

COLORADO

Colorado Department of Transportation Highway Safety Improvement Program (HSIP)



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Prepared by the
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Introduction

In compliance with USC Title 23, Chapter 1, section 152 (“Each State shall establish an evaluation process approved by the Secretary, to analyze and assess results achieved by safety improvement projects carried out in accordance with procedures and criteria established by this section. Such evaluation process shall develop cost-benefit data for various types of corrections and treatments which shall be used in setting priorities for safety improvement projects.”), this report sets forth the Highway Safety Improvement Program (HSIP) developed by the Safety and Traffic Engineering (S&TE) Branch of the Colorado Department of Transportation (CDOT).

This report describes the planning, implementation and evaluation of each aspect of Colorado’s program to reduce the number and severity of traffic accidents and to decrease the potential for accidents on all highways in the State. This is consistent with the overall Mission, Values and Goals of CDOT’s Policy Directive Number 14.

The process for planning and implementing the Colorado HSIP involves the cooperation of a number of departments within State government as well as the participation of local authorities through Metropolitan Planning Organizations (MPOs), Transportation Management Organizations (TMOs), Colorado Counties, Inc. (CCI), the Public Utilities Commission (PUC) and the Colorado Municipal League (CML).

Chapter 1

Traffic Crash Data System

The following information describes the various methods of data acquisition that comprise the Colorado Traffic Crash Data System.

All original accident data is supplied to the Department of Revenue (DOR) by the Colorado State Patrol and local law enforcement agencies. The DOR, in turn, provides information and makes accident reports available to CDOT for analysis. The Uniform Motor Vehicle Law, Colorado Revised Statutes (1995 supp.), reads in part:

42-4-1606(4), "It is the duty of all law enforcement officers who receive notification of traffic accidents within their respective jurisdictions or who investigate such accidents either at the time of or at the scene of the accident or thereafter by interviewing participants or witnesses to submit reports of all such accidents to the department [Department of Revenue] on the form provided including insurance information received from any driver, within five days of the time they receive such ..."

42-1-216, "... all records of accidents must be preserved by the department [Department of Revenue] for a period of six years."

42-1-208, "The department [Department of Revenue] shall receive accident reports required to be made by law and shall tabulate and analyze such reports and publish annually, or at more frequent intervals, statistical information based thereon as to the number, cause and location of highway accidents."

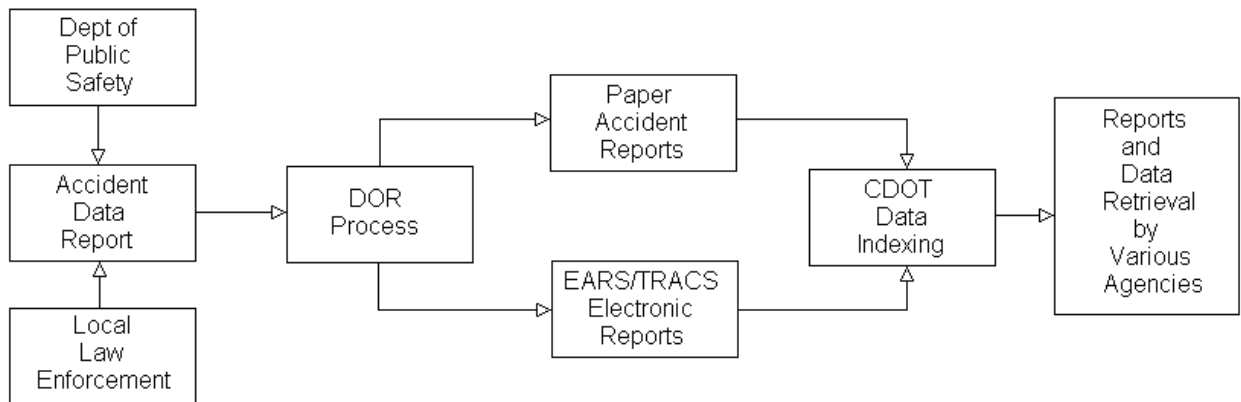
The flow chart, shown on the next page, describes the various steps of data reporting, acquisition, coding and analysis. Descriptions of the functions of each involved organization are discussed in this report.

The flow chart shows the following steps resulting in the final accident data files:

1. Accident (DR 447 or Electronic Entry) report form completed by responsible law enforcement agency. Since January of 1981, a single standard form has been used.
2. Reports are received by the DOR where they are assembled into groups of 100 for processing. Reports are then entered into the DOR computer data files.
3. Reports are sent to the Safety and Traffic Engineering (S&TE) Branch of CDOT where location data indexing and coding of engineering-related items are performed.
4. The S&TE Branch ultimately files these reports where they are easily accessed for further analysis and review.

Considerable effort is made at each step of the data entry procedure to insure the quality of the final data. A high level of cooperative effort is maintained between DOR, CDOT and the Department of Public Safety.

Data Flow Chart for the Accident/Crash Data



From the DOR, data is provided to CDOT in a variety of forms:

1. Special reports, continuous and upon request
2. Monthly Standard Summary of Motor Vehicle Accidents
3. Actual crash reports
4. Internet transfer of electronic data files

Analysis of crash data is done in many different forms, some of which are listed on the following pages.

A. Routine Traffic Crash Studies

- 📊 Monthly Standard Summary of Motor Vehicle Traffic Accidents (DOR)
- 📊 Annual Report of Motor Vehicle Accident Summary for the Highway Performance Monitoring System (S&TE)
- 📊 Annual evaluation of the Colorado Highway Safety Improvement Program (S&TE)
- 📊 Ranked listings of crash study locations (S&TE)

B. Crash Studies as Requested

- 📊 Location Studies - roadway segments or intersections on all highway systems (S&TE)
- 📊 Crash Rates and Hazard Indices by location or road class (S&TE)
- 📊 Justification of safety improvement projects (S&TE)
- 📊 Before/After analysis of safety improvement projects (S&TE)
- 📊 Studies for inclusion in environmental impact statements (S&TE)

C. Special Studies and Functions

- 📊 Annual Report of Crashes and Rates on State Highways (S&TE)

Project Development

The process of project development consists of three basic steps: Planning, Scheduling and Evaluation.

Planning

Highway and safety projects are identified through a variety of methods: Accident frequency distribution, accident rate (including rate-quality control) and accident severity. These methods can be found in Chapter 3.

Special studies are conducted for highway geometric features such as narrow bridges, railroad-grade crossings, steep grades, truck escape ramps, median barriers, analysis of candidate HES sites, work zones, Grade Severity Rating System (GSRS), sections with sharp curves and other locations identified through public input and the safety assessment process.

Scheduling

Using the above methods, program priorities are established in a variety of ways and are discussed under the various project categories.

Evaluation of RRX and HES projects

The annual report entitled "Before and After Study of Effectiveness of the Hazard Elimination Program Analysis" covers this in detail. In addition, individual evaluations are performed as requested.

Another valuable document prepared by the Safety and Traffic Engineering Branch on an annual basis is "Crashes and Rates on State Highways". This report was first prepared utilizing traffic accident data for calendar year 1975. Since that time, it is published annually using the latest available accident and traffic volume data. It has proven to be a useful and important tool in the analysis and selection of locations for safety improvement projects. The report describes traffic accidents and associated rates on the Colorado State Highway System for each calendar year. The report enables S&TE to track yearly changes in accident rates on various highway segments, statewide.

Two major sources of data are required to produce this report: Computerized traffic volume data from CDOT's Division of Transportation Development (DTD), and computerized accident data gathered and maintained by the S&TE Branch.

Chapter 2

Rail-Highway Grade Crossing Program

Federal Section 130 Funds

The federal Section 130 program earmarks funds for individual grade crossing safety projects on Colorado's streets, roads, and roadways. Section 130 projects are identified and prioritized based on an accident prediction analysis and benefit/cost ratio. The Colorado Department of Transportation (CDOT) Safety and Traffic Engineering Branch administers the Section 130 program and is CDOT's point of contact with railroads, the Public Utilities Commission (PUC), and/or local agencies on all CDOT/railroad contracts.

Overview of Federal Section Program

Each year, Federal Highway Administration (FHWA) apportions funds to help improve rail-highway safety, pursuant to 23 U.S.C. (United States Code) Section 130 and related federal law. These funds must be applied toward projects for the elimination of hazards at rail-highway crossings, including the separation or protection of grades at crossings, the reconstruction of existing railroad grade crossing structures, and the relocation of highways to eliminate grade crossings.

Of the annual program funding available, at least half shall be available for the installation of active warning devices at rail-highway at-grade crossings. The balance of funds may be applied, at CDOT's discretion, toward grade crossing active warning devices or other eligible projects under this section. CDOT's policy goal has been to apply half of the program funds toward grade crossing active warning devices, and half of the program funds toward new grade separation structures.

Under this strategy, CDOT is capable of constructing five to seven grade crossing upgrades (e.g., installation of flashing lights, gates, and bells) each year on a continuing basis. Due to the high cost of a typical grade separation structure, it is impractical for CDOT to apply the remaining half of the annual apportionment to a new grade separation project each year. Instead, in the past, CDOT would allow apportionments to "pool" until a meaningful amount was available for such a project.

Typically, 100% participation of the federal funds are applied to safety improvements of rail-highway at-grade crossings. Such projects often consist of installation of active warning devices at locations that only have passive warning devices or inadequate active warning devices. Most of these projects are on local roads and streets (most rail-highway crossings located state highways have already been upgraded). Local agencies may have greater incentive to participate in the program if the project is not conditioned on local matching funds. Section 130 funding for grade separation structures is on a 90:10 federal matching basis.

CDOT recently amended its approach to funding grade separation projects under this program. Instead of "pooling" previous years' apportionment, CDOT plans to utilize the "advance construction" funding concept and apply up to two future years' apportionment (plus any current pool funds) toward a suitable grade separation project. The advantage of this approach is that CDOT does not have to wait several years for the funds to

accumulative to the level needed. Instead FHWA can obligate the necessary funds based on the “advance construction” premise and the funding can be converted at a later date when funds are actually available. This ensures that funds are obligated in a timely manner.

Eligibility

The following types of projects are eligible to receive federal Section 130 program funding:

- ✚ Installation and upgrade of railroad crossing warning systems
- ✚ Reconstruction of existing railroad grade crossing structures
- ✚ Separation of grades at crossings
- ✚ Relocation of highways to eliminate grade crossings
- ✚ Relocation and realignment of railroad tracks to eliminate grade crossings
- ✚ Installation of active advance warning signs
- ✚ Traffic signal preemption
- ✚ Removal of obstructions in sight triangle
- ✚ Construction of median barriers
- ✚ Intelligent Transportation System (ITS) improvements
- ✚ Grade crossing closures

Solicitation of Candidate Projects

To develop and implement safety improvement projects that will reduce the number and severity of train collisions with motor vehicles, bicycles and pedestrians, CDOT’s Safety and Traffic Engineering Branch solicits all agencies having jurisdiction over public rail-highway crossings for candidate grade crossing device projects once every three years. The solicitation is directed to cities, counties, the CDOT Regions, and the Public Utilities Commission. The process for solicitation of candidate projects is as follows:

- ✚ The CDOT Safety and Traffic Engineering Branch sends a request for applications to all agencies having jurisdiction over public rail-highway crossings.
- ✚ The Metropolitan Planning Organizations (MPOs) and PUC also encourage local agencies to submit applications for off-system grade crossing improvements.

Ranking, Selection and Prioritization of Projects

A statewide priority list of grade crossing improvement projects is developed every year. This is done as a cooperative effort between CDOT, the PUC, FHWA, and the MPOs, as follows:

- ✚ State applications and the applications received from local authorities are combined, evaluated and ranked by using the Federal Railroad Administration’s “Resource Allocation Procedures.”

This task is performed by the Safety and Traffic Engineering Branch and representatives from the PUC. Crossings not meeting the minimum Manual on Uniform Traffic Control Devices (MUTCD) requirements are given top priority for improvement.

- ✚ A prioritized listing of projects is created
- ✚ The Safety and Traffic Engineering Branch, by separate procedure, develops an annual list of projects to be funded under the Section 130 program, for inclusion in CDOT's Integrated Safety Plan
- ✚ Projects are funded in the final priority order, to the extent funds are available
- ✚ Using a prioritized list of projects, CDOT assigns the top candidates to an appropriate fiscal year plan, according to available funds
- ✚ Candidate projects that are not initially selected and budgeted may be resurrected later in the three-year planning cycle, if a higher-ranked project should be abandoned for any one of various reasons
- ✚ If a project does not get approved during the current planning cycle, the sponsoring agency may re-nominate it during the next open solicitation

Typical rail-highway at-grade crossing safety improvements fall under the following categories:

- ✚ Eliminate crossing
- ✚ Make site improvements (e.g., increase sight distance, etc.)
- ✚ Initiate crossing surface improvements
- ✚ Installation of active warning devices and/or improvement
- ✚ Some combination of the above measures.

Chapter 3

Hazard Elimination Selection Program

Under this program all public roadways are eligible for participation. Colorado's procedure for complying with the Federal requirements has evolved over the years. In years past, the procedure for identifying high accident locations was limited to considerations of accident frequency, accident severity, and highway classification. Colorado uses a three year project selection cycle to address safety projects.

The identification process now includes a comparative analysis element. This allows for the highway segments in question to be evaluated and compared against all other similar highways in the state. In addition, this revised procedure is better prepared to provide analysis for both spot locations as well as segments. Our latest mathematical evaluation technique is known as the Weighted Hazard Index and Binomial Probability method, or WHI and BP method.

This selection method begins with an initial analysis of the accident database for locations with WHI values greater than or equal to zero statewide. The WHI is a statistic computed by considering accident frequency, accident severities (injuries and fatalities), traffic volumes within a section, length of the section, and a comparison with the accident history of similar highways. Resulting positive values of the WHI indicate highway sections which have an accident frequency/severity history higher than the statewide average and thus a potential for safety improvement (see Figure 1).

Similarly, an analysis is performed using the Binomial Probability analysis method know as Pattern Recognition and Direct Diagnostics (see Figure 2). Typically, this technique is reserved for intersections and spot locations, but is also applicable to all locations, including segments. In the past it has been difficult to conduct a comparative analysis for intersections and spot locations, but this new method is particularly well suited for locations of this type. A cutoff of 90% probability and a total of three accidents in a three-year period are used as a minimum to provide a cutoff threshold.

Subsequently, a statewide composite listing is compiled for all locations meeting the minimum WHI and BP cutoff criteria. This listing is then stratified by Region and provided to the appropriate CDOT Regions and Local Agencies for review.

Figure 1 - Procedure for Calculating the Weighted Hazard Index

1. Determine the number of fatal, injury, and property damage only accidents; minimum of 7 total accidents or 3 fatal accidents within a three-year study period.

2. Compute the weighted number of accidents (A_w):

$$A_w = PDO + (5 \times INJ) + (12 \times FAT)$$

Where: PDO = No. of property damage only accidents
INJ = No. of injury accidents
FAT = No. of fatal accidents

3. Compute the weighted accident rate (R_w):

$$R_w = \frac{A_w}{VMT}$$

Where VMT is vehicle-miles of travel in millions

$$VMT = \frac{ADT \times (Section\ Length) \times (No\ of\ Days\ in\ Time\ Period)}{10^6}$$

4. Compute the weighted critical accident rate (R_{wc}):

$$R_{wc} = R_{wa} + 1.5 \sqrt{\frac{R_{wa}}{VMT}} - \frac{1}{2 \times VMT}$$

Where R_{wa} is the statewide weighted average accident rate for the highway class in question.

$$R_{wa} = \frac{A_{wa}}{VMT_a}$$

A_{wa} is the statewide accidents and VMT_a is the statewide vehicle-miles traveled for that particular highway class.

5. Compute the Weighted Hazard Index (WHI):

$$WHI = R_w - R_{wc}$$

Figure 2 - Procedure for Calculating the Binomial Probability

For a location or Segment of Roadway:

Compute the cumulative Binomial Probability (BP) of an accident type or related accident characteristics using the formula below:

$$Cum BP = \sum_{i=0}^{Nai-1} \frac{Nti!}{(Nti - i)!i!} P_i^i (1 - P_i)^{Nti-i}$$

Where:

Cum BP = Cumulative Binomial Probability in Percent

Nai = Number of Accidents of that Type or Related Characteristic Observed at the Location

Nti = Total Number of Accidents at the Location

P = Statewide Average Percent of Specific Accident Type or Related Characteristic for the Type of Facility

An observed cumulative Binomial Probability of 90% or greater suggests a presence of an accident pattern and a susceptibility to correction.

The initial candidate listing of high hazard locations is reviewed by each engineering Region. The Regions use the high hazard listing along with other information such as their own operational reviews, input from citizens, staff and city/county personnel as well as other ongoing or scheduled construction activities in order to determine the most feasible and beneficial candidate safety project submittals.

The Region may also choose to nominate other safety project locations besides those mentioned on the listing. Any regional nominations not on the list will still need to meet the "cutoff" criteria discussed above.

Off the state highway system submittals are also solicited from local authorities through the various MPOs and the Special Highway Committee of the Colorado Counties, Inc. and the Colorado Municipal League. These candidate proposals for safety improvement projects are submitted for locations identified using the locals' own high hazard locations identification system. As with the region applications, all submittals will be required to meet the minimum cut off values. Copies of project applications received in the Safety and Traffic Engineering Office from locals are submitted to the Region offices for comments, evaluation and approval. The Region offices are specifically requested to verify project cost estimates, and when necessary, are also requested to make project cost adjustments with the submitting local authorities' concurrence.

Application submittals are evaluated and approved by the Regions and submitted to the Safety and Traffic Engineering Office. The applications are then tested to assure that all meet the necessary Pass/Fail criteria. Submittals not meeting the minimum criteria will be

taken off the qualified list and disqualified from further evaluation and funding consideration.

Following the Pass/Fail evaluation, Safety and Traffic Engineering will conduct a Benefit Cost analysis and list candidate projects in descending priority order based upon their Benefit/Cost (B/C) Ratio (see Figure 3). Funding approval is recommended for those projects exhibiting B/C ratios greater than or equal to 1.0. Projects exhibiting B/C ratio's less than 1.0 are not considered cost effective and consequently are not recommended for funding. Projects are funded based on the B/C priority order to the extent funds are available.

Figure 3 - Procedure for Calculating the Benefit/Cost Ratio

The Benefit/Cost ratio is the annual expected benefit divided by the estimated annual average project cost. The B/C formula used is:

$$\frac{B}{C} = \frac{\text{Expected Benefit}}{\text{Estimated Cost}} = \frac{\text{Equivalent Uniform Annual Costs}}{\text{Equivalent Uniform Annual Costs}}$$

Where: $B = [(PDO)(a) + (INJ)(b) + (FAT)(c)] \times ARF$

PDO is the Number of Property Damage Only Accidents

INJ is the Number of Injury Producing Accidents

FAT is the Number of Fatality Producing Accidents

a is cost per PDO accident

b is cost per INJ accident

c is cost per FAT accident

ARF is the Accident Reduction Factor for the type of proposed

and: $C = (PCE \times CRF) + AMC$

PCE is the Project Cost Estimate

CRF is the Capital Recovery Factor

AMC is the Annual Maintenance Cost

High Risk Rural Roads Program

The High Risk Rural Roads (HRRR) Program employs the same evaluation criteria and selection process as the Hazard Elimination Selection (HES) Program, but the projects that are funded are reserved for roadways classified as rural two-lane roads.

Chapter 4

Hazard Elimination Funding Allocation Process

Steps to follow for the allocation of HES dollars to the CDOT Regions and Local Agencies:

✚ The Safety and Traffic Engineering (S&TE) Branch will send the following to the Regions:

- 1) Prioritized locations based on the WHI method that identifies segments
- 2) Prioritized list of locations by the Binomial Probability (BP) method which identifies intersections

Since this list will already be prioritized, the Regions can select projects directly from the list or provide their own candidates.

✚ If the Regions choose locations other than those from the list, Safety and Traffic Engineering will complete a WHI, BP, and B/C analysis on those locations as well.

✚ After selecting their candidate locations, each Region will send S&TE a list of those locations for WHI, BP, and B/C analysis. This will ensure that the candidate projects selected have met the requested federal guidelines as specified in the “U.S. Code, Title 23, Chapter 1, Section 152, paragraph (f) of the Hazard Elimination Program” which reads as follows:

“Each State shall establish an evaluation process approved by the Secretary, to analyze and assess results achieved by safety improvement projects carried out in accordance with procedures and criteria established by this section. Such evaluation process shall develop cost-benefit data for various types of corrections and treatments which shall be used in setting priorities for safety improvement projects”.

✚ The selected allocation method formula distributes funds based on the percent of accidents occurring in each of the Regions. The percentages for the Regions are listed as follows:

Region 1	8.47%	Region 4	15.52%
Region 2	16.26%	Region 5	4.73%
Region 3	9.33%	Region 6	45.69%

The source of funding comes exclusively from the Federal Hazard Elimination Program of SAFETEA-LU. The Regions would receive the following from which up to approximately 50% would be available to the local authorities.

The boxes below illustrate examples of the funding allocations of FY 2008, 2009 and 2010:

Total for Regions				
Region	Percent	FY2008	FY2009	FY2010
1	8.47%	\$ 692,621	\$ 678,954	\$ 558,239
2	16.26%	\$ 1,329,637	\$ 1,303,399	\$ 1,071,661
3	9.33%	\$ 762,946	\$ 747,891	\$ 614,920
4	15.52%	\$ 1,269,124	\$ 1,244,080	\$ 1,022,890
5	4.73%	\$ 386,789	\$ 379,156	\$ 311,744
6	45.69%	\$ 3,736,230	\$ 3,662,502	\$ 3,011,329

Total for Locals				
Region	Percent	FY2008	FY2009	FY2010
1	8.47%	\$ 737,233	\$ 722,685	\$ 594,195
2	16.26%	\$ 1,415,278	\$ 1,387,350	\$ 1,140,687
3	9.33%	\$ 812,088	\$ 796,062	\$ 654,527
4	15.52%	\$ 1,350,868	\$ 1,324,211	\$ 1,088,773
5	4.73%	\$ 411,701	\$ 403,577	\$ 331,823
6	45.69%	\$ 3,976,879	\$ 3,898,403	\$ 3,205,288

✚ The Regions are in charge of submitting their lists to the S&TE Branch for both the Region and the Locals. The Regions are also in charge of dividing the total dollars between Region projects and Local projects. If a Region does not spend all dollars allocated, then another project should be submitted until all dollars have been spent. If a Region goes over the allocated dollars, the Region will be responsible for covering the difference in funds. It is the objective of the S&TE Branch to maximize accident reduction within limited budgets by making safety improvement allocation where it does the most good and prevents the most accidents.