Continuous Evaluation Of In-Service Highway Safety Feature Performance

Final Report 482

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DISCLAIMER

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16. Abstract –

This report documents the research effort, findings, conclusions, and recommendations of a study to develop a program for the continuous in-service evaluation of highway safety features. The study consisted of two phases and eight tasks.

An in-service evaluation program was developed, which includes the following four major subsystems:

- Level I - Continuous Monitoring Subsystem: A computerized database created by merging four linked files: highway and traffic data, accident data, maintenance data, and roadside feature inventory.
- Level II - Supplemental Data Collection Subsystem: Supplemental field collection of data on the roadway, roadside and selected safety feature, and manual review of hard copies of police accident reports to obtain information otherwise not available from the computerized database.
- Level III - In-depth Investigation Subsystem: In-depth investigation of selected accidents to assess performance of roadside safety features.
- New Product Evaluation Subsystem: Targeted at potential problems encountered with the construction/ installation and maintenance of new roadside safety devices.

A field trial of the Level II supplemental data collection subsystem, which demonstrated its feasibility, was successfully conducted with the assistance of the ADOT Phoenix Maintenance District and the Arizona Department of Public Safety.

It is recommended that ADOT consider the establishment of a continuous in-service evaluation program. The program may be implemented in phases, depending on the availability of manpower and resources.

The conceptual framework of a proposed National Center for In-Service Performance Evaluation of Roadside Safety Features was also developed under this study and presented in a white paper. It is recommended that this idea be pursued further, particularly with the AASHTO Task Force on Roadside Safety or the Mid-States Pooled Fund Program.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS					APPROXIMATE CONVERSIONS FROM SI UNITS				
Symbol	When You Know	Multiply By	To Find	Symbol	Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH					**LENGTH**		
in	inches	25.4	millimeters	mm	mm	millimeters	0.039	inches	in
ft	feet	0.305	meters	m	m	meters	3.28	feet	ft
yd	yards	0.914	meters	m	m	meters	1.09	yards	yd
mi	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi
		AREA					**AREA**		
in^2	square inches	645.2	square millimeters	mm^2	mm^2	Square millimeters	0.0016	square inches	in^2
ft^2	square feet	0.093	square meters	m^2	m^2	Square meters	10.764	square feet	ft^2
yd^2	square yards	0.836	square meters	m^2	m^2	Square meters	1.195	square yards	yd^2
ac	acres	0.405	hectares	ha	ha	hectares	2.47	acres	ac
mi^2	square miles	2.59	square kilometers	km^2	km^2	Square kilometers	0.386	square miles	mi^2
		VOLUME					**VOLUME**		
fl oz	fluid ounces	29.57	milliliters	mL	mL	milliliters	0.034	fluid ounces	fl oz
gal	gallons	3.785	liters	L	L	liters	0.264	gallons	gal
ft^3	cubic feet	0.028	cubic meters	m^3	m^3	Cubic meters	35.315	cubic feet	ft^3
yd^3	cubic yards	0.765	cubic meters	m^3	m^3	Cubic meters	1.308	cubic yards	yd^3
	NOTE: Volumes greater than 1000L shall be shown in m^3.								
		MASS					**MASS**		
oz	ounces	28.35	grams	g	g	grams	0.035	ounces	oz
lb	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb
T	short tons (2000lb)	0.907	megagrams (or “metric ton”)	mg (or “t”)	Mg	megagrams (or “metric ton”)	1.102	short tons (2000lb)	T
		TEMPERATURE (exact)					**TEMPERATURE (exact)**		
°F	Fahrenheit temperature	5(F-32)/9 or (F-32)/1.8	Celsius temperature	°C	°C	Celsius temperature	1.8C + 32	Fahrenheit temperature	°F
		ILLUMINATION					**ILLUMINATION**		
fc	foot candles	10.76	lux	lx	lx	lux	0.0929	foot-candles	fc
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2	cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE AND PRESSURE OR STRESS					**FORCE AND PRESSURE OR STRESS**		
lbf	poundforce	4.45	newtons	N	N	newtons	0.225	poundforce	lbf
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa	kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

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1. INTRODUCTION

1.1 Problem Statement

Modern roadside safety features have been designed and crash tested to meet National Cooperative Highway Research Program (NCHRP) Report 350 guidelines. [1] Although these guidelines assure that safety devices function well for the impact conditions set forth in the guidelines, there are many unknowns and concerns about the field performance of most roadside features. Differences between field performance and crash test results can arise due to many factors, including:

- Field impact conditions that are not included in crash test guidelines, such as non-tracking and side impacts.
- Site conditions that adversely affect vehicle kinematics before, during, or after impact with the safety device, such as roadside slopes and ditches.
- Performance sensitivity to installation details, such as soil resistance or barrier flare configuration.

The only practical method for generating field performance data for roadside safety features is through in-service evaluation. Further, due to the large numbers of accidents that are normally required to evaluate the relative performance of various safety features, a continuous evaluation procedure is highly desirable. The procedure should allow transportation engineers to identify the overall safety performance of a feature as well as identify potential weaknesses or problems with the design.

1.2 Study Objectives

The objectives of this research project, as presented in the statement of work, are: *to develop a program for the Arizona Department of Transportation (ADOT) to conduct continuous in-service evaluation of highway safety features, evaluate this program through field trials, and work with other states at developing a nationwide database of in-service evaluations of highway safety features.*

1.3 Study Scope

The study is divided into two phases and eight tasks:

Phase I - Develop Work Plan

Task A - Conduct a Literature and State-of-the-Practice Review
Task B - Develop In-Service Evaluation Program Outline
Task C - Design Field Trial
Task D - Prepare Interim Report

Phase II – Implement Work Plan

Task E - Develop In-Service Evaluation Program
Task F - Conduct Field Trial
Task G - Prepare White Paper for a National Database
Task H - Prepare Final Report

Phase I was basically the planning phase, involving a review of the literature and of the state-of-the-practice of in-service performance evaluation of roadside safety features, development of the outline for the in-service performance evaluation program, and design of the field trial. Results of the Phase I activities and the planned Phase II activities were summarized in an interim report submitted to and approved by the Arizona Department of Transportation (ADOT). (2)

The Phase II activities included: development of an in-service performance evaluation program, conduct of a field trial, and conceptual development of a national database for in-service performance evaluation. The research effort, findings, conclusions and recommendations are documented in this final report.

Chapter II of the report provides a review of the literature and the state-of-the-practice. The proposed continuous in-service evaluation program is presented in Chapter III. The conduct and results of the field trial are summarized in Chapter IV. The concept of a proposed national center on in-service evaluation is discussed in Chapter V. A summary of the findings and recommendations is presented in Chapter VI.

The form and instruction manual used with the field trial are shown in Appendix A and a white paper on the proposed national center on in-service evaluation is included as Appendix B.

2. LITERATURE REVIEW AND STATE-OF-THE-PRACTICE

A review of the literature and the state-of-the-practice was conducted under Task A. Information gathered in this task is summarized in this chapter.

2.1 Literature Review

The importance of in-service performance evaluation for roadside safety features began to gain widespread recognition with the publication of National Cooperative Highway Research Program (NCHRP) Report 118, *Location, Selection, and Maintenance of Highway Traffic Barriers*, in 1971. [3] This document recommended that highway designers consider a new safety device to be experimental until its field performance had been carefully monitored and evaluated and its effectiveness established. After acceptable field performance was demonstrated, a new safety device would then be considered operational and the monitoring of the device's performance could then be discontinued.

This recommendation for in-service evaluation was promulgated through several subsequent publications, including NCHRP Report 153 in 1974, *Recommended Procedures for Vehicle Crash Testing of Highway Appurtenances*, [4] the 1977 American Association of State Highway and Transportation Officials' (AASHTO) *Guide for Selecting, Locating and Designing Traffic Barriers*, [5] and the 1988 and 1996 editions of AASHTO's *Roadside Design Guide*. [6, 7] During this same period, the Federal Highway Administration (FHWA) began to require state departments of transportation (DOTs) to conduct in-service evaluations before a new safety feature could be included in the design standard for use on Federal-Aid highways. When FHWA began issuing formal acceptance letters for safety features, new systems were placed into an experimental category that would allow states to use the device provided some sort of in-service evaluation was conducted.

These AASHTO and NCHRP publications, in concert with FHWA's policies, prompted many states to conduct rudimentary in-service evaluations on new or relatively new safety features. Unfortunately, most of these early studies were extremely limited in objective, duration, or scope. In response to the less than spectacular results of these early efforts, a section covering in-service evaluations was included in NCHRP Report 230, *Recommended Procedures for the Safety Performance Evaluation of Highway Appurtenances*. [8] This report lists the following six objectives for an in-service evaluation study:

1. Determine if design goals are achieved in the field and identify changes that might improve field performance.
2. Acquire a broad range of collision performance information for typical field installations.

3. Identify special operational problems, such as vulnerability to pilferage, vandalism, and corrosion.
4. Examine influence of climate/environment on collision performance.
5. Examine the influence that the feature exhibits on highway operational characteristics, such as congestion, accident rates or patterns. These influences may be indirect such as through disruption of surface drainage or drifting of snow.
6. Acquire routine installation and maintenance information and identify opportunities to reduce overall costs.

These same objectives have been echoed in subsequent publications by Solomon and Boyd [9] and Ross, et al.[1] Although some in-service evaluations were successfully conducted, most of these studies collected little meaningful accident information. The most common problem with these studies was the limited accident exposure that could be generated with a few "experimental" installations. In recognition that its experimental/operational classifications were placing a burden on both highway agencies and manufacturers without generating the expected in-service performance evaluations, FHWA changed its policy in 1993. Thereafter, all safety features that successfully met full-scale crash testing criteria were deemed operational. However, FHWA continues to encourage the state DOTs to conduct in-service performance evaluations so that more meaningful data can be generated for those devices that gain wide acceptance.

With the publication of updated crash testing guidelines in NCHRP Report 350[1] and the mandate by FHWA that all future roadside safety features used on the National Highway System (NHS) meet the new guidelines, the emphasis on recent studies of in-service performance evaluation has changed to address existing features that fail to meet the new guidelines so that these features may continue to be used on the NHS until replaced by new features. Examples of such studies include a study by Washington DOT on the Breakaway Cable Terminal (BCT) and a study by Kansas DOT on temporary concrete barriers. [10,11] Also, the work conducted under NCHRP project 22-13 on in-service performance evaluations of longitudinal barrier systems has heightened the interest of state DOTs in this area. [12]

As indicated by the objectives for an in-service performance evaluation, a thorough study of this type requires collection of different types of information, including: safety performance data, installation/repair summaries and cost data, and highway operational information. Most of the in-service performance evaluations conducted to date have successfully identified installation and maintenance costs for roadside safety hardware. Most states routinely record bid tabulations in sufficient detail to identify installation costs. Further, in order to seek reimbursement from drivers of errant vehicles, many states now routinely track the cost of repair after an accident. Qualitative assessment of a safety device with regard to objectives 3, 4, and 5 can normally be obtained by interviewing construction and repair crews as well as field personnel in regions where the devices are commonly used.

On the other hand, the safety performance data, i.e., impact performance record, is much more difficult to generate. Various approaches for identifying the impact performance of roadside safety features have been used in previous in-service evaluation studies, including:

- Review of accident data.
- Review of maintenance records.
- Site inspection.
- Periodic inspection.
- Published procedure.

More detailed descriptions of these approaches are presented in the following sections.

2.1.1 Accident Data

The easiest method for evaluating the performance of roadside safety features is to query state computerized accident databases. Although queries of state accident databases are normally the first step in the examination of the in-service performance of safety devices, this approach is fraught with difficulty and few reported studies have been strictly limited to analysis of existing computerized databases. First, computerized databases are limited to reported accidents and, therefore, indicate much higher severity than the overall average when unreported incidents are included. Second, computerized databases are based on police accident reports that are dependent for consistency upon the investigating officers who prepared the reports and the clerical staff who transcribed the information from the reports into the database.

Although police officers are generally conscientious about completing accident reports, their knowledge of roadside safety features is extremely limited. For example, few investigating officers would know the difference between the various types of guardrails or the ever-increasing variety of guardrail terminals. Another example is that officers could seldom distinguish between an impact on the side of a guardrail terminal and one involving the longitudinal barrier itself. As a result, most in-service evaluation efforts that relied on computerized databases have supplemented the accident data with other information, such as collecting roadside inventory data or manual review of hard copies of accident reports. For instance, a roadside inventory can be used to determine the type of guardrail struck in an accident by cross-linking locations of accidents with guardrail installations. One recent application of this approach compared accident histories for weak post guardrails, including cable and W-beam systems, to strong post guardrails. [13]

Another problem is the lack of information on the conditions of the roadside safety feature at the time of impact and the highway and traffic characteristics where the feature is installed. For example, roadside barriers are frequently installed on the edge of a slope, in asphalt shoulders, or in other situations where the safety performance might be degraded. The locations and physical conditions, such as lateral offset, mounting height and the conditions of the rail and posts, of the roadside barriers may also affect their performance. Most of this information is not available from computerized databases, thus necessitating the collection of supplemental data.

Despite the limitations, analysis of computerized databases could provide a good indication of the actual performance of the various barrier systems, especially when used to compare similar systems. It should be noted that variations in traffic exposure could also affect the comparison among systems. For example, if barrier system A is used mostly on lower speed roadways while barrier system B is used mainly on Interstate highways, comparison of the performance of these two barrier systems should take into account the fact that accidents involving barrier system A would likely reflect lower impact speed and hence lower impact severity.

Manual review of hard copies of accident reports has also been used as a supplement to the analysis of computerized accident databases. For example, in a study of the safety performance of turned-down guardrail terminals, a sample of all ran-off-road accidents involving guardrails was analyzed.[(14)] Hard copies of accident reports were obtained and manually reviewed to identify accidents involving terminal sections. Although there was some difficulty in determining the exact location of the impact in some of the records, this approach gave a good indication of the performance of the turned-down guardrail terminals for reported accidents. This type of analysis is still limited to police-reported accidents and it is necessary to also include unreported incidents in order to establish the true performance of a system. Nevertheless, a number of studies have utilized state accident databases, supplemented by analysis of the original accident reports, to identify overall severity levels of roadside features.[(15-20)]

2.1.2 Maintenance Record

As mentioned above, in order to fully assess the performance of a roadside safety appurtenance or feature, it is necessary to look at both reported accidents and unreported incidents. One of the easiest procedures for estimating the extent of unreported incidents is to examine maintenance records. Devices that are easily damaged, such as breakaway signs and luminaire supports, would almost always require repair after an impact. Maintenance records for these devices can be compared to the time and location of police accident reports to identify which repairs are from reported accidents and which are from unreported incidents. This would provide an estimate of the total number of impacts with the roadside safety feature. The value of examining maintenance records diminishes as a feature’s durability and resistance to damage increase. For example, maintenance records for concrete barriers would identify few vehicular impacts that were not reported to police.

A number of studies used maintenance records to supplement police-reported accident data with varying degrees of success. (21-23) Studies that used retrospective analyses of historical maintenance records were generally less successful than those that incorporated maintenance crews in a prospective data collection process. (24-27) Collecting new data using maintenance crews could significantly increase the cost and complexity of the study, not to mention the additional workload for the already undermanned maintenance crews, but the additional information obtained can be very helpful in identifying the types and nature of accidents for which a safety device functions well.

2.1.3 Site Inspection

Another approach is to have designated personnel inspect accident sites to document the details of a system's performance in an accident, the nature and conditions of the impact, and the roadside conditions associated with the safety device in question. For this type of study, a notification system is set up with law enforcement agencies or maintenance forces to notify the project team of accidents, either reported or unreported, involving a particular roadside feature. A team member is then dispatched to the site for a thorough investigation. In some studies, site inspection was part of a detailed investigation of the accident, including documentation of roadway and roadside characteristics, extent of damage to the safety feature, and photographs of the scene. (28-31) Other studies incorporated site inspections strictly to ascertain what type of system was struck and whether the system performed as expected. (32-34) Overall, these types of site inspections are the best method for identifying weaknesses and sensitivities of the safety system to various design parameters.

In some studies, site inspections were conducted long after the occurrence of the accidents. (35,36) In most cases, the site inspections were conducted after the safety features had been repaired. The assumption is that the safety features would be restored to their pre-impact conditions and these late site inspections would still yield useful information regarding the roadside and traffic characteristics associated with the accidents. Site inspections have also been used as a means of estimating the frequency of unreported accidents. (37,38) Recently constructed safety features were inspected for evidence of impact damage, e.g., tire marks on a concrete barrier. The damages were then compared to reported accidents and maintenance records to estimate the frequency of the devices being struck without generating an accident report or requiring any repair. Unfortunately, this approach tends to overestimate the impact frequencies since it is sometimes impossible to identify impacts with multiple impact points on the barrier. Also, this approach does not readily lend itself to an ongoing in-service evaluation program.

2.1.4 Periodic Inspection

Another common method for supplementing accident and maintenance records is to identify all impacts with a safety feature through periodic inspection of the safety feature. This approach typically involves visual inspection of all safety features included in the study to isolate evidence of an impact. The inspections should be conducted with sufficient regularity to minimize the chance that two impacts occur at the same location between inspections. Visual observation of the roadside is the same procedure used by Hutchinson and Kennedy [39] and Cooper [40] to study median and roadside encroachments. Although this procedure is costly, time consuming, and difficult to sustain over long periods, it has been widely used in previous in-service evaluation efforts. [41-46] Not surprisingly, none of these studies identified sufficient accidents to establish the impact performance of any roadside safety devices.

Periodic inspections require long data collection periods and large numbers of roadside safety features in order to collect meaningful data. One of the most thorough studies to date has involved roadside monitoring of many different safety features in two states over a 12-month period. [12] This research incorporated periodic visual inspection of guardrail terminals on over 1100 km (685 miles) of highway throughout the study period. Despite the extensive mileage of highways covered, only 84 reported and unreported accidents were identified that involved either a breakaway cable terminal (BCT) or a modified eccentric loader terminal (MELT), which are the most commonly used terminals in the two states involved in the study. Further, the vast majority of these 84 incidents were identified through either police officer or maintenance notification.

2.1.5 Published Procedures

Solomon and Boyd [9] attempted to develop recommended procedures for in-service evaluation of roadside safety hardware. Unfortunately, this study focused on developing procedures for evaluation of new hardware items prior to wide scale application. As mentioned above, this approach has little chance of developing meaningful accident data due to the limited exposure that can be generated when only a few devices are installed. In an effort to overcome this deficiency, the authors recommended detailed investigations of each accident with the goal of reconstructing the accident to determine impact speed, vehicle trajectory, and points of penetration or snagging on the device. The basic goal was to conduct a qualitative evaluation of the system's performance for each accident in an effort to develop a meaningful understanding of the device's behavior in lieu of collecting a statistically significant sample of accidents. Note that increasing the level of investigative detail may deter many highway agencies from participating in a broad cooperative effort. Further, conducting a qualitative analysis requires the analyst to be much more sophisticated regarding the dynamic response of a roadside safety feature. Hence, this approach does not appear to be very attractive for implementation by state DOTs.

2.2 State-of-the-Practice

The project staff is not aware of any state DOT with a continuous in-service performance evaluation program. All previous in-service evaluation studies were conducted on an ad hoc basis to assess the safety performance of specific roadside safety features. Under NCHRP project 22-13,[12] a survey was sent to approximately 240 roadside safety professionals in state DOTs, FHWA regional and divisional offices, roadside hardware manufacturers, universities and other research institutions. Forty-five states responded to the survey, of which 19 had performed some type of in-service evaluations. Eighteen of the 45 responding states have some type of existing roadside hardware inventory, although some are reportedly outdated.

Most of the states cited police accident reports (84%) and maintenance records (80%) as data sources used in the in-service evaluation studies. On-site investigation was also used in the majority (64%) of studies while only 20 percent of the studies used inventory reports as a data source.

The most common problem reported is the difficulty in obtaining accident reports in a timely manner, if at all. These problems can be attributed to poor coordination between the agencies involved including the researchers, police and maintenance forces.

3. CONTINUOUS IN-SERVICE EVALUATION PROGRAM

3.1 General

The proposed in-service evaluation program for ADOT includes four major subsystems or components that complement each other:

- Level I - Continuous Monitoring Subsystem.
- Level II - Supplemental Data Collection Subsystem.
- Level III - In-Depth Investigation Subsystem.
- New Product Evaluation Subsystem.

The Level I subsystem is the continuous element and the backbone of the in-service evaluation program. A computer database will be created by merging various data files into a single database for analysis. No supplemental or field data collection is envisioned for this subsystem. The database will be analyzed periodically, e.g., semi-annually or annually, to produce standard reports for general trend analysis and problem identification. The database could also be used to conduct comparative analyses on an ad hoc basis for selected roadside safety features and highway sections.

The Level II subsystem will be conducted on an ad hoc basis for selected roadside safety features. While the Level I subsystem can identify general trends and some problems, it lacks the information for more detailed analyses, particularly information on roadside conditions and the safety features. To supplement the Level I subsystem data, on-site inspections will be conducted to collect additional data on the roadway, roadside, and selected safety feature. Also, hard copies of police accident reports may be reviewed to obtain information otherwise not available from the computerized database.

The Level III subsystem will be used in selected studies where a high level of detail (and the associated high cost) is deemed necessary. Even with on-site inspections and review of hard copies of police accident reports under the Level II supplemental data collection subsystem, there will be instances in which more detailed information is needed, particularly with regard to impact conditions and the performance of roadside safety features. This will require in-depth investigation to collect sufficiently detailed data to allow for reconstruction of the crashes in order to estimate impact conditions and to assess the performance of roadside safety features.

New product evaluation is an integral part of in-service evaluation, but it is different from the other three subsystems. The evaluation will be targeted at problems encountered with the construction/installation of the roadside safety device. Due to the small number of installations of a new product, the number of accidents involving the new device is expected to be very small. Thus, any accident information will likely be anecdotal. However, the information will still be of great value to identify any potential problems that may require further in-service evaluation.

More detailed discussions for these four proposed subsystems for the in-service evaluation program are presented in the following sections.

3.2 Level I - Continuous Monitoring Subsystem

It is envisioned that the database for the Level I continuous monitoring subsystem will consist of the following four linked files:

- Highway and Traffic Data File,
- Accident Data File,
- Maintenance Data File, and
- Roadside Feature Inventory File

As envisioned, these four data files have different units of measure. The Highway and Traffic Data File is based on highway sections, i.e., each data record contains highway and traffic information for a homogeneous highway section. The Accident Data File is based on accidents, i.e., each data record contains information on an accident. The Maintenance Data File is based on maintenance activities, i.e., each data record represents a maintenance activity. The Roadside Feature Inventory File is based on roadside features, i.e., each data record contains information on a roadside feature. These four data files should contain location information based on a common location identification system so that they can be linked or merged together for the purpose of analysis. The location identification system shown herein is based on the Route Number and Milepost system, but a global positioning system (GPS) based system is being implemented and should be the location identification system in the future.

The Highway and Traffic Data File contains highway and traffic information on highway sections. Each highway section should be homogeneous to the extent that the values of the data elements remain unchanged within each section. Table 1 shows a list of desired data elements for this data file. It is anticipated that most of the desired data elements would be available from existing roadway inventory and traffic data files.

The Accident Data File contains information on individual accidents. Table 2 shows a list of desired data elements for this data file. The existing Arizona Accident Location, Identification and Surveillance Systems (ALISS) data file contains most of the needed information, including the data element “First Harmful Event,” which is critical for the purpose of the continuous monitoring subsystem. However, the level of detail available on the object struck is very general, which limits the usefulness of the ALISS data file for monitoring accidents involving roadside features. Another limitation is the lack of information on “Impact Sequence” and “Most Harmful Event.”

TABLE 1. HIGHWAY AND TRAFFIC DATA FILE
- DESIRED DATA ELEMENTS

IDENTIFICATION (for entire highway section)

- Route No.
- Direction
- Milepost

HIGHWAY AND TRAFFIC DATA (for entire highway section)

- Highway Type
- Functional Class
- Number of Lanes
- Divided/Undivided
- Lane Width
- Shoulder Type and Width – Left and Right
- Median Type and Width
- Horizontal Curve
- Vertical Grade and Curve
- Average Daily Traffic (ADT)
- Percent Truck
- Speed Limit

TABLE 2. ACCIDENT DATA FILE - DESIRED DATA ELEMENTS

IDENTIFICATION (for each accident)
- Route No.
- Direction
- Milepost
- Date
- Time of Day

ENVIRONMENTAL FACTORS
- Light Condition
- Road Surface Type
- Type of Location
- Intersection Related
- Special Location
- Unusual Road Condition
- Traffic Control Devices
- Non-Intersection Road Character
- Road Grade
- Road Curvature *
- Road Surface Condition

ACCIDENT FACTORS
- Total Number of Traffic Units
- Direction of Travel
- Prior Action
- Traffic Unit Action
- Manner of Collision
- First Harmful Event
- Impact Sequence *
- Most Harmful Event *

VEHICLE FACTORS
- Vehicle Type
- Vehicle Year, Make & Model
- Disabled/Towed
- Vehicle Damage Rating *
- Vehicle Condition

DRIVER/OCCUPANT FACTORS
- Driver Age & Sex
- Driver Injury Severity
- Highest Occupant Injury Severity *
- Conditions Influencing Driver
- Violations/behavior
- Vision Obstruction

OTHER
- Narrative Description **
- Collision Diagram **

* Data elements not currently available
** Derived from hard copy of police accident report

The Maintenance Data File contains information on maintenance and repair activities associated with roadside features. Table 3 shows a list of desired data elements for this data file. This information is important for identifying unreported incidents involving roadside features, i.e., crashes that were not reported to a law enforcement agency, but that resulted in damage to some roadside feature(s). For roadside safety devices that are highly effective, such as crash cushions, it is not unusual for the impacting vehicle to sustain only minor damage so that the vehicle can be driven away from the scene without reporting to law enforcement agencies. Thus, only accidents resulting in disabling damage to the vehicles or injuries to the drivers/occupants are reported to the police. Any assessment on the performance of such devices based on reported accident data only could lead to the erroneous conclusion that the device is not effective while exactly the opposite is true.

TABLE 3. MAINTENANCE DATA FILE - DESIRED DATA ELEMENTS

IDENTIFICATION (for each maintenance activity)
- Route No.
- Direction
- Milepost
- Other Identifier (e.g., run no. for tri-cable barrier)
- Date (mm/dd/yyyy)
- Incident DR Spell out No. (if applicable)

MAINTENANCE ACTIVITY
- Roadside Feature Type
- Type of Maintenance Activity
- Material Usage
- Cost

The Roadside Feature Inventory Data File contains information on the locations and characteristics of individual roadside features. ADOT does not currently have such a data file although some consideration is being given to developing one. Note that the list of desired data elements would be different for each roadside feature depending on its function and characteristics. For illustration purposes, Table 4 shows a list of desired data elements for an inventory of the cable median barrier system.

The existing ADOT data system lacks some details required by the Level I continuous monitoring subsystem, specifically the lack of a roadside feature inventory system. Any analysis requiring exposure data will not be feasible without information on the number and locations of the roadside features.

TABLE 4. ROADSIDE FEATURE INVENTORY FILE - DESIRED DATA ELEMENTS

IDENTIFICATION

- Route No.
- Direction
- Milepost
- Run No.

ROADSIDE FEATURE CHARACTERISTICS

- Location - Median/Roadside
- Beginning Milepost
- Ending Milepost
- Length of Run
- Lateral Offset
- Slope from Shoulder to Feature
- Slope Type
- Standard Drawing Number
- Last Inspection Date
- Height to Top of Top Cable
- Spacing between Cables
- Post Spacing
- Cable Tensioning
- Condition of Cables
- Condition of Posts

Note. The list of desired data elements will vary depending on the specific roadside feature. This table shows a list of desired data elements for a tri-cable barrier and is intended for illustration purposes only.

Information on the specific roadside feature struck in an accident is very general and lacks desired details. For example, if the cable median barrier is the roadside feature under study, it is not possible to determine if a cable barrier is impacted just from the coded data. The “First Harmful Event” would only indicate that a barrier was struck without information on the type of barrier Also, it would not be possible to identify accidents in which the impact with the cable barrier is not a first harmful event, e.g., a vehicle struck a sign support prior to impacting with the cable barrier.

Ideally, if a roadside feature inventory file is available, more detailed information on the struck roadside feature can be obtained by matching the roadside feature inventory data to the accidents. Until the roadside feature inventory data file is developed, it may be possible to supplement the information on the roadside feature struck by matching maintenance records to accident records if the locations and dates of occurrence are reported accurately. The underlying assumption is that the maintenance activity on a roadside feature is the result of a traffic accident, whether it is reported or unreported to law enforcement agencies.

The matching process will first involve screening of the maintenance records to identify activities that are likely to have been caused by vehicular crashes. Activities that are not related to vehicular crashes, such as routine maintenance or damages resulting from natural events, will be eliminated. The maintenance records will then be matched with accident records by location and date of occurrence. This matching process is admittedly a rough approximation. However, in the absence of a better alternative, it may provide some additional information. The accuracy of the matching process can be greatly enhanced by checking hard copies of the matched police accident reports. However, this is a labor intensive process and unlikely to be implemented.

Except for the roadside inventory database that is still under development, the other databases, i.e., roadway inventory, accident data, traffic data, and maintenance records, are already in place. Thus, the effort required to develop this continuous monitoring subsystem will be moderate, including:

- Review of individual databases to identify data elements to be incorporated into the continuous monitoring subsystem.
- Identification of any additional data needs and the feasibility of collecting these additional data items.
- Programming to merge the databases together and extract the required data elements to create a database for the continuous monitoring subsystem.
- Programming to generate standardized reports periodically as well as any ad hoc or special report(s).

3.3 Level II - Supplemental Data Collection Subsystem

The next level of in-service evaluation, Level II, involves field data collection and manual review of accident reports to supplement the Level I computerized data. Level II studies will be ad hoc in nature, i.e., each study will be designed and conducted for the evaluation of a specific roadside safety device.

The supplemental data collection effort will include either one or both of the following approaches:

- On-site inspection to collect data at accident sites.
- Manual review of police accident reports.

Even with roadside inventory, data pertaining to roadside conditions and details of the struck device are likely to be limited. If the particular study requires more information than is available from the computerized database, it is necessary to collect supplemental site data. For example, if the question pertains to the performance of guardrails on slopes, it is necessary to know what the sideslopes are at the accident sites plus an exposure measure, i.e., the distribution of sideslopes in the field, in order to address this question properly. This would require on-site inspections to be conducted. Another example is to assess the effect of barrier mounting height on performance of a guardrail. This would require measuring the mounting height of the struck guardrails.

It probably would be easier from a logistics standpoint to utilize maintenance personnel for this site data collection since they are already in the field and they are the ones repairing the damaged systems. With this approach, the maintenance crew will be asked to complete a field data collection form whenever a safety device included in the study is repaired and submit the completed form to the manager of the in-service evaluation program. While this approach is appealing from a logistic standpoint, it is not without its drawbacks. First, it will increase the workload on maintenance personnel who are already stretched very thin. Second, the maintenance personnel may not have the knowledge and expertise to properly complete the form and extensive training and quality control may be required to assure accuracy and validity of the data.

The alternative is to use dedicated personnel to collect the data. This is the better approach from the training and quality control standpoint, but not as efficient as using maintenance personnel since the data collectors will have to make special trips to the accident sites for the data collection effort. The dedicated personnel approach was used with the field trial effort. Given the limited scope of the field trial, the additional effort did not adversely affect the operation of the District. However, for any large-scale data collection effort, the availability of manpower would be an important issue that would need to be resolved. Based on the field trial experience, the involved District personnel favored the dedicated personnel approach, citing training and consistency concerns.

Another source of supplemental information is from manual review of hard copies of police accident reports. While most of the information from the police accident report is already available from the computerized database, some additional information may be gleaned from review of the collision diagram and the accident narrative. For example, the diagram and narrative may provide information such as the point of initial impact with the safety feature (e.g., nose or side of guardrail terminal), vehicle orientation at impact (e.g., yawing sideways), performance of the feature (e.g., vehicle penetrated or vaulted guardrail), and post-impact trajectory of the vehicle (e.g., rollover or any secondary impact). In addition, for accidents resulting in fatality and serious injury, the police investigations are typically very detailed with documentation of such information as scene evidence, vehicle inspections, injury reports, toxicology reports, and extensive photographic coverage. The additional information can be very helpful in addressing some questions, particularly for impacts in which the safety features failed to perform as designed.

For the field trial effort, review and tabulation of data from the accident reports were conducted by the project staff and not by District personnel. While the District personnel can be trained for coding the information from the accident reports, it appears that coding by the researchers would be a better approach from the standpoint of accuracy and consistency.

The pieces for this Level II supplemental data collection subsystem are already in place, though not integrated. Currently, the ADOT Traffic Operation Center (TOC) is notified of all accidents involving damage to ADOT properties. The TOC then notifies maintenance personnel to initiate and schedule inspection and repair. Also, police accident reports (DRs) are routinely reviewed for impacts with and damages to ADOT properties. In essence, the notification system is already in place. It needs to be formalized to insure that the appropriate parties are notified in a timely manner. Also, there does not seem to be any problem with obtaining police accident reports other than the usual time lag.

However, since the evaluation effort will be ad hoc in nature, the specifics of this subsystem will have to be developed and established on a study-by-study basis. Only the framework for this subsystem can be set up on a continuing basis. In other words, a framework for this supplemental data collection subsystem will first be set up, but the specifics will have to be developed for each study to address the objectives and scope of the study.

There are many ways a Level II study may be triggered. For example, results from the Level I continuous monitoring system may show an unexpected increase of accidents involving a particular roadside feature or device. Another trigger may be media coverage of a particular type of accident and political demand for countermeasures, such as cross-median crashes. A Level II study may also be initiated by ADOT personnel in charge of this continuous in-service monitoring program, such as members of the Technical Advisory Committee (TAC) or the program manager, based on inputs from the field or other operating entities.

3.4 Level III - In-Depth Investigation Subsystem

Even with the site inspections and manual review of police accident reports under the Level II supplemental data collection subsystem, there is still a lack of detailed information on impact conditions, such as impact speed and angle, vehicle orientation, driver responses, etc. Such detailed information is needed if one wants to fully understand what happened in an accident, especially if the safety feature failed to perform properly, such as the penetration or vaulting of a guardrail by an impacting vehicle, spearing of a vehicle by a guardrail terminal, malfunction of a breakaway device, etc. In-depth investigation would be required in order to obtain such detailed information as described in the next section.

Under the in-depth investigation subsystem, very detailed information will be collected on each accident, including data on the accident site, the vehicle(s) involved, the safety feature(s) struck, and severity of injuries. The information will then be used to reconstruct the accident to estimate the impact conditions (e.g., point of impact, impact speed and angle, vehicle orientation, post-impact trajectory, subsequent impact(s) if any, etc.) and to assess the performance of roadside safety devices (e.g., why the devices failed to perform properly in the accident).

Given the nature of the detailed data collection, the reconstruction, and the clinical analysis, it is logical to expect that the level of expertise and experience required for the field personnel and the cost per accident for the in-depth investigation would be very high. Consequently, the number of cases investigated will likely be relatively small. Thus, the sampling scheme tends to be heavily biased toward accidents resulting in fatal or serious injury or failure of the roadside safety device.

ADOT's Risk Management section currently has a team of two to three investigators to investigate all fatal accidents and accidents that could potentially result in litigation. Given the similarity in the investigation protocol and the small number of accidents to be studied, this team could serve as the nucleus for the in-depth investigation subsystem, if so desired by ADOT management. However, these investigators are already fully committed and not available. Thus, this Level III in-depth investigation subsystem is unlikely to be implemented in the foreseeable future and any future in-depth investigation will likely be handled by outside contractors as part of some ad hoc research studies.

3.5 New Product Evaluation Subsystem

The new product evaluation subsystem is different from the other three subsystems in that it is targeted exclusively at new products. It will complement the existing functions of the product evaluation program at ADOT. Due to the small number of initial installations for any new roadside safety feature, the number of expected accidents will be very small and it will take a very long data collection period to obtain any meaningful sample size. Thus, the emphasis of this new product evaluation subsystem is aimed at detecting any potential problems associated with the construction/installation and maintenance of the new safety device so that the problems can be resolved prior to large-scale deployment of the device. While the expected number of accidents may be very small and anecdotal in nature, the information could nonetheless provide some insights into potential performance problems that may require further study under the in-service evaluation program.

For each new roadside safety device, a process will be established to solicit inputs from construction inspectors and maintenance personnel. The process will include:

- A one-page form for construction inspectors to report any problem or difficulty associated with installation of the new device.
- A one-page form for maintenance personnel to report any problem or difficulty associated with maintenance of the new device.
- The form for maintenance personnel will also have entries for recording both reported and unreported accidents. For reported accidents, copies of the police accident reports will be attached.
- For any accident resulting in fatality or injury or failure of the device, an in-depth investigation will be conducted for detailed clinical analysis.

The information will be reviewed and compiled by the staff of the in-service evaluation program and reported back to the product evaluation program coordinator with recommended actions, if any.

ADOT currently has construction checklists for the following eight products:

- Cable Median Barrier System,
- W-Beam Guardrail System,
- ET-2000-LET Terminal,
- ET-2000 PLUS Terminal,
- SKT-350 Terminal,
- FLEAT-350 Terminal,
- SRT-350 Terminal, and
- SRT-350 (8-Post) Terminal.

In addition, there are guidelines for weighing and combining ratings of the individual attributes in order to arrive at an overall rating.

At a separate request from the project TAC, the researchers also reviewed these eight checklists as well as the weighting guidelines. The comments and recommendations were consolidated into five documents:

- Cable Median Barrier System,
- W-Beam Guardrail System,
- Energy Absorbing Terminals (including ET-2000-LET, ET-2000-PLUS, SKT-350, and FLEAT-350 Terminals),

- Non-Energy Absorbing Terminals (including SRT-350 and SRT-350 (8 Post System) Terminals), and
- Weighting guidelines.

This concept can be expanded to include inputs from the maintenance forces with a one-page form to report any problem or difficulty associated with maintenance of the new device and entries for recording both reported and unreported accidents. For reported accidents, copies of the police accident reports will be attached.

For any accident resulting in fatality or injury or device failure, an in-depth investigation should be conducted for detailed clinical analysis. As mentioned above, the expected number of such accidents will be very small for any new products and these investigations would not impose an undue burden on the investigators. On the other hand, the information could be invaluable in identifying potential problems prior to full-scale deployment of the device.

The complexity of new devices, availability of information on devices using similar technology, the number of initial installations, the expected number of accidents involving the device and other variables proscribe a hard and fast rule on the length of new product monitoring periods. The key is for the product evaluation program coordinator to be satisfied that the device is performing as intended.

3.6 Data Analysis

Each of the four program subsystems serves a different function, i.e., different level of analysis. More detailed descriptions of the intended analyses for the four subsystems are presented in the following sections.

3.6.1 Level I - Continuous Monitoring Subsystem

The analyses to be conducted with this subsystem will be retrospective in nature (i.e., based on past information) and directed at problem identification, e.g., trend analysis, comparative analysis, etc. The analyses could be route-specific (i.e., analyze accident or maintenance records for all roadside devices on selected sections of highways), device-specific (i.e., analyze accident or maintenance records for selected devices regardless of highway type), or a combination of both (i.e., analyze accident or maintenance records for selected devices on selected highway sections). These analyses will be conducted periodically on a routine basis, e.g., annually or semi-annually to produce standardized reports for generalized trend analysis and problem identification. Examples of standardized reports may include:

- Frequency (or rate) and severity of reported accidents and frequency (or rate) of unreported accidents involving various roadside features, broken down by year, highway type (or functional class), and traffic volume for each District and statewide.

- Trend analysis of frequency (or rate) and severity of reported and unreported accidents involving various roadside features.

The database can also be used to conduct ad hoc comparative analyses for selected roadside safety features and highway sections. Examples include

- Comparison of frequency (or rate) and severity of reported accidents and unreported accidents before and after installation of median barriers.
- Trend analysis of frequency (or rate) and severity of reported accidents and unreported accidents involving various roadside safety features for specific highway sections.

The extent of the analyses is dependent on the availability and the level of detail of the roadside inventory database. Without roadside inventory data, the in-service evaluation will be limited by the categories available from the "Object Struck" variable in the accident data file. Unfortunately, the categories are gross in nature and non-discriminating, e.g., guardrail, bridge rail, utility pole, etc. In addition, the roadside inventory data, together with traffic data, will also provide a measure of exposure that is vital for proper analysis. It is, therefore, strongly recommended that a roadside inventory database be created for use with the in-service evaluation program.

It should be noted that there are limitations associated with police-reported accident data, such as inaccuracies in reporting of the object struck and location, which could adversely impact the validity of the analyses.

The extent of unreported accidents is also critical in the in-service evaluation of roadside safety features. An unreported accident is one in which the incident is not reported to a law enforcement agency for various reasons, e.g., no or minor injury to vehicle occupants and little damage to vehicle, concern for potential increase to insurance premium, etc. The proportion of unreported accidents tends to be higher for single-vehicle, ran-off-road accidents since there is no second party involved and the liability is limited to repair of the vehicle, roadside hardware damage and medical expenses for the vehicle occupant(s), if any. It is reasonable to assume that the severity of an unreported accident is relatively low with little or no injury to the occupants and minor damage to the vehicle since the driver is able to remove the vehicle from the accident site.

The proportion of unreported accidents is a good indication of the effectiveness or performance of a roadside safety feature. An effective roadside safety feature may have a very high proportion of unreported accidents while the few reported accidents may result in high severity due to unusual circumstances. If only reported accidents are included in the analysis, one can erroneously conclude that the safety feature is not effective while the exact opposite is true. Thus, it is very important to look at both reported and unreported accidents in any in-service performance evaluation.

The extent of unreported accidents will be estimated by comparing reported accidents to maintenance records. First, it is necessary to determine from the maintenance record if the repaired damage is the result of impact by an errant vehicle. Second, accident reports will be matched to the maintenance records that are the results of impacts. Unmatched maintenance records will then be considered as unreported accidents. This approach admittedly has some limitations. Only unreported accidents with damages sufficient to warrant maintenance work will be included. This will exclude incidents with no damage or little damage that do not require maintenance. This is probably not a problem for roadside safety features that are easily damaged, such as breakaway signs and luminaires, but it could be a significant factor for roadside safety features that are not easily damaged, such as concrete barriers and bridge rails. Great care should therefore be taken in analyzing the extent of unreported accidents.

Sample sizes available from the database are typically fairly large and sufficient for statistical analysis. The limitations with the analysis are mainly lack of detail on the safety feature and on the accidents themselves. In order to conduct more detailed analyses, additional data beyond the computerized database will be necessary, as will be discussed under Level II and Level III subsystems in the following sections.

3.6.2 Level II - Supplemental Data Collection Subsystem

Evaluation studies with supplemental data collection are generally prospective in nature, i.e., collecting data as new accidents occur. This approach can also be used retrospectively with the underlying assumption that the accident sites and the struck roadside safety features were restored to pre-impact conditions, which may or may not be valid. Generally speaking, this approach is better suited for prospective studies than retrospective studies. The analyses would be ad hoc in nature and can be route-specific, device-specific, or a combination of both. The analyses to be conducted with this supplemental data collection subsystem will be mostly directed at problem identification and comparative analysis, similar to those with the continuous monitoring subsystem, but with greater detail. Examples of ad hoc comparative type of analysis that may be addressed with this database include:

- Comparison of safety performance between different guardrail types as a function of highway type, speed limit, lateral offset, mounting height, etc.
- Effect of sideslope and lateral placement on guardrail performance.

The level of detail of the supplemental data that is collected limits the extent of the analyses. Since the data collection is developed on an ad hoc or study-by-study basis, the level of detail should be designed to specifically address the study objectives. As expected, the sample size available for analysis will be smaller than that for the continuous monitoring subsystem due to the costs associated with the supplemental data collection. However, the sample size should be designed to be large enough for statistical significance.

3.6.3 Level III - In-Depth Investigation Subsystem

The in-depth investigation subsystem will be used only in rare situations in which the need for the very detailed information justifies the high expense. For example, accidents resulting in fatality or serious injury, accidents involving major failure of the roadside safety device, high profile accidents attracting public attention, and accidents likely to result in litigation, may be worth the high expense.

The in-depth investigation will be ad hoc and prospective in nature and accident based. The analysis will be clinical in nature, e.g., failure analysis to define the performance/failure envelope for a specific roadside safety device. The sample size would be relatively small since a large sample size would be very expensive and require data to be collected over a long period of time or over a very large area. With a small sample size, the analysis results will be anecdotal in nature, with little or no statistical significance.

However, in-depth investigation may be the only means of truly understanding the impact performance of selected roadside safety devices. The continuous monitoring subsystem and supplemental data collection subsystem are both based on police reported data and maintenance data, which are lacking in details for assessing what actually happened in a crash, such as whether the device performed properly and what caused the fatal or serious injuries. While in-depth investigations are very expensive to conduct, they provide data that are otherwise not available and may be worth the expenses in certain situations.

3.6.4 New Product Evaluation Subsystem

The new product evaluation subsystem is intended as a complement to the existing checklists used with new construction. All analyses will be prospective and anecdotal in nature and will include:

a. Problems encountered with installation and maintenance of new devices,
b. Potential problems with impact performance.

The checklists that inspectors use to check on new construction and that maintenance personnel use to monitor the condition of existing features would identify potential problems with installation and maintenance of the device. Information on all reported and unreported accidents involving the device plus in-depth investigation of accidents involving fatal or serious injury or failure of device would provide a good indication on potential problems with impact performance of the device.

3.7 Recommended Continuous In-Service Performance Evaluation Program

In summary, the proposed continuous in-service performance evaluation program consists of four major subsystems:

- Level I - continuous monitoring subsystem,
- Level II - supplemental data collection subsystem,
- Level III - in-depth investigation subsystem, and
- New product evaluation subsystem.

The Level I continuous monitoring subsystem is the continuous element and backbone of the proposed in-service evaluation program. Thus, it is recommended that, at a minimum, the Level I continuous monitoring subsystem should be developed and maintained on a continuing basis. The major pieces of the subsystem, with the exception of the roadside inventory data, are already in place and its development is simply a matter of integrating them. ADOT is already developing a roadside inventory data system as part of the data warehousing effort.

A major part of the new product evaluation subsystem is also in place already with the checklists for new constructions. It is a relatively small incremental effort to add the reporting form for maintenance personnel in order to identify potential maintenance problems as well as to keep tab of reported and unreported accidents involving these new devices. This appears to be a worthwhile effort and is, therefore, recommended to ADOT for consideration. In-depth investigation of accidents involving these new devices that result in fatal or serious injury or failure of the device is also recommended. The number of expected accidents would be very small and should not pose any major problems to the workload of the investigators. Any information on potential problems with the impact performance of new devices would be invaluable and well worth the effort to gather it.

The Level III in-depth investigation subsystem would require resources beyond what ADOT currently has or will have in the foreseeable future. Thus, despite the importance of the in-depth accident data to the understanding and resolution of problems associated with the impact performance of roadside safety devices, the establishment of this subsystem is not recommended at this time. As will be discussed later in Chapter V, "Proposed National Center," in-depth investigation may best be done on the national level under the proposed center.

The Level II supplemental data collection subsystem, similar to what was done under the field trial, is ad hoc in nature and can be developed on an as-needed basis or in a gradual manner as permitted by available resources. It is, therefore, recommended that this supplemental data collection subsystem be developed and utilized on an as-needed basis.

One critical element to the success of the continuous in-service performance evaluation program is the choice of a program manager. The program manager will be responsible for the planning and conduct of the program as well as coordination with cooperating agencies, both within and outside of ADOT. It is also recommended that a Technical Advisory Committee (TAC), consisting of representatives from the cooperating agencies, be established. The purposes of the TAC are:

- Provide guidance and assistance to the program manager,
- Assure that the program manager has the necessary cooperation among the participating agencies.
- Decide what safety feature(s) is to be evaluated under the program, and
- Review evaluation results and recommended actions.

4. FIELD TRIAL

4.1 General

The purpose of the field trial was to work out any potential problems that might be encountered in the actual implementation of the in-service performance evaluation program. The initial plan was for the field trial to encompass all four subsystems of the program even though the individual subsystems might be phased in gradually. However, since the computerized data were not at a stage that could be used for the Level I continuous monitoring subsystem, it was not included in the field trial. The Level III in-depth investigation subsystem was also not included due to lack of resources. The item selected for study - cable median barrier - was not a new product, so the new product evaluation subsystem was not applicable for the field trial. Instead, the effort was directed at review of the checklists and weighting guidelines. Thus, the field trial encompassed only the Level II supplemental data collection subsystem

The following roadside safety devices were identified as candidates for the field trial in the kick-off meeting:

- Guardrail terminal,
- Crash cushion,
- Cable median barrier,
- Breakaway sign, and
- Breakaway luminaire.

Given the relatively short data collection period for the field trial, it was necessary to select the device with the most exposure, i.e., largest number of expected impacts. This ruled out crash cushions due to the small number of installations. Breakaway signs and luminaires had higher exposure and tended to have a relatively high proportion of unreported incidents. However, all indications were that these breakaway devices were performing well in the field and there was no pressing need for an in-service performance evaluation of these devices. Thus, the choice narrowed down to guardrail terminals and cable median barriers. With the recent introduction of several new terminals, a comparison of impact performance among the various guardrail terminals would be of great interest. On the other hand, installation of cable barriers in medians to prevent cross-median accidents had also been a topic of recent interest and worthy of an in-service performance evaluation study.

The cable median barrier was recommended and eventually selected for the field trial for several reasons. First, the use of cable median barriers in medians was a relatively new safety countermeasure, but was gaining popularity due to increased concerns over cross-median accidents at these locations. It was important to make sure that the cable median barrier was performing as intended. Second, the number of expected reported accidents and unreported incidents involving cable median barriers would be higher than that for guardrail terminals. Sample size was an important consideration given the short data collection period. Third, the design for the in-service evaluation of cable barriers was simpler than that for guardrail terminals and thus better suited for the field trial.

The field trial was conducted in the Phoenix Maintenance District as agreed upon by the TAC and District personnel during the kickoff meetings.

4.2 Study Design

Table 5 summarizes the information on cable median barriers and reported accidents as provided by the Phoenix Maintenance District.

TABLE 5. IMPACT INFORMATION ON CABLE MEDIAN BARRIERS

Highway	Total Miles: Cable Barrier	Total Hits 7/00 to 10/01	Hits Per Mile	Hits Per Month	Hits per Mile/Month
I-10 Maricopa	18.10	200	11.05	12.50	0.69
SR 51 Squaw Peak	9.99	158	15.82	9.88	0.99
US 60 Superstition	5.71	20	3.50	1.25	0.22
101 Agua Fria	20.16	160	7.94	7.94	0.50
101 Pima	25.73	153	5.95	5.95	0.37
101 Price	12.68	50	3.94	3.13	0.25
202 Red Mountain	2.75	28	10.18	1.75	0.64
Totals:	95.56	769	8.05	48.06	0.50

There were a total of 95.56 miles of cable median barriers in the Phoenix Maintenance District on seven different sections of highways. Over a 16-month period from July 2000 to October 2001, there were a total of 769 incidents or hits involving cable median barriers for an average of 48.06 hits per month and 0.50 hits per mile per month.

For the purpose of the field trial, a target sample size of about 30 incidents was planned. The planned sample size was selected to minimize any impact the field data collection might have on the routine operations of the Maintenance District.

Based on the locations of the cable median barriers and the associated frequencies of hits, it appeared that the simplest sampling scheme was to select one highway section and record all incidents involving vehicular impacts with cable median barriers on that highway section over a three-month time period. Either I-10 Maricopa or SR 51 Squaw Peak would serve the purpose with 12.5 and 9.88 hits per month for these highway sections, respectively. The Phoenix Maintenance District eventually selected the SR 51 Squaw Peak section for the field trial. It should be noted that the primary purpose of the field trial was to assess the feasibility of and potential problems with implementing an in-service performance evaluation program. Thus, the location of data collection was of secondary importance to this study.

A field data collection protocol was developed by the project staff and is shown as Appendix A. The field data collection form is designed to fit on a single page and consists of four parts and 17 data items, as shown in Table 6.

TABLE 6. ENTRIES FOR FIELD DATA COLLECTION FORM

A. Identification
   1. Date of Incident
   2. Reported to Police
   3. Incident DR (Police Accident Report) No.
   4. Control Section
   5. Route No.
   6. Milepoint

B. Guardrail Information
   7. Location of Cable Median Barrier
   8. Lateral Distance from Edge of Lane
   9. Paved Shoulder Width
   10. Slope from Shoulder to Guardrail
   11. Mounting Height

C. Impact Performance
   12. Impact Performance

D. Guardrail Damage
   13. Length of Contact
   14. No. of Posts Damaged
   15. No. of Cables Broken
   16. Splice Damaged?
   17. Anchor Damaged?

The data elements are mostly self-explanatory and can be completed by maintenance personnel with the accompanying instructions. Thus, no additional training was deemed necessary or actually conducted.

4.3 Study Results

The data collection period for the field trial was from November 22, 2001 through March 3, 2002. A total of 28 cases were identified, including 21 reported accidents and 7 unreported incidents.

While the purpose of the field trial was to evaluate the feasibility of the Level II supplemental data collection subsystem and the sample size is relatively small, there are some useful insights regarding cable median barriers that could be gleaned from the limited data, highlights of which are:

- The extent or rate of unreported crashes involving cable median barriers is 25 percent (7 of 28 incidents).
- There was a clustering of 7 incidents between milepoint 9.0 and 9.9. A follow-up investigation of potential causes for such clustering may be of interest.
- There is little variation in roadway characteristics among the crash sites since a single highway section was selected for the study. Consequently, no evaluation can be made regarding the effects of some of the roadway characteristics on cable median barrier crashes, such as lateral offset of the cable barrier, shoulder width, slope type and rate, and barrier height.
- The length of contact with struck barriers ranged from 1.5 to 105 meters (5 to 344 ft) with an average of 23 meters (75 ft). The number of damaged posts ranged from 1 to 25 with an average of 6 posts. There was no reported incident of broken cable, damaged splice, or damaged anchor.
- Light trucks, i.e., pickup trucks and sport utility vehicles, accounted for 25 percent (5 of 20) of the vehicles involved in reported crashes, with the remaining incidents involving passenger type vehicles.
- The majority of the involved drivers were male (59%) and under the age of 45.
- The injury severity for the 21 reported accidents was very low. The most severe was a non-incapacitating injury in one accident, with minor injuries in four more accidents. There were 11 accidents with no injuries and four with unknown injuries.

4.4 Discussions and Recommendations

A debriefing with ADOT and Department of Public Safety (DPS) personnel involved in the field trial was conducted on May 1-2, 2002. Highlights of the discussions and recommendations are summarized as follows:

- Manpower and availability. Workload for the field trial was limited for DPS and ADOT. Additional manpower will be needed at the District level for future full-scale studies. Use of dedicated personnel for data collection is preferred over maintenance personnel due to training and consistency concerns.
- Notification System. The notification system for reported accidents was from DPS to TOC to District personnel, typically on the same day. Unreported incidents were identified based on routine inspection by District personnel. The notification system seemed to work very well; all parties were reliably notified in a timely manner. However, the addition of further screening criteria, such as injury severity, could cause some problems.
- Data Collection Form & Instructions. There were no apparent problems with the form and instructions.
- Personnel Training. The general consensus was that formal training was not needed for the field trial. However, some limited training may be needed in the future, depending on the complexity of the roadside feature studied.
- Quality Control. No quality control was needed for the field trial since only one person collected all the data. However, for a full-scale study involving multiple data collectors, quality control would be needed to assure accuracy and consistency.
- Time Lag in Data Flow. Time lag is not a problem for notification or completion of the field form. However, there is a substantial time lag for obtaining the DR reports.

While the scope of the field trial is limited, it clearly demonstrates the feasibility of the Level II supplemental data collection subsystem. There are areas that can be improved to foster more smooth and efficient operation in future studies, such as time lag in acquiring DR reports, meeting manpower requirements, training for investigators, etc.

5. PROPOSED NATIONAL CENTER

5.1 General

A conceptual framework for a national database with the mission of in-service performance evaluation of roadside safety features was developed under Task G of this research project, "Prepare White Paper for a National Database." In the course of developing this conceptual framework, the scope of the effort was expanded from a national database to a National Center for In-Service Performance Evaluation of Roadside Safety Features. As specified in the work scope, a paper describing this conceptual framework for a proposed National Center was prepared and submitted to the Transportation Research Board (TRB) for presentation at the 2002 Annual Meeting. However, the paper was not accepted by TRB for presentation or publication. The paper was then revised as a Task G report and is presented in Appendix B.

Details of the proposed National Center are presented in Appendix B and will not be repeated herein. Only a summary is presented in this chapter, including discussions on:

- Objectives,
- Scope,
- Organization and funding, and
- Potential benefits.

5.2 National Center Objectives

The fundamental objectives of this proposed National Center for In-Service Performance Evaluation of Roadside Safety Features are to:

- Compile and disseminate information on in-service performance evaluation.
- Provide a single point of contact for questions, technical support and exchange of information on in-service performance evaluation.
- Provide a focal point for future conduct of in-service performance evaluation studies, including multi-state pooled-fund studies.

Note that these are the desired objectives of the proposed National Center. The actual implementation of a National Center may encompass all or only some of these objectives, depending on the interest and availability of resources.

5.3. Scope of Proposed National Center

The scope of the proposed National Center can vary greatly depending on the selected objectives and the available resources. To accomplish all three objectives stated in the previous section, the proposed National Center's scope would include the following tasks:

1. *Collect and compile information on in-service performance evaluation.* Available information on in-service performance evaluation would be collected and compiled. An extensive literature search and review was already conducted under NCHRP Project 22-13, which would serve as a good starting point for this task. However, the information would have to be brought up-to-date.

2. *Critically review available information on the validity and usefulness of in-service evaluation*. The available studies will be critically reviewed and summarized by a recognized authority, on a consistent basis, to aid the user agencies in drawing the appropriate conclusions.

3. *Create a national database on in-service performance evaluation.* A national database on in-service performance evaluation will be developed from available information and accompanying critical reviews.

4. *Prepare bibliography and summary reports on individual roadside safety features.* The National Center staff will prepare bibliographies and summary reports on individual roadside safety features to assist the user agencies in analyzing past studies and drawing appropriate conclusions. The bibliographies will be updated as new research reports are published.

5. *Develop a web-based system for querying the national database, posing of questions, and exchanging information.* A web site will be set up to allow users to query the national database and to download the pertinent information. The web site could also provide a forum for users to pose questions and to exchange information.

6. *Convert existing information to electronic format*. In order for the national database to be web based, the documents will have to be converted from hard copies to electronic format, e.g., PDF or HTML format. The electronic files can then be downloaded via the web site.

7. *Disseminate information upon request*. Information will be disseminated to user agencies upon request via the web site or by mailing CD-ROMs or hard copies of the reports.

8. *Provide technical support upon request*. The National Center will serve as a single point of contact to provide technical support to user agencies in addressing detailed questions beyond the initial query of the national database and review of available literature.

9. *Monitor ongoing studies pertaining to in-service performance evaluation and update the database as studies are completed*.

10. *Conduct studies on in-service performance evaluation, including multi-state, pooled-fund studies*. The biggest potential task and client service for the proposed National Center would be to serve as the focal point for conduct of ongoing or new studies on in-service performance evaluation, including multi-state, pooled-fund studies. The scope of the work for the proposed National Center will include:

    - Design of study,
    - Development of standardized data collection protocol,
    - Conduct pilot study,
    - Training of data collection personnel,
    - Monitoring of data collection effort,
    - Quality control of collected data,
    - Compilation of collected data into a data file for analysis,
    - Data analysis, and
    - Preparation of study report.

5.4 Organization and Funding Sources

For an undertaking such as the proposed National Center to be successful, it is critical to have the proper organization and funding sources. It is probably too much to expect that any state transportation agency would be willing and able to effectively undertake or sponsor this effort. Thus, the effort will have to be at the national level, or at least involve a number of states. There are many options available for establishing and operating the proposed National Center for In-Service Performance Evaluation, but only the two options that are the most practical and likely to succeed are presented herein.

A responsible agency will have to take the lead to initiate and direct the proposed National Center. This agency is ideally national in scope and has the resources to fund and manage this effort. The responsible agency will define the mission, objectives and scope of the project, secure the required funding, select the contractor for the actual work, and direct and maintain oversight on the program.

Potential candidates for this responsible agency include the AASHTO Task Force on Roadside Safety (TFRS) and the Mid-States Pooled Fund Program administered through the Nebraska Department of Roads (NDOR).

5.5 Potential Benefits of Proposed National Center

The creation of a national database and center on in-service performance evaluation of roadside safety features would have significant benefits for all transportation agencies that are involved with roadside safety. The database would provide transportation and research agencies with ready access to information on real-world impact performance of various roadside safety features. Examples of how the information may be utilized include:

- Selection among competing roadside safety appurtenances,
- Identification of performance limits,
- Field trials of new roadside safety appurtenances and features,
- Establishment of upgrading policy, and
- Assessment of relevance.

5.6 Discussions and Recommendations

The conceptual framework of a proposed National Center for In-Service Performance Evaluation of Roadside Safety Features is presented herein, including the mission, objectives, scope, organization and funding source, and potential benefits. This idea was presented to the Mid-States Pooled Fund Program in 2002 and was well received, but did not result in any action. It is recommended that this idea of establishing the National Center for In-Service Performance Evaluation be also presented to the AASHTO Task Force on Roadside Safety for their consideration and perhaps further pursued with the Mid-States Pooled Fund Program.

Some of the functions proposed for the National Center are, in some respects, already accomplished under NCHRP Project 22-13. Specifically, available information on in-service performance evaluation was collected and compiled into a database. The information was reviewed, summarized and rated, although a more critical review to assess its validity and usefulness is recommended. The database is available through a web-based system. General guidelines for conduct of in-service performance evaluation studies were developed and a study assessing the performance of on longitudinal barrier systems was conducted.

It is, therefore, recommended that the available information and web-based system from NCHRP Project 22-13 be used as the starting point for the proposed National Center and that the scope of the effort be expanded to include the following activities not available under the current project:

- Monitor ongoing studies pertaining to in-service performance evaluation and update the existing database as studies are completed,
- Prepare bibliographies and summary reports on roadside safety features,
- Convert existing information to electronic format,
- Expand the web site to allow for posing of questions and exchange of information,
- Provide technical support upon request, and
- Conduct studies on in-service performance evaluation on selected features.

6. SUMMARY AND RECOMMENDATIONS

6.1 Summary of Findings

As stated previously, the objectives of this research project were to develop a program for the continuous in-service evaluation of highway safety features, evaluate this program through field trials, and work with other states at developing a nationwide database of in-service evaluations of highway safety features. The objectives were accomplished in the study. A summary of the findings and conclusions is presented as follows:

- The conceptual framework of an in-service evaluation program was developed, which includes the following four major subsystems or components that complement each other:

    - Level I - Continuous Monitoring Subsystem.
    - Level II - Supplemental Data Collection Subsystem.
    - Level III - In-depth Investigation Subsystem.
    - New Product Evaluation Subsystem.

- The Level I continuous monitoring subsystem is the continuous element and the backbone of the in-service evaluation program. A computerized database will be created by merging these four linked files: highway and traffic data, accident data, maintenance data, and roadside feature inventory, into a single database. The database will be analyzed periodically to produce standardized reports for generalized trend analysis and problem identification. The database can also be used to conduct comparative analysis on an ad hoc basis for selected roadside safety features and highway sections. With the exception of the roadside feature inventory that is currently under development, the other data files are available and can be linked together under a common location identification system.

- The Level II supplemental data collection system complements the Level I continuous monitoring subsystem with field collection of data on the roadway, roadside and selected safety feature, and manual review of hard copies of police accident reports to obtain information otherwise not available from the computerized database. Studies under the Level II supplemental data collection subsystem will be conducted on an ad hoc basis for selected roadside safety features.

- The Level III in-depth investigation subsystem involves in-depth investigation of selected accidents, including reconstruction of the crashes to estimate impact conditions and to assess the performance of roadside safety features. This subsystem will be used in selected studies where the highest level of detail is deemed necessary.

- The new product evaluation is targeted at problems encountered with the construction, installation and maintenance of new roadside safety devices. Also, accidents involving the new devices will be monitored to identify potential problems with impact performance.

- A field trial of the Level II supplemental data collection subsystem was conducted with the assistance of the ADOT Phoenix Maintenance District and DPS. Accidents involving cable median barriers, both reported and unreported, were identified over a three-and-a-half month period (11/22/01 through 3/3/02). Supplemental field data were collected at each accident site and police accident (DR) reports were obtained from DPS. The field trial clearly demonstrated the feasibility of the subsystem. There are areas that can be improved to foster more smooth and efficient operation in future studies, such as time lag in acquiring DR reports, meeting manpower requirements, training for investigators, etc.

- A total of 28 cases were identified in the field trial, including 21 reported accidents and 7 unreported incidents for an unreported rate of 25 percent. The injury severity from the 21 reported accidents was very low. The most severe was a non-incapacitating injury in one accident, with minor injuries in four more accidents. There were 11 accidents with no injury and four with unknown injury.

- The conceptual framework of a proposed National Center for In-Service Performance Evaluation of Roadside Safety Features was developed under this study and presented in a white paper. The basic objectives of this proposed National Center are to:

  – Compile and disseminate available information on in-service performance evaluation.
  – Provide a single point of contact for questions and technical support and exchange of information on in-service performance evaluation.
  – Provide a focal point for future conduct of in-service performance evaluation studies, including multi-state, pooled fund studies.

- The scope of the proposed National Center would include the following tasks:

  1. Collect and compile information on in-service performance evaluation.
  2. Critically review available information on its validity and usefulness.
  3. Create a national database on in-service performance evaluation.
  4. Prepare bibliography and summary reports on individual roadside safety features.
  5. Develop a web-based system for query of the national database, posing of questions, and exchange of information.
  6. Convert existing information to electronic format.

7. Disseminate information upon request.
8. Provide technical support upon request.
9. Monitor ongoing studies pertaining to in-service performance evaluation and update database as studies are completed.
10. Conduct studies on in-service performance evaluation, including multi-state, pooled-fund studies.

- For an undertaking such as the proposed National Center to be successful, it is critical to have the proper organization and funding sources. The effort will have to be at the national level, or at least involve a number of states. First, a responsible agency will have to take the lead to initiate and direct the proposed National Center. One logical choice for this responsible agency would be the AASHTO Task Force on Roadside Safety (TFRS); another is the Mid-States Pooled Fund Program administered through the Nebraska Department of Roads (NDOR).

6.2 Recommendations

It is recommended that ADOT consider the establishment of a continuous in-service evaluation program. The program may be implemented in phases, depending on the availability of manpower and resources. The various steps in the establishment of the program, not necessarily in sequential order, are as follows:

- Assign a program manager and a technical advisory committee to direct and oversee the effort.
- Develop a roadside feature inventory file and merge it with other existing data files to create an integrated database for the Level I continuous monitoring system.
- Develop the standardized reporting to be generated from the database.
- Expand the current scope of the new product evaluation subsystem to include maintenance and accident data.
- Conduct supplemental field data collection on selected roadside safety devices as need arises.

Given the lack of trained and experienced field investigators, the Level III in-depth investigation subsystem is not recommended for implementation at this time. However, to truly understand and evaluate the impact performance of roadside safety devices, in-depth investigation would be necessary. Perhaps this subsystem's goals can be accomplished using outside contractors on a project-by-project basis or, better yet, as part of the National Center for In-Service Performance Evaluation.

The establishment of a National Center for In-Service Performance Evaluation of Roadside Safety Features would be desirable, not only for ADOT, but for other state transportation agencies as well. This National Center would provide a single point of contact for information and technical support on in-service performance evaluation, and a focal point for future conduct of in-service performance evaluation studies. There appears to be interest in such a National Center among some state transportation agencies. It is recommended that this idea be pursued further, particularly with the AASHTO Task Force on Roadside Safety or the Mid-States Pooled Fund Program.

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APPENDIX A

FIELD DATA COLLECTION PROTOCOL

CONTINUOUS EVALUATION OF IN-SERVICE HIGHWAY SAFETY FEATURE PERFORMANCE

SPR Study 482, FY'99

FIELD TRIAL PROTOCOL

Prepared for

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IN-SERVICE PERFORMANCE EVALUATION PROGRAM

FIELD TRIAL PROTOCOL

Introduction

As part of the effort to develop an in-service performance evaluation program for the Arizona Department of Transportation, a field trial to demonstrate the feasibility of the program is to be conducted. It was proposed and approved by the Technical Advisory Committee (TAC) to conduct the field trial in the Phoenix Maintenance District and the roadside safety feature to be studied is the Tri-Cable Median Barrier.

The protocol for this field trial is covered in this document and includes the following major components:

- Sampling plan,
- Field data collection form and instructions, and
- Evaluation plan.

Brief discussions on each of these major components are presented as follows.

Sampling Plan

The following table summarizes the information on cable median barriers and reported accidents as provided by the Phoenix Maintenance District.

Highway	Total Miles: Cable Barrier	Total Hits 7/00 to 10/01	Hits Per Mile	Hits Per Month	Hits per Mile/Month
I-10 Maricopa	18.10	200	11.05	12.50	0.69
SR 51 Squaw Peak	9.99	158	15.82	9.88	0.99
US 60 Superstition	5.71	20	3.50	1.25	0.22
101 Agua Fria	20.16	160	7.94	7.94	0.50
101 Pima	25.73	153	5.95	5.95	0.37
101 Price	12.68	50	3.94	3.13	0.25
202 Red Mountain	2.75	28	10.18	1.75	0.64
Totals:	95.56	769	8.05	48.06	0.50

There are a total of 95.56 miles of cable barriers in the Phoenix District on seven different sections of highways. Over the sixteen-month period from July 2000 to October

2001, there were a total of 769 incidents or hits involving cable barriers, for an average of 48.06 hits per month and 0.50 hits per mile per month.

For the purpose of the field trial, a target sample size of about 30 incidents is planned. The planned sample size is selected to minimize any impact the field data collection may have on the routine operations of the District. However, the project staff would welcome a large sample size if the test schedule and the workload of the District will permit a larger sample size.

Looking at the locations of the cable barriers and the associated frequencies of hits, it appears that the simplest sampling scheme is to select one highway section and record all incidents involving vehicular impacts with cable barriers on that highway section over a three-month time period. Either I-10 or SR 51 would serve the purpose with 12.5 and 9.88 hits per month for these highway sections, respectively. However, the actual choice of which highway section to monitor would be at the discretion of ADOT. Since the purpose of the field trial is to evaluate the data collection protocol and not actual analysis, the location where the data will be collected is of secondary importance to this study.

Data Collection Form and Instruction

A proposed field data collection form for this project, with associated instructions, is shown in Attachment A. The form is designed to fit on a single page and consists of four parts and 17 data entries, as follows:

- Identification
  - 1 Date of Incident
  - 2 Reported to Police
  - 3 Incident DR No.
  - 4 Control Section
  - 5 Route No.
  - 6 Milepost
- Cable Barrier Information
  - 7. Location of Cable Barrier
  - 8. Lateral Distance from Edge of Lane
  - 9. Paved Shoulder Width
  - 10. Slope from Shoulder to Guardrail
  - 11. Mounting Height
- Impact Performance
  - 12. Impact Performance
- Cable Barrier Damage
  - 13. Length of Contact
  - 14. No. & Type of Posts Damaged

15. No. of Cables Broken
16. Splice Damaged?
17. Anchor Base Damaged?

The data elements are mostly self-explanatory and can be completed by maintenance personnel with the accompanying instructions. No additional training is deemed necessary. However, if ADOT feels that training is required, a member of the project staff will travel to the Phoenix District to provide the necessary training. It is estimated that it will take less than 15 minutes to complete the form. It is our understanding that the District is already receiving the incident DR report on a routine basis. Thus, no additional effort is required to obtain the DR reports. The only equipment required for the field data collection effort is a measuring tape and a carpenter's level.

Evaluation Plan

While the planned sample size from the field trial is too small for any actual evaluation, it is anticipated that the data, if collected with sufficient sample size and merged with other available data, would be able to address various questions regarding the in-service performance evaluation of the tri-cable barrier. Examples of questions that may be addressed with the data are presented as follows:

- Locations of incidents involving vehicular impact with cable barriers. Information on the locations of incidents can be analyzed to discern any clustering, i.e., locations where multiple incidents occurred, or other patterns pertaining to the locations. This information, when combined with the Continuous Monitoring Subsystem database (which includes roadway, roadside and police reported accident data), would allow analysis of locations with higher than average (or expected) incident frequencies to assess what, if any, roadway and roadside characteristics and environmental factors may have contributed to the occurrence of higher than average incidents. This information could in turn be used to refine the current warrants and guidelines on installation of cable barriers to assure appropriate applications.

- Extent of unreported incidents. One long-standing question is the extent of unreported incidents for longitudinal barriers. There have been several studies assessing this topic, but the results varied widely and there is no general consensus. Information from this study could provide further insights into this related topic, which would be of great interest to the roadside safety community.

- Impact performance of tri-cable median barriers. This study could provide valuable information on the impact performance of cable barrier, including: effectiveness of the cable barrier to contain and redirect impact vehicles;

proportion of impacts resulting in overriding and vaulting of the vehicle over the cable barrier; potential of a vehicle underriding the barrier; and probability of an impacting vehicle penetrating the cables. Note that, while the data provides information on the impact performance of tri-cable barriers, it lacks the details to assess the factors contributing to the unsatisfactory performance.

- Damage to tri-cable barriers in vehicular impacts. Data from the study could provide information on the damage to cable barriers in vehicular impacts and the associated repair costs. The information would be helpful in assessing the cost-effectiveness of installing cable barriers as a safety treatment in situations such as medians.

Attachment A

Field Data Collection Form and Instructions

Cable Barrier In-Service Performance Data Form

Please complete this form for each incident involving vehicular impacts with tri-cable median barrier, whether it is reported to the police or not, and send the completed form with the police incident DR report (if reported to police) to:

Steve Owen, Research Engineer
Arizona Transportation Research Center
206 S. 17th Ave., MD 075R
Phoenix, Arizona 85007

IDENTIFICATION

1. **Date of Incident**: __ __ / __ __ / __ __
   m m d d y y

2. **Reported to Police**: ☐ Yes ☐ No

3. **Incident DR No.**: ________________

4. **Cable Run No.**: ________________

5. **Route No.**: ______________________

6. **Milepost / NB / SB** _______________

CABLE BARRIER INFORMATION

7. **Location and Type of Cable Barrier**

   ☐ Median Single or ☐ Median Double

8. **Lateral Distance from Nearest Lane Edge Stripe:** ___ ___ . ___ ft

9. **Paved Shoulder Width:** ___ ___ . ___ ft

10. **Slope from Shoulder to Cable Barrier:**

    Type: ☐ Gravel/ Grass ☐ Paved

    Slope: ☐ 10:1 ☐ 6:1 ☐ 4:1
    ☐ 3:1 or Steeper ☐ None

11. **As-Built Height: Top Cable**:___ ___ in.

IMPACT PERFORMANCE

12. **Barrier Impact Performance**

    ☐ Redirected Vehicle onto Shoulder Or Back into Traffic Lanes

    ☐ Vehicle Came to Rest Against Cable Barrier

    ☐ Vehicle Overrode Cable Barrier

    ☐ Vehicle Underrode Cable Barrier

    ☐ Vehicle Penetrated Cable Barrier

    ☐ Unknown

CABLE BARRIER DAMAGE

13. **Length of Contact**: ______ feet

14a. **No. of Line Posts Damaged**: ___ ___
14b. **No. Anchor Posts Damaged**: ___ ___

15. **No. of Cables broken**: ___

16. **Splice Damaged?** ☐ Yes ☐ No ☐ N/A

17. **Anchor Base Damaged?** ☐ Yes ☐ No

COMMENTS? (Use Back of Page Also):

INSTRUCTIONS

This form should be completed for each incident involving vehicular impacts with the median tri-cable barrier, whether it is reported to the police or not. Please send the completed form with the police accident report (if applicable) to:

Steve Owen, Research Engineer
Arizona Transportation Research Center
206 S. 17th Ave., MD 075R
Phoenix, Arizona 85007

The form has four parts and a total of 17 data entries. The four parts are:

- Identification - 6 data entries.
- Cable Barrier information - 5 data entries.
- Impact performance - 1 data entry.
- Cable Barrier damage - 5 data entries.

Identification

This portion of the form provides general identification information on the incident and includes the following information:

1. Date of Incident - Enter date of incident in month/day/year format.
2. Reported to Police - Check yes or no if incident is reported to the police.
3. Incident DR No. - Enter the incident DR number if it is reported by police.
4. Control Section - Enter Cable Run number
5. Route No. - Enter highway route number, for example, SR 51.
6. Milepost / NB / SB - Enter milepost and direction – NB or SB.

Cable Barrier Information

This portion of the form provides general information on the involved Cable Barrier and includes the following information:

7. Location / Type of Cable Barrier - Check whether this installation is single median barrier or double median barrier.
8. Lateral Distance from Edge of Lane - Record the lateral distance to the nearest 0.1 foot from the center of the edge line paint stripe to the Cable Barrier.

9. Paved Shoulder Width - Record width of paved shoulder to the nearest 0.1 foot.

10. Slope from Shoulder to Cable Barrier - Record the surface of the slope from the paved shoulder to the guardrail, whether it is grass/gravel landscaping, or paved. Record the rate of the slope - 10:1, 6:1, 4:1 or 3:1 or steeper, at the point of initial impact with the cable barrier. The rate of slope is defined as the ratio of horizontal distance to the vertical rise in elevation. For example, a 10:1 slope has a change of elevation of 1 foot for every 10 feet of horizontal distance.

To measure the rate of slope, place a carpenter's level perpendicular to the travel lane. Raise the lower end of the level until it is horizontal, then measure the vertical distance, D, in inches from the ground to the bottom of the level at the raised end of the level. Depending on the length of the level used, determine the rate of slope from the following table:

	Vertical Distance, D (in.)		
Rate of Slope	4-ft Level	3-ft Level	2-ft Level
10:1	4.8 in.	3.6 in.	2.4 in.
6:1	8.0 in.	6.0 in.	4.0 in.
4:1	12.0 in.	9.0 in.	6.0 in.
3:1	16.0 in.	12.0 in.	8.0 in.

11. As-Built Cable Height - Record to the nearest inch the as-built height of the barrier, measured from ground level to the top of the top cable.

Impact Performance

This portion of the form describes the impact performance of the tri-cable barrier.

12. Impact Performance - Check the entry that best describe the impact performance of the cable barrier. If more than one entry is applicable, e.g., the vehicle overrode the barrier and penetrated behind the barrier, check both the entries for "Vehicle Overrode Cable Barrier" and "Vehicle Penetrated Cable Barrier."

    - Redirected Vehicle onto Roadside/shoulder or Back into Traffic Lanes - The cable barrier contained and redirected the impacting vehicle onto the roadside or shoulder area or back into the traffic lane.

- Vehicle Came to Rest Against Cable Barrier - The impacting vehicle was contained by the cable barrier and came to rest against the barrier.
- Vehicle Overrode Cable Barrier - The impacting vehicle went on top of the cable barrier, but did not penetrate the barrier.
- Vehicle Underrode Guardrail - The impacting vehicle went under the cable barrier, but did not penetrate the barrier.
- Vehicle Penetrated Cable Barrier - The impacting vehicle penetrated the barrier and went behind the barrier.

Cable Barrier Damage

This portion of the form describes the damage to the cable barrier as result of the vehicular impact and includes the following information.

13. Length of Contact - Record to the nearest foot the length of contact by the impacting vehicle on the cable barrier.
14. No. of Posts Damaged - Record the number of posts damaged, either line posts or anchor posts, that need to be replaced or repaired.
15. No. of cables broken - Record the number of broken cables. If none, enter none or zero (0).
16. Splice Damaged? - Check yes, no, or not applicable (N/A). Enter yes if one or more cables are broken at a splice. Enter no if one or more cables is broken, but not at a splice. Enter N/A if none of the cable is broken.
17. Anchor Base Damaged? - Check yes or no. This applies to the in-the-ground footing and the breakaway cable and post bases. Enter yes if the anchor components are actually damaged or if the anchor moved in the ground for one inch or more, and describe the damage in your Comments. Enter no if the anchor assembly is not damaged, or moved in the ground for less than one inch.

Comments

If there are any unusual circumstances associated with the incident, e.g., the cable barrier was previously damaged in another incident and not repaired at the time this incident occurred, please provide any notes, sketches or comments on the back of the form or on a separate sheet.

APPENDIX B

A PROPOSED FRAMEWORK FOR A NATIONAL CENTER ON IN-SERVICE PERFORMANCE EVALUATION OF ROADSIDE SAFETY FEATURES

A PROPOSED FRAMEWORK FOR A NATIONAL CENTER ON IN-SERVICE PERFORMANCE EVALUATION OF ROADSIDE SAFETY FEATURES

1. INTRODUCTION

Under Task G, "Prepare White Paper for a National Database," a conceptual framework for a national database of information about in-service performance evaluation of roadside safety features was to be developed. In the course of developing this conceptual framework, the scope of the effort was expanded from a national database to a National Center for In-Service Performance Evaluation of Roadside Safety Features. A white paper describing this conceptual framework for a proposed National Center was prepared and submitted to the Transportation Research Board (TRB) for presentation at the 2002 Annual Meeting. However, the paper was not accepted by TRB for presentation or publication. The white paper was then revised as a Task G report and is presented herein.

2. BACKGROUND

Great strides in roadside safety have been achieved over the past several decades in the United States, from the adoption of the clear zone concept to a new generation of guardrail terminals and crash cushions. Despite all these advances in roadside safety, one area has been lacking, which is the in-service performance evaluation of roadside safety features. There have been studies in this regard, but the efforts have been limited. The result is that there is little available information on the impact performance of roadside safety features under real-world conditions. This lack of information on the in-service performance of roadside safety features was clearly evident during recent discussions on the continuing use of existing roadside safety appurtenances that failed to meet the crash testing guidelines set forth in National Cooperative Highway Research Program (NCHRP) Report 350. (1) There is a clear and demonstrated need for better compilation and dissemination of available information on in-service performance evaluation, as well as for increased efforts to implement these evaluations.

Roadside safety features are required to meet stringent crash testing guidelines set forth in NCHRP Report 350. However, a safety device that successfully met crash testing requirements does not necessarily perform well in the field for a number of reasons. First, crash tests are conducted under idealized conditions and may not be representative of real-world conditions. For example, crash tests are conducted on level ground while actual field installations could involve slopes and uneven terrain. Second, environmental conditions vary widely in the field, from saturated soil to frozen ground. Third, although impact conditions selected for crash testing are believed to represent the "worst practical case," real-world impact conditions vary widely, including those outside of the test parameters, such as non-tracking impacts. Variations in impact conditions could adversely affect the safety performance of a safety feature. Finally, there may be unforeseen problems with installation and maintenance of the device that can significantly degrade its safety performance. Thus, in-service performance evaluation is needed to assure that safety devices are indeed performing as intended in the field.

There has recently been additional attention focused on in-service performance evaluation, such as NCHRP Project 22-13. [2] However, most of these efforts have been ad hoc studies addressing specific roadside safety devices, e.g., longitudinal barriers under NCHRP Project 22-13. There needs to be an ongoing and concerted effort in order to address the large number of existing and new roadside safety devices.

In-service performance evaluation tends to be rather labor-intensive, requiring field personnel to collect data over an extended period of time. In today's climate of reduced manpower and increased workload, it may be difficult for a single state transportation agency to undertake a comprehensive in-service performance evaluation. This would be less of a problem if several States share the data collection effort. However, to conduct a multi-state, pooled-fund study would require an extensive organizing and coordinating effort, which again poses a formidable obstacle to implementation.

In order to promote better compilation and dissemination of available information and increased efforts on in-service performance evaluation, a National Center dedicated to the in-service performance evaluation of roadside safety feature is needed. This white paper outlines a conceptual framework for such a National Center, including discussion on:

- Mission and objectives,
- Scope,
- Organization and funding, and
- Potential benefits.

3. MISSION AND OBJECTIVES

The mission and objectives of this proposed National Center for In-Service Performance Evaluation of Roadside Safety Features are to:

- Compile and disseminate available information on in-service performance evaluation.
- Provide a single point of contact for questions and technical support and exchange of information on in-service performance evaluation.
- Provide a focal point for future conduct of in-service performance evaluation studies, including multi-state, pooled fund studies.

The first objective of this proposed program is to compile and disseminate available information on in-service performance evaluation. As mentioned previously, there have been numerous prior studies in this area and the information was centralized and organized under NCHRP Project 22-13. The information is now available from a web site set up by Worcester Polytechnic Institute, the contractor for NCHRP Project 22-13. User agencies desiring information on a particular roadside safety device can readily query and access the information with minimal effort. However, this is an ad hoc effort and, as new in-service performance studies are conducted, this database will have to be updated periodically if it is to remain a valid information source.

The second key objective is to provide a single point of contact for questions, technical support, or exchange of information on in-service performance. Currently, when a user agency has a question regarding a specific roadside safety device, there is no established means of seeking the answer. It is less of a problem for proprietary products since the question can be posed to the manufacturer. However, for non-proprietary devices, the user agency may have to obtain the information from Federal Highway Administration (FHWA), researchers, or colleagues in other states. It would be most helpful to user agencies if there is a single consistent point of contact, such as the proposed National Center, through which they can address their questions, seek technical help, or exchange information with other user agencies.

The third objective of the proposed National Center is perhaps the most ambitious, and will require much more resources than the first two objectives. As discussed above, it would be desirable to pool resources from multiple States in the conduct of future studies on in-service performance evaluation. This spreads the resources and workload so that the task would not become overwhelming for a single State. The biggest challenge for this approach is the effort required to organize and to coordinate activities among the participating States. The proposed National Center can serve this function, thus promoting a continuing effort on in-service performance evaluation.

Note that these are the desired missions and objectives of the proposed National Center. The actual implementation of a National Center may encompass all or only some of these objectives, depending on the interest and availability of resources.

4. SCOPE OF PROPOSED NATIONAL CENTER

The scope of the proposed National Center can vary greatly depending on the selected missions and objectives and the available resources. To accomplish all three missions and objectives stated in the previous section, the proposed National Center would perform the following activities:

1. Collect and compile available information on in-service performance evaluation.

2. Critically review available information on its validity and usefulness.
3. Create a national database on in-service performance evaluation.
4. Prepare bibliographies and summary reports on individual roadside safety features.
5. Develop a web-based system for querying the national database, posing of questions, and exchanging information.
6. Convert existing information to electronic format.
7. Disseminate information upon request.
8. Provide technical support upon request.
9. Monitor ongoing studies pertaining to in-service performance evaluation and update database as studies are completed.
10. Conduct studies on in-service performance evaluation, including multi-state, pooled-fund studies.

More detailed discussions of these tasks are presented below.

Task 1. Conduct Literature Search. The first task is to collect and compile available information on in-service performance evaluation. As mentioned previously, there have only been limited efforts devoted to in-service performance evaluation. Thus, the available literature is not too voluminous. Also, under NCHRP Project 22-13, an extensive literature search and review was conducted, which would serve as a good starting point for this task. However, to ensure completeness of the literature and to identify any new studies since the search was conducted under NCHRP Project 22-13, a new literature search using available computerized databases would be necessary. In addition, a full survey of state departments of transportation (DOTs) and leading research agencies would be conducted to identify any published, unpublished, and ongoing studies not included in the computerized databases. Copies of the pertinent reports would then be requested from the performing or sponsoring agencies and catalogued for use with the national database.

Task 2. Perform Critical Review of Literature. As may be expected, the quality of the past research and the associated reports may vary greatly from very poor to excellent. Also, there may be conflicts among results from studies on the same roadside safety feature. Thus, in drawing conclusions from past studies, user agencies may be exposed to some risk due to the variability of the research results and recommendations. Furthermore, user agencies may not have the time or the in-house expertise to sift through the many existing studies to draw the appropriate conclusions. It would be most helpful if the available studies were critically reviewed and summarized by a recognized authority, on a consistent basis, to aid the user agencies in drawing the appropriate conclusions.

Task 3. Develop National Database. A national database on in-service performance evaluation would then be developed from available information and accompanying critical reviews. Each record would correspond to a specific study and should contain, as a minimum, the following information:

- Keywords, such as type of roadside safety feature, manufacturers' product name, etc., to allow for search of the database,
- Name of performing agency,
- Name(s) of author(s),
- Contact information for performing agency and author(s),
- Title of study,
- Identification code(s) for available report(s), and
- Identification code(s) for critical review(s).

Task 4. Prepare Bibliographies. As mentioned previously, user agencies may not have the time or the in-house expertise to analyze past studies and draw appropriate conclusions. It would be desirable for the National Center staff to prepare bibliographies and summary reports on individual roadside safety features to relieve the user agencies of this task. This work can be done over a number of years to even the workload. A number of roadside safety features would be selected each year for which bibliographies and summary reports would be prepared and distributed to the participating state agencies. The information would also be part of the national database available to other users. The bibliographies would be updated as new research reports are published.

Task 5. Establish Web-Based System. With the proliferation of the Internet, the most efficient means of providing access to the national database would be a web-based system. A web site would be set up to allow users to query the national database and download pertinent information. The web site could also provide a forum for users to pose questions and to exchange information. This will require some initial investment to set up the web site for this purpose. However, this would be the most logical and efficient means of disseminating the information in the long run. Currently, a web site is set up under NCHRP Project 22-13. While the capability of the current web site is less comprehensive than desired, it may serve as a good example and starting point.

Task 6. Convert File Formats. In order for the national database to be web based, the documents will have to be converted from hard copies to electronic format, e.g., PDF or HTML format. This would require scanning the reports into electronic files or requesting electronic copies of the reports from the performing or sponsoring agencies. The electronic files can then be downloaded via the web site.

Task 7. Disseminate Information. Upon establishment of the web-based system, user agencies may then query the national database and download files as well as pose questions or exchange information. For users without web access, or who prefer not to use the web site, the information can be disseminated in the traditional way by mail with CD-ROMs or hard copies of the reports. The same applies in situations where the requested information is in a file too large for download over the Internet.

Task 8. Provide Technical Support. In situations where the posed questions are beyond just querying the national database and reviewing available literature, it would be desirable for the National Center to have the capability to provide technical support to the user agencies. There is no established mechanism for user agencies to seek answers to specific questions. This requires the user agency with the question to contact agencies and individuals that may be knowledgeable in the subject area, such as FHWA, universities, research institutions, and colleagues from other state agencies. The National Center can serve as a single point of contact to answer all such questions, to contact performing agencies and authors, and to provide related technical support, which would greatly simplify the process for user agencies.

Task 9. Monitor Progress of Ongoing Studies. The National Center would also monitor all ongoing studies pertaining to in-service performance evaluation and update the database as studies are completed. Again, reports for the new studies will be requested from the performing or sponsoring agencies. The studies will then be critically reviewed and added to the national database and to previously published bibliographies on roadside safety features. Since the number of in-service performance evaluation studies is expected to be relatively small on an annual basis, the level of effort required for this task would likely be relatively minor.

Task 10. Conduct Research. The biggest potential task and client service for the proposed National Center would be to serve as the focal point for conduct of ongoing studies on in-service performance evaluation, including multi-state, pooled-fund studies. The scope of the work for the proposed Nation Center will include:

- Design of study
- Development of standardized data collection protocol,
- Conduct pilot study,
- Training of data collection personnel,
- Monitoring of data collection effort,
- Quality control of collected data,
- Compilation of collected data into a data file for analysis,
- Data analysis, and
- Preparation of study report.

Each proposed new study protocol will first have to be designed in accordance with the objectives of the study. This will include considerations for such questions as:

1. Questions to be addressed.
    - What specific questions are to be addressed?

- How the questions are going to be analyzed in the study?

2. Data elements to be collected.
   - What data elements are needed for the analysis?
   - What data elements are currently available in existing databases?
   - How may the data be extracted for use with the study?
   - What data elements will require field data collection?

3. Sample size and sampling scheme.
   - What is the required sample size for proper analysis of the posed questions?
   - How is the data to be sampled, including such considerations as geographical representation, data collection period, etc.?

A standardized data collection protocol will be developed, including:

- Sampling scheme. A scheme for determining the survey sample would be determined. For example, the sampling scheme could be the entire population, i.e., 100 percent, or a random or stratified random sample, or a sample of convenience. The sampling area may be a selected district(s) or a selected highway type(s) or section(s).
- Notification system. A system of notifying the data collection personnel would be established, e.g., periodic monitoring of police crash reports, maintenance records and personnel, etc.?
- Data elements and definitions. Definitions for the data elements will be developed so that all data are collected under the same definitions.
- Data collection form. A standardized data collection form will be developed for the data collection personnel from all participating states.
- Instructions for field data collection procedures. The data collection form will be accompanied by instructions for field data collection procedures to assure uniformity and consistency among the data collecting personnel.
- Quality control. A quality control procedure will be developed for the National Center personnel to review the field data. Any identified problem will be sent back to the field data collectors for correction or handled by the National Center personnel internally.
- Data coding conventions and entry system. An appropriate system for data coding and entry will have to be developed to enter the field data into a data file suitable for analysis.

The data collection protocol will first be tested in a small-scale pilot study to iron out any unforeseen problems prior to the full-scale data collection effort. The pilot study will be conducted at a few test sites for a short period of time under supervision of the

National Center staff. Results from the pilot study will then be evaluated and the data collection protocol will be revised accordingly.

Field data collection personnel will be trained in the definitions of the data element and applicable field procedures by the National Center staff. Depending on the complexity of the data collection protocol, the training could vary from review of written instructions to training video, to on-line training, to in-class instructions. The data collection effort could then commence upon completion of the training. The National Center staff will monitor and provide quality control of the collected data. Feedback will be provided to the field personnel as necessary to ensure that the collected data is accurate, complete, and in accordance with the field data collection protocol. The collected data will then be coded and compiled into a data file for analysis. Upon completion of the data collection effort, the compiled data will be analyzed and results of the study presented in a final report.

5. ORGANIZATION AND FUNDING SOURCES

For an undertaking such as the proposed National Center to be successful, it is critical to have the proper organization and funding sources. It is probably too much to expect any State transportation agency to be willing and able to effectively undertake or sponsor this effort. Thus, the effort will have to be at the national level, or at least involve a number of states. There are many options available for establishing and operating the proposed National Center for In-Service Performance Evaluation, but only two primary options that are the most practical and likely to succeed are presented herein.

A responsible agency will have to take the lead to initiate and direct the proposed National Center. This agency is ideally national in scope and has the resources to fund and manage this effort. The responsible agency will define the mission, objectives and scope of the project, secure the required funding, select the contractor for the actual work, and direct and maintain oversight on the program.

One logical choice for this responsible agency would be the AASHTO Task Force on Roadside Safety (TFRS) since it represents all of the State transportation agencies, and its mission and responsibility are focused on roadside safety. While the Task Force does not have any direct resources, it can request for such funding through the NCHRP program. The actual technical work will be handled by a contractor, such as a university or research agency, under contract to NCHRP. Since there is already an ongoing effort under NCHRP Project 22-13 with Worcester Polytechnic Institute as the contractor, one option is to expand the effort and scope of the ongoing project with additional funding to include the other components of the proposed National Center. Another related option is to establish a new project and select a new contractor through the request-for-proposal process. This project would be managed by NCHRP with the TFRS providing the direction and oversight to the project. Drawbacks to this approach are that the project may not be selected for funding and it would require a very long lead-time.

Another logical possibility for the responsible agency is the Mid-States Pooled Fund Program administered through the Nebraska Department of Roads (NDOR). This program already has the organization and funding in place. Thus, the National Center can be initiated in a relatively short period of time once the decision is made by the program to pursue this project. The drawback is that the program is regional in scope, involving only 11 state transportation agencies. Also, the work established under this pooled-fund program will be conducted by the Midwest Roadside Safety Facility at the University of Nebraska at Lincoln and not be open to other contractors.

6. POTENTIAL BENEFITS OF PROPOSED NATIONAL CENTER

The creation of a national database and center on in-service performance evaluation of roadside safety features would have significant benefits for all transportation agencies that are involved with roadside safety. The database would provide transportation and research agencies with ready access to information on real-world impact performance of various roadside safety features. Examples of how the information may be utilized include, but are not limited to, the following applications:

- <u>Selection among competing roadside safety appurtenances.</u> For a given application, typically there are competing roadside safety appurtenances or features available. The State transportation agencies are constantly faced with the problem of selecting among competing appurtenances or features for incorporation into their design standards. Selection of a specific feature is based on many factors, such as crash test data, compatibility with existing hardware, cost, installation and maintenance requirements, personnel training, etc. Unfortunately, in-service performance data is seldom available. Information on real-world impact performance of various roadside safety appurtenances and features would be of great help to the States in selecting appurtenances or features that are most appropriate for their applications.

- <u>Identification of performance limits</u>. In-service performance data would help State transportation agencies to identify the performance limits of roadside safety appurtenances in terms of roadway, roadside and traffic conditions. Although the impact conditions used in crash testing are unquestionably extreme in accordance with the "practical worst condition" philosophy, roadside safety appurtenances are typically evaluated with full-scale crash testing under idealized site conditions, e.g., no side slope. However, there are possibly unforeseen combinations of site and impact conditions that could contribute to the failure of the appurtenances to perform properly, i.e., exceeding the performance limits of the appurtenances. The in-service performance evaluation could help users to identify and avoid these performance limits that could lead to improper performance of appurtenances.

- Conduct field trials of new roadside safety appurtenances and features. As new roadside safety appurtenances and features are introduced, it would be important for the potential user agencies to have valid in-service performance information prior to incorporating the appurtenances and features into the standard drawings for full-scale implementation. Since new roadside safety appurtenances and features are typically introduced on a limited experimental basis, the number of installations and associated crashes in any given State are generally too small for any meaningful evaluation. Combining data from several States would provide a larger sample size and more meaningful evaluation.

- Establishment of upgrading policy. With the introduction of new crash testing guidelines, some existing appurtenances may fail to meet these new guidelines. This raises the question of whether it may be necessary to upgrade the existing appurtenances to approved designs that meet the new guidelines. In-service performance information is critical in determining if it is cost-beneficial to upgrade existing appurtenances that no longer meet the new guidelines. If an existing appurtenance is performing very well in the field, then there is no need to upgrade, even though the appurtenance does not conform to the new guidelines. On the other hand, if an existing appurtenance is performing poorly in the field, then an upgrading program may be appropriate.

- Assessment of relevance. In the current effort under NCHRP Project 22-14[(2)] to update the crash testing guidelines set forth in NCHRP Report 350, one of the first questions asked about any proposed update or revision is its relevancy, i.e., "How does the proposed revision compare to real-world impact conditions and what are the consequences?" Unfortunately, there are no in-service performance evaluation data available to answer these questions accurately and effectively and to address the relevancy issue.

7. DISCUSSIONS AND RECOMMENDATIONS

This report has presented the conceptual framework of a proposed National Center for In-Service Performance Evaluation of Roadside Safety Features, including the mission, objectives, scope, organization and funding source. It is recommended that this idea of establishing the National Center for In-Service Performance Evaluation be presented to the AASHTO Task Force on Roadside Safety and the Mid-States Pooled Fund Program for their consideration.

Some of the functions proposed for the National Center are, in some respects, already accomplished under NCHRP Project 22-13. Specifically, available information on in-service performance evaluation were collected and compiled into a database. The information was reviewed, summarized and rated, although a more critical review to assess its validity and usefulness is recommended. The database is available through a web-based system. General guidelines for conduct of in-service performance evaluation studies were developed and a study assessing the performance of longitudinal barrier systems was conducted.

It is, therefore, recommended that the available information and web-based system from NCHRP Project 22-13 be used as the starting point for the proposed National Center and that the scope of the effort be expanded to include the following activities:

- Monitor ongoing studies pertaining to in-service performance evaluation and update the existing database as studies are completed.
- Prepare bibliographies and summary reports on individual roadside safety features.
- Convert existing information to electronic format.
- Expand the web site to allow for posing of questions and exchange of information.
- Provide technical support upon request.
- Conduct studies on in-service performance evaluation on selected features.

REFERENCES

1. H. E. Ross, Jr., D. L. Sicking, R. A. Zimmer, and J. D. Michie, "Recommended Procedures for the Safety Performance Evaluation of Highway Features," *NCHRP Report No. 350*, National Cooperative Highway Research Program, Transportation Research Board, Washington, D. C., 1993.

2. "In-Service Performance of Traffic Barriers," Worcester Polytechnic Institute, NCHRP Project 22-13, National Cooperative Highway Research Program, Transportation Research Board, Washington, D. C., ongoing.