MATERIAL ASSESSING SAFETY HARDWARE (MASH)

2009

In-Service Performance Evaluation

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7.1 PURPOSE

As mentioned in Chapter 1, in-service performance evaluation (ISPE) is a very important step in the assessment of the impact performance of a new or extensively modified safety feature. The purpose of in-service performance evaluation is to determine and document the manner in which the safety feature performs during a broad range of collision, environmental, operational, and maintenance situations for typical site and traffic conditions. The in-service performance evaluation remains an important follow-up to the crash test experiments described in previous chapters. Testing and analysis only partially assess the efficacy of a feature and a more thorough and in-depth knowledge of the feature is important to its proper implementation.

Although the crash testing guidelines set forth in this report assure that safety devices function well for the specified test conditions, there are many unknowns and concerns about the impact performance of the roadside features under real-world conditions. 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, such as roadside slopes and ditches, that adversely affect vehicle kinematics before, during, or after impact with the safety device; and
- Sensitivity to installation details, such as soil resistance or barrier flare configuration.

Therefore, if necessary, conduct an in-service performance evaluation to assess and monitor field performance of roadside safety features. In-service performance evaluation allows user agencies to identify the overall impact performance of a feature as well as identify potential weaknesses or problems with the design.

The following sections describe goals and suggested procedures for in-service performance evaluation. However, the random and extremely complex nature of vehicular crashes coupled with resource limitations of transportation agencies greatly restrict the extent to which these goals can be met and the procedures can be carried out.

7.2 OBJECTIVES

The objectives of in-service performance evaluation include:

1. Demonstrate that design goals are achieved in the field and identify modifications that might improve performance.

2. Acquire a broad range of collision-performance information on features installed in typical and special situations. It is desirable to include information such as exposure data and data on occupant injuries and vehicular impact conditions from which severity index values could be defined. In addition to "reported crashes," a measure of the more numerous brush hits and drive-away collisions can be monitored to establish failure/success ratio and collision damage repair costs.

3. Identify factors that may compromise or defeat a feature's performance. Examples of such factors include vulnerability of the feature to pilferage or vandalism, accelerated corrosion or degradation of materials due to de-icing salts and other contaminants, and susceptibility damage during snow plowing or mowing operations.

4. Examine the influence of climate/environment on collision performance. To be determined are the effects, if any, of extremes in heat and cold, ice, snow, rain, wind, and dust on the collision performance and maintenance of the safety feature.

5. Examine the influences that the feature may exhibit on other highway conditions that, in turn, may adversely affect highway operations and traffic. Such factors to be monitored are traffic congestion, change in accident rates or patterns, disruption of surface drainage, or the cause of snow or debris buildup.

6. Acquire routine maintenance information. As a part of this effort, the feature's design and layout should be examined for possible modifications that would lower installation, maintenance, and damage repair costs. Problems encountered during routine maintenance and damage repair should be documented and reported. Note that frequency of repair and repair demand (after both nominal and severe impacts) are critical factors. Systems that can sustain numerous or severe impacts while remaining serviceable offer substantially better protection to motorists than those that are rendered out of service by virtually every impact. This becomes especially critical on high-volume roadways, on roadways where maintenance activities cause congestion and increased risks of accidents, and at problem or high-accident locations. Information of this type can become the primary consideration in selection of a barrier system for such locations.

7.3 IN-SERVICE PERFORMANCE EVALUATION PROGRAM

Depending on the questions posed, in-service performance evaluation could involve different approaches with varying degrees of detail. NCHRP Report 490, *In-Service Performance of Traffic Barriers*, (108) presents one such approach with detailed step-by-step procedures on conduct of an in-service performance evaluation. The procedures described in this report are intended mainly for evaluation of a specific roadside feature; however, it can be expanded to include continuous monitoring of several types of features as part of a long-term safety management system. This approach utilizes maintenance forces as the main source of data collection, supplemented by data from police accident reports. Figure 7-1, reproduced from NCHRP Report 490, shows the various steps of this in-service performance evaluation process. Detailed procedures for each of these steps are outlined in the report and will not be repeated herein.

Instead, a more general discussion on the conceptual framework of a comprehensive in-service performance evaluation is presented herein. The conceptual framework covers not only evaluations using the procedures detailed in NCHRP Report 490, but also other aspects of in-service performance evaluation. In general, in-service performance evaluation includes two separate, but integrated, programs that address different aspects of in-service performance evaluation:

- new feature evaluation, and
- continuous monitoring.

More detailed descriptions of these two programs are presented as follows.

7.3.1 NEW FEATURE EVALUATION

While a new or extensively modified feature may have successfully met all evaluation criteria set forth in the guidelines, there are still questions pertaining to its impact performance under actual field conditions. Thus, it is important to consider the need for evaluating in-service performance as a new feature is deployed in order to assure that the system is performing as designed under real-world conditions.

The in-service performance evaluation of a new or extensively modified feature presents some unique issues. First, the number of initial installations is typically very small for a new feature. Consequently, the number of crashes involving these installations will also be very small. The small sample size would limit the statistical significance of the results of the evaluation, and render it more anecdotal and subjective in nature. To increase the sample size of crashes, the alternatives are to increase the number of initial installations or increase the evaluation period. There is a practical limit to the length of the evaluation period, e.g., three to five years. The more logical approach is to increase the number of initial installations. However, as discussed previously, a state transportation agency may not want to widely deploy a new feature without any in-service evaluation. This dilemma is best resolved by pooling resources among state transportation agencies that are interested in the same feature. Each agency could install and monitor a small number of initial installations. The results can then be combined to provide a larger sample size. This approach allows the agencies to keep the number of initial installations small for each state, yet provides a sufficient sample size for evaluation.

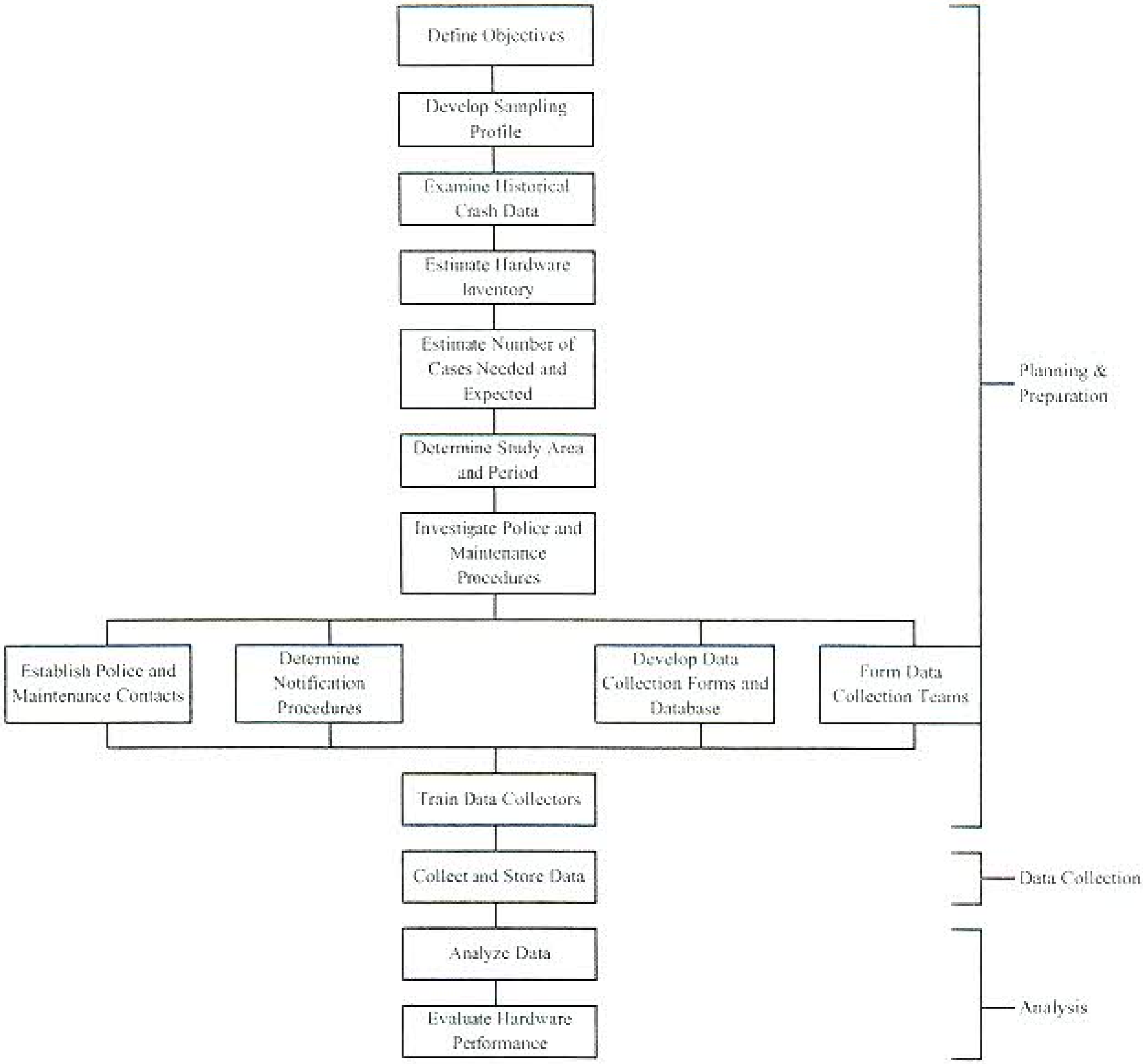

Figure 7-1. Flowchart of the In-Service Performance Evaluation Process (108)

Second, other than design drawings and prototype installations for the crash tests, there is no real-world experience with installing or maintaining the feature. Even with the best designs, it is reasonable to expect that there will be some unforeseen problems that need to be ironed out with the initial installations. Thus, one of the objectives of the in-service performance evaluation for a new feature is to identify and resolve any problems associated with the installation and maintenance of the feature.

Given that the true impact performance of a new or extensively modified feature under real-world conditions is not known, it recommended that in-service performance evaluation of the feature be conducted prior to widespread deployment of the feature.

The in-service performance evaluation of a new or extensively modified feature should include the following components:

- **Installation and maintenance checklist**—The checklist includes a list of items related to the construction, installation, and maintenance of the device. Any identified problem should be investigated and documented, and the information should be forwarded to the designers for appropriate corrective action.
- **Inventory**—The inventory should include location and design details of the installations so that the information can be matched to the crash data for evaluation.
- **Crash monitoring**—The monitoring should include both reported and unreported crashes involving the installations. The crashes are identified from police notification or accident reports for reported crashes and maintenance notification or logs for unreported crashes. For reported crashes, the investigation should include: obtaining a copy of the police report; visiting the site to document any available scene evidence, such as tire marks, damage to the installation, final rest position, etc.; and taking photographs of the site. For unreported crashes, the investigation will be limited to documentation of the site and system damage.
- **In-depth investigation**—Crashes involving the new feature that resulted in a fatal or serious injury should be investigated in-depth. In addition to obtaining the police accident report and documenting the site, the involved vehicle should be examined and efforts made to reconstruct the crash in terms of impact configuration and conditions, e.g., point of impact, speed, angle, vehicle orientation, etc., and to assess the impact performance of the feature, i.e., whether the device performed as designed and, if not, whether there are extenuating circumstances.

The results of the in-service performance evaluation should be summarized in a report which should include, but not be limited to:

- Number and locations of installations;
- List of problems identified with the construction, installation, and maintenance of the device and subsequent remedies;
- Frequency and severity of reported and unreported crashes;
- Documentation of crashes resulting in fatal or serious injuries;
- Assessment of in-service performance evaluation of feature; and
- Recommended changes or modifications to the design and application of the feature.

7.3.2 CONTINUOUS MONITORING

Even after a device has successfully undergone the new feature in-service performance evaluation, a continuous monitoring system is strongly recommended to ensure that the device continues to perform satisfactorily and in keeping with changes in field conditions. The continuous monitoring system has similar components to the new feature evaluation system, including:

- Maintenance checklist,
- Inventory,
- Crash monitoring, and
- In-depth investigation.

However, the setup of the continuous monitoring program is very different from that of the new feature evaluation system. With a new feature, the number of initial installations and the resulting crashes are expected to be relatively small. Thus, monitoring of the new feature evaluation system is typically small in scope and can be managed even manually. In comparison, the number of installations and associated crashes are likely to be much greater with the full-scale deployment of a feature. This provides a much larger sample size suitable for statistical analysis. Thus, the continuous monitoring system should be computerized to keep it manageable and to minimize manpower requirements.

The continuous monitoring system would consist of the following three subsystems:

- computerized database subsystem,
- supplemental data collection subsystem, and
- in-depth investigation subsystem.

The backbone of the continuous monitoring system is a computerized database created by merging the following data files:

- **Highway and traffic data**—Items of interest include such information as: highway type, functional class, number of lanes, lane width, shoulder width, average daily traffic, percent truck, etc.
- **Maintenance records**—There are two general areas of interest regarding the maintenance records. First, the records are reviewed to identify problems associated with maintenance of the device. Any identified problem should be investigated and documented and the information forwarded to the designers for appropriate corrective action. Second, the records are compiled to determine the extent of unreported crashes, which is part of the evaluation of the impact performance of the feature.
- **Roadside feature inventory data**—The inventory data should include location and design details of the installations so that the information can be matched to the crash data for evaluation.
- **Crash data**—Police reported crashes involving the feature of interest are matched to the roadside feature inventory data or by location on the highway.

The computerized database should be analyzed periodically, e.g., annually, for generalized trend analysis and problem identification. 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). Examples of such analyses may include:

- Frequency/rate and severity of reported crashes and frequency/rate of unreported crashes involving various roadside features, broken down by year, highway type/functional class, traffic volume for each district and statewide;
- Trend analysis of frequency/rate and severity of reported and unreported crashes involving various roadside features.

The database can also be used to conduct comparative analysis on an ad hoc basis for selected roadside safety features and highway sections. Examples of ad hoc comparative type of analysis that may be addressed with this database include:

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

The supplemental data collection subsystem is intended to supplement the computerized database for analyses in which the level of detail of the computerized database may not be sufficient. The supplemental field collection may include specific data on the selected roadway, roadside, and safety feature or manual review of hard copies of police accident reports to obtain information otherwise not available from the computerized database, or both. Studies under the supplemental data collection subsystem will be conducted on an ad hoc basis for selected roadside safety features, e.g., comparison of impact performance between different guardrail types as a function of highway type, speed limit, lateral offset, mounting height, etc.

The 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. This subsystem requires resources typically beyond what user agencies have currently or will have in the foreseeable future. Thus, this subsystem is likely limited to ad hoc studies conducted by outside contractors.

7.4 DISCUSSIONS

While there is no formal requirement for in-service performance evaluation, it is highly recommended that some form of an in-service performance evaluation program be implemented, perhaps as part of the safety management system. NCHRP Report 490 (108) presented detailed procedures for one approach to the conduct of in-service performance evaluation. The conceptual framework presented above covers additional aspects and approaches for an in-service performance evaluation program. However, it should be emphasized that it is intended as a conceptual framework and user agencies should select the specific aspect or approach that best fits the needs and resources of the agency. Ideally, the in-service performance evaluation program would include both new feature evaluation and continuous monitoring. The new feature evaluation system would assess the impact performance and operational characteristics of any new or extensively modified feature to make sure that the feature is performing as designed. The continuous monitoring system would monitor the operational performance of various safety features in case there are changes in the vehicle fleet or highway operating conditions that adversely affect the performance of roadside safety features.

Also, in today's environment of limited manpower and increased workload, it would be a good idea to pool resources among several states with interest in the same safety features in order to obtain larger sample sizes and reduce the workload of individual states. It is further recommended that a national center for in-service performance evaluation be established as a clearinghouse to disseminate the information and to coordinate such efforts.