yes	-20 No	-80 Yes	-64 Yes
113	Bicycle non-construction improvements	6	30 Yes	-14 No	26 Yes	35 Yes	30 Yes		32 Yes	31 Yes	49 Yes	32 Yes	-1 No	-11 No	36 Yes	35 Yes	40 Yes	2 No	40 Yes	37 Yes
114	Impact Attenuators	3	2 No		16 Yes	-27 Yes	2 No		-14 No	4 No	-3 No	-14 No	45 Yes	-36 No	26 Yes	-36 No	-2 No	-2 No	74 Yes	2 No
115	Signing and Pavement Markings	86	1 Yes	12 Yes	0 No	2 Yes	1 No	15 Yes	2 Yes	2 Yes	-13 Yes	-36 Yes	-71 Yes	-134 Yes	-40 Yes	-15 Yes	-15 Yes	-12 Yes	-16 Yes	-9 Yes
116	Install Traffic Calming Features	2	8 No	100 Yes	3 No	-16 No	8 No		13 No	20 No	42 No	36 No			42 No	23 No	100 No		71 No	42 No

117	Add paved shoulders	24	4 No	0 No	11 Yes	-11 Yes	7 Yes	2 No	9 Yes	2 No	-2 No	-4 No	20 Yes	39 Yes	13 No	-1 No	-1 No	23 No	8 No	15 Yes
118	Add turn lane/s & pavement resurfacing	10	32 Yes	34 No	41 Yes	21 Yes	32 Yes		40 Yes	28 Yes	45 Yes	16 No	37 Yes	19 No	-10 No	9 No	61 Yes	1 No	21 No	41 Yes
119	Reconstruct bicycle/multi-use path	1	37 Yes	100 No	40 Yes	33 Yes	37 Yes		64 Yes	24 Yes	17 No	38 No	52 Yes	4 No	61 No	36 No	52 No			71 Yes
120	Construct median, add signal, & pavmnt.resurfacing	4	9 Yes	-104 No	34 Yes	-30 Yes	9 Yes		-6 No	13 Yes	31 Yes	4 No	22 No	-53 No	-55 Yes	-9 No	32 No		100 No	33 Yes
121	Reconstruct median/median improvments	20	-8 Yes	58 Yes	1 No	-21 Yes	-15 Yes	39 Yes	7 Yes	-14 Yes	-20 Yes	-33 Yes	9 Yes	0 No	-43 Yes	-10 No	1 No	-5 No	26 No	-19 Yes
122	Construct LT and RT lanes	5	-8 No	-7 No	-4 No	-12 No	-12 Yes	39 Yes	5 No	-8 No	-1 No	-72 Yes	11 No	-22 No	-107 Yes	15 No	-114 Yes	20 No	47 No	19 No
123	Paved shoulders & rumble strips	6	0 No	40 Yes	-2 No	-1 No	-18 Yes	27 Yes	-4 No	4 No	-34 Yes	-72 Yes	-49 Yes	-69 Yes	0 No	-12 No	10 No	32 No	17 No	18 Yes
124	Upgrade traffic signal	8	15 Yes	-351 Yes	26 Yes	8 No	16 Yes	8 No	5 No	17 Yes	9 No	14 Yes	13 No	-246 Yes	-17 No	5 No	21 No	-10 No	-20 No	31 Yes
125	Traffic signals, guardrail, signing & lighting	0																		
126	Traffic signals, resurfacing, turn lanes, lighting	7	3 No	100 No	13 Yes	-12 Yes	1 No	12 No	-23 Yes	5 No	9 No	11 No	-2 No	25 No	-71 Yes	-86 Yes	20 No	-15 No	48 No	13 No
127	Resurface, guardrail, signing & pavt. markings	3	-19 Yes	33 No	13 Yes	-28 Yes	-19 Yes		-17 Yes	-20 Yes	-103 Yes	-81 Yes	-143 Yes	-175 Yes	-233 Yes	19 No	-83 Yes	16 No	-68 No	-47 Yes
128	Add Ped crossing mid-block with signals	7	-40 Yes	-119 Yes	-16 Yes	-72 Yes	-40 Yes		-37 Yes	-40 Yes	-42 Yes	-62 Yes	-43 Yes	-48 Yes	-70 Yes	31 No	-40 Yes	34 Yes	100 No	-36 Yes
129	Add Ped crossing mid-block without signals	5	-34 Yes	6 No	-19 Yes	-52 Yes	-34 Yes		-24 Yes	-42 Yes	-91 Yes	-40 Yes	-23 Yes	-62 Yes	-143 Yes	-22 No	-107 Yes	1 No	-6 No	-59 Yes
130	Add roundabout to intersection	2	46 Yes	100 Yes	58 Yes	32 Yes	46 Yes		41 Yes	47 Yes	65 Yes	17 No	76 Yes	-90 Yes	44 Yes	5 No	-1607 Yes	-8 No	100 No	66 Yes
131	Convert shldr inverted rumble to audible edgeline	0																		

132	New inverted AUDIBLE marking on CL or edgeline	67	12 Yes	20 Yes	16 Yes	6 Yes	5 Yes	20 Yes	12 Yes	13 Yes	11 Yes	11 Yes	-37 Yes	-132 Yes	18 Yes	34 Yes	-1 No	34 Yes	45 Yes	7 Yes
133	Use of ITS safety system device(s)	3	67 Yes	40 No	67 Yes	67 Yes	67 Yes		64 Yes	69 Yes	71 Yes	72 Yes	60 Yes	78 Yes	62 Yes	52 Yes	66 Yes	46 Yes	80 Yes	66 Yes
134	High friction surface treatment (tyregrip, etc.)	8	-15 Yes	-47 Yes	-12 Yes	-18 Yes	-18 Yes	23 Yes	-18 Yes	-11 Yes	-65 Yes	-81 Yes	-488 Yes	-254 Yes	-171 Yes	5 No	-797 Yes	-159 Yes	-91 Yes	17 Yes
135	Modify signal timing and phasing	7	-16 Yes	-54 No	-3 No	-27 Yes	-16 Yes		-1 No	-22 Yes	-27 Yes	-35 Yes	-1 No	-182 Yes	-66 Yes	-17 No	-37 No	-3 No		-12 No

Note: Positive CRF means the improvement type is expected to reduce the particular crash type, and vice versa. "Yes" means the corresponding CRF represents a significant crash reduction or increase. Use of CRFs that were developed with a project sample size (Column C) of less than five is not recommended.