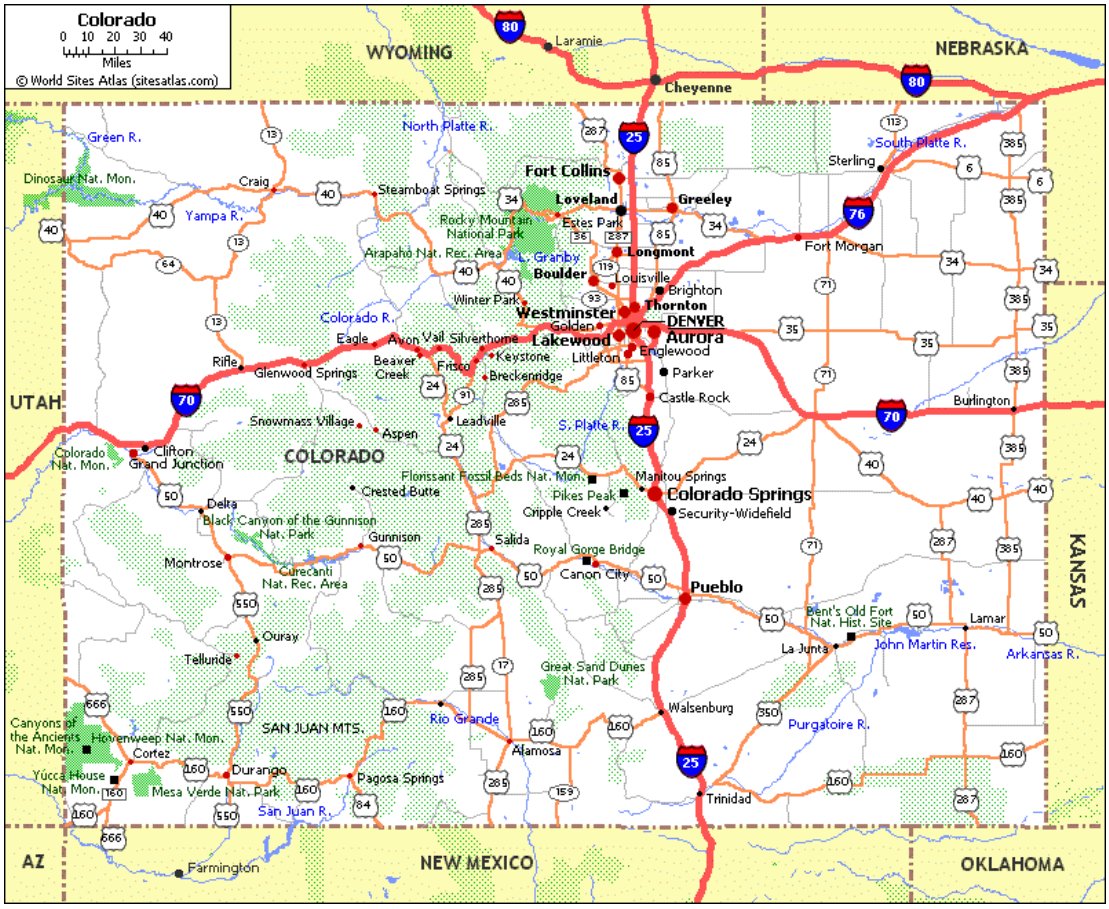
COLORADO

Highway Safety Improvement Program (HSIP)



August 2002

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Colorado Department of Transportation

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Introduction

In compliance with CFR 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 processes for planning and implementing the Colorado HSIP involves the cooperation of a number of State Departments and the participation of the locals through the Metropolitan Planning Organizations (MPOs), Transportation Management Organizations (TMOs), the Colorado Counties, Inc (CCI), Public Utilities Commissions (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.

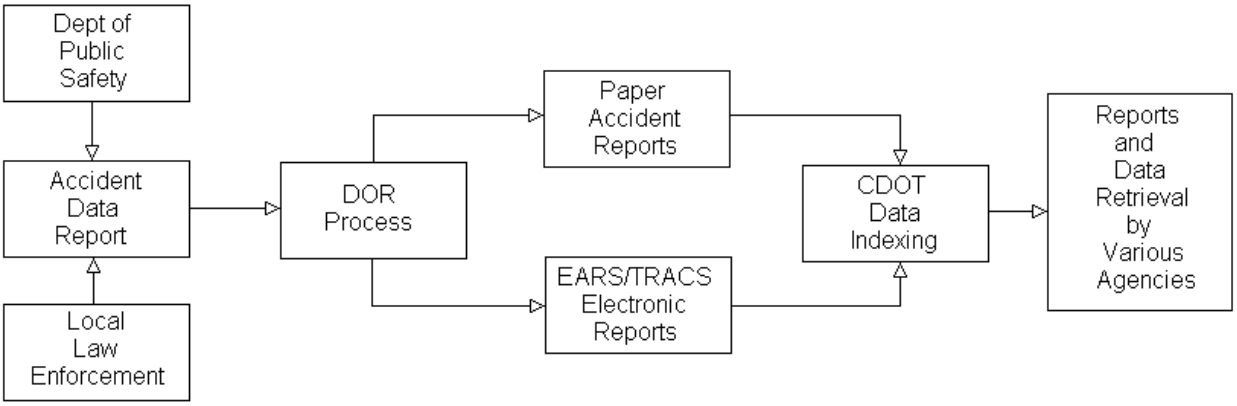
2. Reports are received by the DOR where they are assembled into groups of 100 for processing. Reports are then entered into the DOR computer data files.

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 file these reports where they are easily accessible 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 Colorado Highway Safety Improvement Program (S&TE)
- Ranked listings of crash study locations (S&TE)

B. Crash Studies as Requested

- Location Studies - roadway section or intersection 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 also conducted for specific highway geometric features such as narrow bridges, railroad-grade crossings, steep grades, truck escape ramps, median barriers, HES analysis, work zones, Grade Severity Rating System (GSRS), sections with many sharp curves and other locations identified through public input and safety assessment process program.

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 useful and an 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 individual calendar year as shown by the date on the cover. The report enables S&TE to keep track of yearly changes in accident rates on all the various segments of highways, 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 funds provided under Section 130 of Title 23 United States Code are for the improvement of rail-highway crossings. Currently, annual program funds total approximately $2.3 million. All public roads are eligible for these funds. Section 130 requires that a minimum of 50% of the allocated funds be used for grade crossing protection devices.

Project prefixes are:

RRP, SRP - Grade crossing protection devices on Federal-Aid System
RRO, SRO - Grade crossing protection devices off the Federal-Aid System
RRS - Grade separation projects

RRO/RRP

Based on a multi-year planning schedule, a Statewide priority list of grade crossing improvement projects is developed. This is done as a cooperative effort between CDOT, the Public Utilities Commission (PUC), the Federal Highway Administration (FHWA), Metropolitan Planning Organizations (MPOs), the Special Highway Committee of Colorado Counties, Inc., and the Colorado Municipal League, as follows:

1. A listing of State Highway Crossings is prepared by the Safety and Traffic Engineering Branch with input from the region offices.

2. The MPOs and the Special Highway Committee solicit applications for off-system grade crossing improvements from local authorities.

3. Project cost estimates (submitted by CDOT Regions and the locals) are all sent to PUC for verification and approval.

4. State highway crossings and the applications received from local authorities are then combined and prioritized using Federal Railroad Administration's (FRA) "Resource Allocation Procedures". This task is performed by the Safety and Traffic Engineering Branch and representatives from the PUC. Crossings not meeting the minimum MUTCD requirements are considered as top priority for improvement.

5. Projects are funded in the final priority order, to the extent funds are available.

6. When projects are approved for funding, the implementation of rail-highway crossing projects includes an on-site review by a diagnostic team. This team is

composed of representatives from CDOT, PUC, railroad companies and local governments.

The on-site field reviews involve a detailed discussion of the proposed improvements for the particular rail-highway crossing. The diagnostic team reviews the inventory data. Accident data are discussed and exposure factors, sight distance, road approaches, surface conditions and alternative types of protection are considered. At the conclusion of the field review, the engineering region office documents the recommendations of the diagnostic team and the process of programming crossing improvement projects is begun.

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 traffic control device and/or improvement
- Combination of all these

RRS

Fifty percent of each year's allocation is intended for grade separation projects. Locations are selected from a priority list prepared by the Safety and Traffic Engineering Branch and representatives from the PUC (using FRA's "Resource Allocation Procedures") Typically, CDOT constructs one such project every 3-4 years, using multi-year Section 130 apportionments. A project may also involve funding from other categories (Local Safety, Bridge Replacement, etc.).

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.

This year a new identification process began that now includes a comparative analysis element. This allows for the highway segment in question to be evaluated/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's greater than or equal to zero statewide. The WHI is a statistic computed by considering accident frequency, accident severities (injuries and fatalities), traffic volume 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.

Similarly an analysis is done using the Binomial Probability analysis method. Typically this technique is reserved for intersections and spot locations. In the past it has been difficult to conduct comparative analysis for intersections and spot locations, but this new method is particularly well suited to these type locations. A cutoff of 90% probability and a total of three accidents in a three-year period are used as a minimum to provide the 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 regions for review.

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

5. Compute the Weighted Hazard Index (WHI):

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

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= 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 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 once evaluated and approved by the regions and submitted to the Safety and Traffic Engineering Office are 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. 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.

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

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

Where: B = [(PDO)(a) + (INJ)(b) + (FAT)(c)] x 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 improvement(s)

and: C = (PCE x CRF) + AMC

PCE is the Project Cost Estimate
CRF is the Capital Recovery Factor
AMC is the Annual Maintenance Cost

Chapter 4

Hazard Elimination Funding Allocation Process

Steps to follow for the allocation of HES dollars to the regions:

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

  1) Prioritized locations based on WHI method that identifies segments,
  2) Prioritized list of locations by 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 the regions have selected their locations, each region will send S&TE the list of locations and we will perform a 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 consists of the funds being allocated by combining 60% of accidents with 40% of the Other region Priorities (ORP = 45% VMT, 40% Lane Miles, 15% TMT). The percentages for the regions are proposed as follows:

Region 1	10.81%	Region 4	16.56%
Region 2	16.56%	Region 5	6.44%
Region 3	11.83%	Region 6	37.81%

There are two sources of funding 1) Section 152 specific HES dollars 2) Sanction dollars which we may or may not get based on whether the Open Container Law passes. If combined, we have the best case scenario. Under this

best case scenario, the regions would receive the following from which up to approximately 50% would be given to the locals.

The boxes below illustrate examples of the funding allocations of FY 2004, 2005 and 2006:

Total for Regions				
Region	**Percent**	**FY2004**	**FY2005**	**FY2006**
1	10.81%	$ 710,323	$ 735,183	$ 760,881
2	16.56%	$ 1,088,654	$ 1,126,755	$ 1,166,140
3	11.83%	$ 777,699	$ 804,917	$ 833,052
4	16.56%	$ 1,088,326	$ 1,126,415	$ 1,165,788
5	6.44%	$ 423,335	$ 438,151	$ 453,466
6	37.81%	$ 2,485,513	$ 2,572,503	$ 2,662,422

Total for Locals				
Region	**Percent**	**FY2004**	**FY2005**	**FY2006**
1	10.81%	$ 756,170	$ 782,635	$ 809,991
2	16.56%	$ 1,158,920	$ 1,199,480	$ 1,241,407
3	11.83%	$ 827,894	$ 856,869	$ 886,820
4	16.56%	$ 1,158,570	$ 1,199,119	$ 1,241,033
5	6.44%	$ 450,659	$ 466,431	$ 482,735
6	37.81%	$ 2,645,938	$ 2,738,542	$ 2,834,265

- The regions would be in charge of submitting their lists to S&TE for both the region and the Locals. The regions would also be 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. Keep in mind that our objective is to maximize accident reduction within limited budgets by making safety improvement allocation where it does the most good and prevents the most accidents.

At the request from FHWA, this process will be tried for a minimum of 3 years and will be evaluated at the end of the 3 years.