CHAPTER 12 SAFETY PROGRAMS/BEFORE & AFTER STUDIES

Section 12.01 Roadway Safety Overview

The Moving Ahead for Progress in the 21st Century Act (MAP-21) went into effect on October 1, 2012 and on December 4, 2015, Fixing America's Surface Transportation Act (FAST Act) was signed into law to provide long-term funding certainty for surface transportation. Together these acts continued the Highway Safety Improvement Program (HSIP) as a core Federal-aid program. The goal of the program is to achieve a significant reduction in traffic fatalities and serious injuries on ALL public roads, which includes non-State-owned roads and roads on tribal and Federal lands. The HSIP requires a data-driven, strategic approach to improving highway safety on all public roads. The HSIP includes the requirement for a comprehensive, data-driven, Strategic Highway Safety Plan (SHSP) that defines State safety goals and describes a program of strategies to improve safety. Each State's SHSP must be updated at least once every 5 years or a state will not be eligible to receive additional formula obligation limitation (ceiling) during the annual redistribution of one-year obligation limitation of Federal-Aid Highway Program Funds (a.k.a. August redistribution).

CTDOT must establish statewide targets for crash reduction and report yearly in its HSIP annual report to FHWA beginning in August 2017. The targets apply to all public roads regardless of functional classification or ownership. The targets are based on 5 performance measures:

1. Number of fatalities
2. Number of serious injuries
3. Rate of fatalities per 100 million Vehicle Miles Traveled (VMT)
4. Rate of serious injuries per 100 million VMT
5. Number of non-motorized fatalities and non-motorized serious injuries

The HSIP targets must be identical to the targets established for NHTSA's (National Highway Traffic Safety Administration) Highway Safety Grants Program. The State must also coordinate with the Metropolitan Planning Organizations (MPO) on the establishment of the targets to the maximum extent practical. MPO's must also establish targets for regional crash reductions within 180 days after the State establishes its targets.

A highway safety improvement project is any strategy, activity or project on a public road that is consistent with the data-driven State Strategic Highway Safety Plan (SHSP) and corrects or improves a road location or feature or addresses a highway safety problem. States are required to have a safety data system to perform problem identification and countermeasure analysis on all public roads, adopt strategic and performance-based goals, advance data collection, analysis, and integration capabilities, determine priorities for the correction of identified safety problems, and establish evaluation procedures.

The framework for highway safety improvement consists of six primary steps:

1. Network screening
2. Diagnosis
3. Countermeasure selection
4. Economic appraisal
5. Project prioritization
6. Effectiveness evaluation

Safety improvement screening and diagnosis can be addressed **reactively** thru hot spot analysis (SLOSSS), **systemically** thru implementation of proven safety countermeasures or **proactively** thru predictive analysis using crash, roadway, and traffic volume data to provide reliable estimates of an existing or proposed roadway's expected safety performance. The reactive method of safety improvement is accomplished thru the Suggested List of Surveillance Study Sites (SLOSSS) for State Highways and thru the Local Road Accident Reduction Program (LRARP) for non-state roadways. Evaluation of an improvement's effectiveness is accomplished thru Before/After analysis.

Section 12.02 State Highway Spot Safety Improvements

The Highway Safety Improvement Program (HSIP) provides federal funding for safety improvement projects, addressing hazardous elements identified at specific locations and along specific roadway sections. Network screening is a process for reviewing a transportation network to identify and rank sites from most likely to least likely to realize a reduction in crash frequency. Identification of locations displaying higher than expected crash rates on the state highway system are accomplished through a system utilizing traffic data consisting of (1) a crash record file, (2) an average daily traffic file, (3) an inventory of certain roadway characteristics. The results are lists of locations that appear to have a higher than expect crash history. These lists are referred to as SLOSSS (Suggested List of Study Surveillance Sites).

Location Analysis & Report

Those locations identified as most likely to realize a reduction in crash frequency are studied in more detail to identify crash patterns, contributing factors, and appropriate countermeasures. Location studies are as extensive as necessary to document the appropriate course of action. Relevant data, such as crash data, collision diagrams, volumes, approach speeds, previous correspondence, field measurements and observations, etc., are compiled. Root causes of crash patterns and trends are identified. Alternative improvements are considered and evaluated in terms of cost, effect upon safety, environmental considerations, changes in traffic flow characteristics, local input, and effect upon other modes of transportation. A report is prepared for each location studied. The scope of that report will vary but will contain sufficient details to adequately document the situation and course of action. Specific SLOSSS Location Report Guidance should be followed to include a site description, analysis of the problem and recommended solution.

Normally, three courses of action could result:

1. No action. The reasons would include the absence of a significant problem, remedial action taken or scheduled, or no engineering solution feasible.
2. Minor work to be accomplished by Maintenance through the issuance of a SM (Service Memo).
3. Recommendation of a project in instances where the improvements are beyond the resources of the Office of Maintenance.

When significant work is being considered the Highway Design Project Development Unit should be consulted to develop a recommended solution and to provide a cost estimate. Highway Design should also be consulted to determine who the prime designer would be if a project is the recommended solution. Prior to recommending a project a benefit/cost analysis should be conducted and the Local Traffic Authority (LTA) of the town/city should be made aware of the study and their concurrence should be obtained. This contact fosters understanding, cooperation, and recognition of the Department's efforts to identify and address problematic conditions in the community.

Section 12.03 Local Road Accident Reduction Program (LRARP)

Under the Code of Federal Regulations – Title 23, Part 924 each state is to develop and implement a highway safety improvement program that has the overall objective of reducing the number and severity of crashes and decreasing the potential for crashes on all public roads. The current Federal Highway Safety Improvement Program emphasizes a data-driven, strategic approach to improving highway safety that focuses on results. The components of planning, implementation and evaluation are required for the use of safety funds on both state and local roads. However, robust roadway data elements have not been available off the state highway system precluding the development of a local road SLOSSS.

Towns assisted by their regional council of government (COG) accomplish the planning component by identifying roadways exhibiting significant crashes provided by the town and CTDOT. Problem areas where there have been concentrations of similar type crashes are identified. All readily available data, plans, crash records, etc., are assembled and analyzed. The objective of this analysis is to identify patterns of crashes and any roadway conditions that could be changed to influence a reduction in those patterns. Countermeasures that will have a clear, direct and positive impact upon perceived problems are then considered including, but not limited to costs, positive impact, negative impacts and the service life of improvements to select the "best" solution that seems to be worth the apparent cost.

Town proposals are submitted to the COG annually for evaluation. Each COG then submits a maximum of 2 proposals per year to the Safety Unit of Traffic Engineering. Each submittal must contain:

- Complete history of crash data i.e. number, injuries, types, roadway conditions, time of day, etc.
- A collision diagram
- An itemized list of construction items and cost
- A concept plan depicting recommended improvements

The Department's Division of Highway Design (Local Roads Unit) and Division of Traffic Engineering reviews all received proposals to ensure that the applications meet the guidelines of the Local Road Accident Reduction Program. Highway Design prepares project cost estimate for comparison to the one supplied in the application. The Division of Traffic Engineering will determine the Benefit/Cost (b/c) ratio using the costs estimated by Highway Design. Municipalities are typically responsible for 10 percent of the contract cost, and all costs for preliminary engineering, design and rights of way. The Division of Traffic Engineering prepares the necessary Recommended Project Memorandum (RPM) to secure the construction funds from the Federal Highway Administration. The Division of Highway Design will administer the project once it has been initiated.

When the project is completed and approximately two years of "after" crash data becomes available, a before and after evaluation of the project may be conducted by the Division of Traffic Engineering. If conducted, the report will be included in the Annual Safety Report to FHWA.

In recognizing that it is difficult to have a large regional safety improvement impact by utilizing the spot improvement method only, the existing LRARP will be revised in the future to fund projects identified in Connecticut Regional Safety Plans (CRiSPs). A CRiSP aims to reduce fatalities and serious injuries on both state and locally owned roads through focusing on key safety emphasis areas. Each one of the 9 regional council of government (COG) in the State is encouraged to identify and document safety concerns they desire to emphasize and address, select appropriate countermeasures to address them and prioritize specific projects. In completing a CRiSP, a region will not only better understand what its safety issues are and how to address them, but also begin to position itself for pursuing funding opportunities to improve safety. Elements identified in a CRiSP can be used to program both spot and systemic improvements. COG's are encouraged to focus on low cost strategies that can be widely applied through the area to achieve the greatest impact in reducing fatalities and serious injuries. Along with identification of specific projects, estimated costs associated with each strategy should be developed to help the region or an individual town budget or decide whether or not to apply for HSIP funding or other Federal-Aid funding.

Section 12.04 Systemic Safety Improvements

Safety improvement projects are intended to improve safety by minimizing or eliminating risk to roadway users on all public roads. Since a significant number of fatal and serious injury crashes are spread over a wide area, it's difficult to address these crashes through the traditional site analysis methods. Rather than managing risk at site specific locations, a systemic approach takes a broader view and looks at risk across an entire roadway system. A system-based approach acknowledges crashes alone are not always sufficient to determine what countermeasures to implement, particularly on low volume local and rural roadways where crash densities are lower, and in many urban areas particularly those where there are conflicts between vehicles and vulnerable road users (pedestrians, bicyclists, and motorcyclists).

The systemic approach does not replace the site analysis approach. There is a need to continue a level of focus on individual locations or roadway segments with a high frequency of serious injury crashes. The systemic approach is a complementary technique that supplements the site analysis approach and provides an expanded comprehensive and proactive approach to road safety efforts. By using the systemic approach agencies can also address the requirements for the Highway Safety Improvement Program, which focuses on fatal and serious injury crashes on ALL public roads.

The key to the systemic approach is evaluating an entire system using a defined set of criteria, which results in a prioritization indicating some elements of the system are better candidates for safety investment than others.

The FHWA Office of Safety has determined that certain processes, design techniques and safety countermeasures have proven to be effective in reducing specific crash types based on effectiveness data for various crash types compiled from a variety of sources. They have identified the types of circumstances and situations that will yield positive results and be cost beneficial for all projects. The widespread implementation of these proven safety countermeasures can serve to accelerate the achievement of local, State and national safety goals. As highway safety programs use a data-driven approach to safety improvements with countermeasure selection based on analytical techniques, the consideration and application of proven countermeasures is most effective.

Section 12.05 Predictive Safety Analysis

The Highway Safety Manual (HSM) is a science-based technical tool to conduct quantitative safety analyses. The HSM allows safety to be quantitatively evaluated alongside other transportation performance measures such as traffic operations, environmental impacts, and construction costs. Using the methodology one can estimate the expected average crash rate of a site, facility or roadway under given geometric design and traffic volumes in a given time period. This methodology is known as a safety performance function (SPF).

The Connecticut Transportation Safety Research Center at UCONN will be developing SPF's and a suite of other products and tools for the State over the next few years.

Section 12.06 Economic Appraisal

Economic appraisals are performed to compare the benefits of potential crash countermeasures to its costs. In an economic appraisal, project costs are addressed in monetary terms. There are two types of economic appraisals, cost effectiveness analysis and benefit-cost analysis. The Department uses the benefit-cost analysis where the expected change in average crash frequency or crash severity is converted to monetary values and compared to the cost of implementing the countermeasure. Any countermeasure that has a ratio greater than 1.0 is considered economically justified. A benefit-cost analysis should be recomputed if there is a major change in scope that results in an increase in cost. When the benefit-cost analysis is recomputed, the latest available crash history may be considered as well.

It is necessary to select a dollar value for the expected benefits in order to use this technique. The Department uses cost figures from the National Safety Council (NSC) which annually estimates costs for fatal and nonfatal injuries. The costs are a measure of medical and other expenses and income not received because of crashes, injuries, and fatalities. It is important to use the latest cost figures to avoid underestimation of benefits.
Benefit:

The benefit is calculated as an annual figure in one of the following equations:

1. B = ADT expansion factor [Q (Pfi x Nfi) + W (Ppd x Npd)] / # of yrs of crash data
2. B = ADT expansion factor [Q (Pfi x Nfi) + Wa (Pa x Na)] / # of yrs of crash data

The second equation is used in situations when a Ppd value is not available for a specific countermeasure.

- ADT expansion factor - volumes generally increase over service life of countermeasure.
- Q - is a value taken from the Injury and Fatal Crash Cost Factors (Q-Book) which is published by the Bureau of Policy and Planning.
- Pfi - percent reduction (in decimal) of fatal and injury crashes. (Use Crash Modification Factors Clearinghouse))
- Nfi - number of fatal and injury crashes possibly affected by the countermeasure.
- Ppd - percent reduction (in decimal) of property damage only crashes. (use clearinghouse)
- Npd - number of property only damage crashes affected by the countermeasure.
- Pa - percent reduction (in decimal) of all crashes (use clearinghouse).
- Na - number of all crashes possibly affected by the countermeasure.
- W - is the cost of property damage only (Pdo) crashes. See Q-Book.

Before the value can be used in the benefit equation, it is necessary to reduce the “W” value by using an additional equation. This is due to the fact that “Na” is the total number of crashes possibly reduced by the countermeasure rather than just the property damage crashes. Also, the property damage cost associated with an injury crash is taken into consideration in the Q factor.

- Wa = [Pdo crash total] x [Cost per Pdo crash] / crash total

The values for Pdo crash total, Cost per Pdo crash and crash total can be found in the Q-Book under the appropriate report.

Cost:
The cost is calculated as an annual figure in the following equation:

C = [Construction Costs / service life of improvement] + annual maintenance/operation costs

- Construction Costs include preliminary engineering, survey, contract items, incidentals, contingencies, rights-of-way and utilities.
- Maintenance/operation costs include sign replacement, re-striping, electricity for signals and other items. Often, historical record of these costs is unavailable at the study location and the costs are often omitted.

Service Life of Improvement:

All improvement projects have a service life. In terms of a countermeasure, the service life corresponds to the number of years in which the countermeasure is expected to have a noticeable and quantifiable effect on the crash occurrence at the site. The service life of a countermeasure reflects a reasonable time period in which roadway characteristics and traffic patterns are expected to remain relatively stable. The expected service life may not necessarily represent the physical life of the improvement.

Rights-of-way should be divided over 100 years to avoid overestimating its cost. The value associated with property long exceeds normal service life and 100 years is a reasonable estimate.

Preliminary Engineering is normally associated with design of a specific countermeasure and its value does not exceed the service life.

Section 12.07 Benefit-To-Cost Ratio (B/C) Method

Evaluating the change in crashes from the implemented safety treatment is an important step in the roadway safety evaluation process. Safety evaluations lead to an assessment of how crash frequency or severity has changed due to a specific treatment or set of treatments. In situations where one treatment is applied at multiple similar sites, safety evaluation can also be used to estimate a crash modification factor (CMF) for the treatment. Safety effectiveness evaluations have an important role in assessing how well funds have been invested in safety improvements. Each of these aspects of safety effectiveness evaluation may influence future decision-making activities related to reallocation of funds and changes to the Department's policies, standards, or practices.

There are numerous methods in the Highway Safety Manual (HSM) for evaluating the effectiveness of a treatment. The method the Department has used for years is for safety effectiveness evaluation is known as observational before/after studies, which is most frequently used. All observational before/after studies use crash and traffic volume data for time periods before and after the improvements of the treated sites. Presently, the Department does not compensate for the statistical bias known as regression-to-the-mean; the observational before/after evaluation is referred to as a simple or naïve before/after evaluation. Historically, the evaluation period the Department has used is two years of crash and traffic volume data before and after the treatment but longer time periods (such as 3-5 years) is recommended to ensure that the results are statistically significant. In order to judge the merits of an improvement and determine if its effectiveness in reducing crashes is statistically significant, regardless of the time period used, a chi-square test is conducted and a 90 percent confidence level is used.

The evaluation report is divided into three phases:

1. Situation - States the reason(s) why the project was initiated.
2. Installation - Type of improvement implemented
3. Results - Interpretation of the crash experience, an analysis of the data, and an evaluation of the improvement's success in reducing the total or specific types of crashes.

In addition, evaluations may be prepared for improvement types as well. These programs may consist of projects that have the same safety classification code (e.g., traffic control signals) or they could be specific improvements on a length of roadway such as gore area improvements on an expressway.

These evaluations are then included in the annual safety report to the FHWA.