# Implementation of Research Findings and Products

## **NCHRP 22-33**

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## **INTRODUCTION**

The primary objective of this research was to develop a unified format and national compatible ISPE methodology employing various individual state database parameters. The unified format and methodology have been discussed in this report and are presented as an Appendix. The next critical step is to implement this methodology broadly in transportation agencies nationwide such that highway agencies can base roadside hardware decisions on observed performance data. Basing roadside hardware decisions and policy on observable data ensures that scare agency resources are targeted at policies and design decisions that will achieve the lowest practical risk to highway users. The following sections describe a detailed implementation plan for the products of this research.

The leadership of the AASHTO Technical Committee on Roadside Safety (TCRS), the Federal Highway Administration (FHWA), and individual Transportation Agencies will be essential for the implementation of this research. Each of these agencies have the potential to benefit from confirming that hardware is performing in the field as expected and identifying areas where improvements are practical. AASHTO and the FHWA have the ability to encourage and coordinate efforts on a national scale. Individual highway agencies have the responsibility to manage highway infrastructure and have the most to gain by implementing data-driven roadside hardware policies. Successful implementation of ISPEs will ultimately be measured through a reduction in serious and fatal roadside crashes.

The following implementation plan identifies the desired outcomes of implementing this research. Each of the following section titles indicates a particular desired outcome. A specific recommendation to achieve the outcomes is presented at the end of each section in an italic font. Suggestions have been made for the parties best suited to execute each identified recommendation. The conclusion of this plan summarizes the identified recommendations to achieve the following desired outcomes:

- ISPE results are used in decision making and policy development;
- ISPEs are performed by trained individuals using a consistent methodology;
- ISPE results are shared among transportation agencies;
- Funding and resources are made available for ISPEs; and
- ISPEs are a Routine Part of Transportation Agency Procedures.

## **DESIRED OUTCOMES**

The best possible outcomes of implementing this research have been outlined in the following sections. Best practices and institutional barriers to implementing ISPEs were identified in several workshops attended by Transportation Agency, AASHTO TCRS, and FHWA personnel and were discussed in the Final Report. The following outcomes and associated recommendations provide solutions for the identified obstacles and build upon the identified best practices to remove institutional barriers to conducting ISPEs. The outcomes are indicated by the section titles and the specific recommendations are provided at the end of each section in an italic font.

#### ISPE Results are Used in Decision Making and Policy Development

The AASHTO TCRS Strategic Plan identified the need to institutionalize in-service performance evaluations (ISPEs). Roadside hardware decisions and policy based on observable field performance ensure that resources are most effectively used to reduce fatal and serious injury run-off-road crashes. In support of that objective, the AASHTO TCRS advanced the

research needs statement (RNS) which led to this research project. The resulting ISPE Guidelines Document developed in this research provides:

- (1) A standardized methodology for researchers and user agencies to assess the field performance of roadside safety features.
- (2) Guidelines for the assembly of in-service performance data.
- (3) Guidelines for the evaluation of in-service performance data.
- (4) Guidelines for the uniform documentation of ISPEs.
- (5) Guidelines for the interpretation and application of ISPE results.

A common misconception about performing ISPEs is that an inventory of roadside hardware is needed but, in fact, "an inventory is <u>not</u> necessary to conduct an ISPE. Transportation agencies, however, may find it beneficial to maintain an inventory of roadside hardware to monitor the field performance of roadside hardware and to address more complex questions." (Carrigan 2023 [Expected]) Roadside hardware inventories are useful if available, but an ISPE can also be performed without inventory information. An observed best practice for ISPEs was the balancing of the inventory costs with the potential savings. Specifically, the budget necessary to collect and maintain a hardware inventory could be balanced by the potential savings which may be realized by avoiding hardware update policies that have little measurable effect in the field.

Another common concern is that data will not be collected consistently or that critical fields would be missed. The ISPE Guidelines Document largely eliminates that concern by establishing a standardized methodology for performing and analyzing ISPEs. In addition, the ongoing NCHRP Project 22-44 is developing a transportation agency data collection methodology and associated data collection guidelines to support ISPEs. The products of these two research products will provide consistent guidelines for planning an ISPE, assembling available data, field procedures for collecting new data, analyzing the data, and documenting the ISPE. (Carrigan 2023 [Expected]) *Transportation Agencies are encouraged to use the data collection methodology being developed under NCHPR Project 22-44 as well as the ISPE Guidelines Document developed in this project when performing ISPEs.* 

Another obstacle to institutionalizing ISPEs is the question of how to best use the results in highway agency decision making and policy development. If there is no immediate use for the ISPE results, highway agencies will have little incentive to allocate the resources needed to perform ISPEs. The AASHTO TCRS strategic plan proposed "that prior to any policy change, a review of the in-service performance of the outgoing hardware be performed. If the hardware is found to be preforming acceptably, then the ISPE may be offered in place of changing the hardware policy. If the performance is judged to be unacceptable, then steps to improve or change the test and evaluation criteria (i.e., MASH) or the site design and installation recommendations (i.e., RDG) should be initiated." (Carrigan 2015) ISPEs should be used to ensure that a new roadside hardware policy is likely to result in measurable and observable reductions in the number of fatal and serious injury crashes.

There is also a need to define was constitutes "acceptable" roadside hardware performance. The TRB AKD20 and AASHTO TCRS advanced a RNS during the Summer 2021 meeting with the objective to develop national guidelines which define acceptable field performance thresholds for roadside hardware. The RNS is provided at the end of this plan and titled "National Guidelines for Defining Acceptable Roadside Hardware Field Performance through In-Service Performance Evaluations (ISPEs)." Establishing national guidelines for defining acceptable field performance will provide a critical element to support national and regional use of ISPE results consistently. The proposed research would develop performance thresholds defining acceptable performance for each of the evaluation criteria established under this research and presented in the *ISPE Guidelines Document*. Furthermore, the proposed research would develop guidelines for the use of ISPEs for establishing or updating existing guidelines and for establishing crashworthiness.

Recently, NCHRP WOD 292 (Roadside Hardware Replacement Analysis User's Guide) developed a method for using ISPE, traffic, and construction cost data to assess when and how to implement future roadside hardware changes. The method uses ISPE data to determine the existing performance in the field, estimate future performance of the proposed hardware and analyze if replacing the hardware is economically practical. Some changes in hardware have been proposed based on the results of crash tests but the likely reduction in fatal and serious crashes is very small and unlikely to be a good investment of agency funds. This is not intended to imply that crash testing is frivolous. Crash test evaluations of roadside safety features have long been recognized as an initial assessment of hardware performance. An ISPE demonstrates how roadside safety features perform within a broader range of real-world conditions such as environmental and operational situations.

The roadside hardware replacement analysis procedure provides a way to develop policy that determines if systemwide replacement, replacement in specific improvement projects, replacement through attrition, or no replacement at all is warranted for different roadways. The roadside hardware replacement analysis procedure is an example of using ISPE results to make data-driven roadside hardware decisions. *Transportation Agencies are encouraged to consider leveraging ISPE results to (a) support the decision to replace or maintain existing hardware; and (b) develop roadside design guidelines.* AASHTO is encouraged to consider leveraging ISPE results to MASH would provide observable improvements in the field. Transportation Agencies and the FHWA are encouraged to consider supporting the funding of the proposed research titled "National Guidelines for Defining Acceptable Roadside Hardware Field Performance through In-Service Performance Evaluations (ISPEs)."

#### ISPEs are Performed by Trained Individuals Using a Consistent Methodology

The lack of availability of training for performing ISPEs has been recognized as an institutional barrier to institutionalizing ISPEs. This research project provided multiple training opportunities for the pilot states and showed that highway agencies could perform ISPEs if provided proper training and support. The training, however, was a one-time effort limited to the pilot states participating in this research. There is a critical need to continue the dissemination of these results and train additional transportation agencies on performing ISPEs using the NCHRP 22-33 methodology.

Fortunately, the FHWA and the National Highway Institute (NHI) recently awarded a contract to develop an NHI course on using the ISPE methodology developed in this research which will fulfill the critical need for additional training. The development of the course is expected to be complete by the fall of 2022. The NHI course is targeted toward individuals who may assemble available data, conduct ISPE analyses, and/or form conclusions regarding the field performance of hardware. By extension, those individuals responsible for the design of an ISPE study will also find value in this training. (NHI 2022 pending) *Transportation Agencies are encouraged to consider arranging for the NHI ISPE training of their employees who are responsible for conducting, reviewing, and interpreting ISPEs.* 

#### **ISPE Results are Shared Among Transportation Agencies**

Another obstacle to implementing the findings of ISPEs is the lack of a clearing house or single location to find information on previously conducted ISPEs. ISPE results generally do not receive wide circulation. Sometimes results were published as journal articles or conference papers but finding these results requires a diligent literature search of many different conference proceedings and journals. Many times, a Transportation Agency's ISPEs result in an internal review that is not readily available outside the agency. The on-line *ISPE Resource Hub* developed under this research project solves this problem by creating a single location where ISPE results can be stored, searched, shared, and reviewed. Information about how to conduct an ISPE and other tools and resources are also shared on the *ISPE Resource Hub*. Transportation Agencies working together can increase not only the pool of data, but also make others aware of what is being studied in other regions. *AASHTO and FHWA should encourage Transportation Agencies consider sharing their ISPE results and consider supporting funding and resource allocations that facilitate sharing*.

The continued hosting of the *ISPE Resource Hub* following the conclusion of this research has been discussed at length during the planning and execution of this research. A recommendation was made prior to progressing to Phase II of the research, that the *ISPE Resource Hub* site would continue to be hosted by RoadSafe LLC for a year following the conclusion of the research. It was anticipated that this time would allow for AASHTO and/or FHWA and the states to determine the best alternative for hosting the ISPE Resource Hub. One possible opinion is to suggest that the recently organized ISPE Pooled Fund take on the responsibility for hosting and maintaining the *ISPE Resource Hub* in the future. *When the ISPE Pooled Fund project is active, it should consider including hosting and maintaining the ISPE Resource Hub in its list of activities.* 

#### Funding and Resources are Made Available for ISPEs.

As always, costs and resources are a concern to Transportation Agencies considering institutionalizing ISPEs. An In-Service Performance Evaluation (ISPE) of Roadway Safety Features Pooled Fund has been established (i.e., TPF-5(481)). "The primary objective of this pooled fund study is to evaluate the performance of roadside safety hardware in the field through inter-state collaboration by using standardized data collection and data analysis with a uniform interpretation of results. The second objective is to provide a forum for states to share in-service performance evaluation (ISPE) data, experiences, practices, information, and resources."(TPF 2021) This pooled fund will give Transportation Agencies the opportunity to collaborate not only through sharing data but also through pooling available resources and minimizing the duplication of efforts. *Transportation Agencies are encouraged to consider participating in the TPF-5(481) pooled fund to minimize the costs of conducting ISPEs and maximize the utility of ISPE results produced by the participants.* 

#### **ISPEs are a Routine Part of Transportation Agency Procedures**

There are two know instances, in addition to the pilot states, of the implementation of the research findings of this project. The first is the recently approved ISPE pooled fund (i.e., TPF-5(481)) that will provide a way for highway agencies to collaborate and share ISPE results. The second is an ISPE of the New England Transportation Consortium (NETC) Steel Bridge Railings which is expected to be completed and published in early 2022. (Carrigan, Plaxico et al. 2022

expected) This project is an excellent example of using an ISPE to evaluate a roadside hardware design (i.e., the NETC bridge railing) and make a decision about its MASH compliance through an ISPE rather than crash testing. Performing more ISPEs that provide good example applications of the ISPE methodology and its use for decision making will help promote the more routine use of ISPEs.

As an example, the most prevalent hardware installed in the United States is unquestionably strong-post w-beam guardrail. The in-service performance of even this common hardware is not well known at present. Conducting a multi-state ISPE of strong-post w-beam guardrail would provide a dramatically improved understanding of the limitation of the hardware as well as the situations where the hardware performance exceeds expectations. An ISPE of the existing inventory of w-beam guardrail developed under NCHRP Report 350 and the increasing inventory of w-beam guardrail developed under MASH would provide the necessary information to states to either support or refute the need to replace the existing Report 350 inventory when new construction is not proposed for a given roadway. Such an ISPE would not only provide an improved understanding of hardware performance but would also provide an example of how ISPEs can be conducted on the national level using the methodology developed under this research. Since this hardware is used nationwide, it will also provide a valuable benchmark for assessing other types of roadside hardware. *AASHTO and NCHRP are encouraged to allocate implementation funding for conducting a routine multi-state ISPE of strong-post w-beam guardrail*.

## CONCLUSIONS

"Simply stated, each member of the community has a vested interest in the performance of hardware on the roadside and each member can play a valuable role in the institutionalization of ISPEs." (Carrigan 2015) AASHTO, through the NCHRP, has provided the catalyst develop this collaborative appropriate to ISPEs through a series of recent research projects. The AASHTO TCRS and FHWA should provide the leadership to change the ultimate standard of safety evaluation from crash testing to in-service field performance evaluations.

It is not enough to create the list of outcomes shown above. Successful implementation of this research will necessitate identifying and empowering champions for each of the outcomes. Recommendations have been provided in italicized text through this implementation plan that indicate the champions and stakeholder might achieve the desired outcomes. The recommendations are summarized in Table 1.

Outcome	Recommendations	Stakeholders
ISPE results are used in decision making and policy development.	Transportation Agencies are encouraged to leverage ISPE results to support the decision to replace or maintain existing hardware.	Transportation Agencies
	Transportation Agencies are encouraged to leverage ISPE results to develop roadside design guidelines.	Transportation Agencies
	AASHTO is encouraged to leverage ISPE results to determine when changes to MASH would provide observable improvements in the field.	AASHTO
	Transportation Agencies and the FHWA are encouraged to support the funding of the proposed research titled "National Guidelines for Defining Acceptable Roadside Hardware Field Performance through In-Service Performance Evaluations (ISPEs)."	Transportation Agencies and FHWA
ISPEs are performed by trained individuals using a consistent methodology.	Transportation Agencies are encouraged to arrange for the NHI ISPE training of their employees who are responsible for conducting, reviewing, and interpreting ISPEs.	FHWA NHI and Transportation Agencies
ISPE results are shared among transportation agencies.	AASHTO and FHWA should encourage Transportation Agencies to share their ISPE results and support funding and resource allocations that facilitate sharing.	AASHTO and FHWA
	When the ISPE Pooled Fund project is active, it should include hosting and maintaining the ISPE Resource Hub in its list of activities.	Transportation Agencies and FHWA
Funding and resources	Transportation Agencies are encouraged to participate in the TPF-5(481)	Transportation Agencies
are made available for ISPEs.	pooled fund to minimize the costs of conducting ISPEs and maximize the utility of ISPE results produced by the participants.	and FHWA
ISPEs are a Routine	AASHTO and NCHRP are encouraged to allocate implementation funding for	AASHTO
Part of Transportation	conducting a routine multi-state ISPE of strong-post w-beam guardrail.	and
Agency Procedures.		NCHRP

Table 1. Summary of Outcomes, Recommendations, and Stakeholders.

## **RESEARCH NEEDS STATEMENTS**

The research needs statements previously developed using the NCHRP standard format and submitted for funding in 2022 is included here. The title of this research need is "National Guidelines for Defining Acceptable Roadside Hardware Field Performance through In-Service Performance Evaluations (ISPEs)."

## American Association of State Highway and Transportation Officials Special Committee on Research and Innovation

## FY20XX NCHRP PROBLEM STATEMENT TEMPLATE

#### **1. PROBLEM TITLE**

National Guidelines for Defining Acceptable Roadside Hardware Field Performance through In-Service Performance Evaluations (ISPEs)

### 2. BACKGROUND INFORMATION AND NEED FOR RESEARCH

One reoccurring theme in each re-writing of crash test and evaluation procedures over the last 40 years is the recommendation to conduct in-service performance evaluations (ISPEs) of roadside safety features. Michie *et al.* recommended ISPEs in the National Cooperative Highway Research Program (NCHRP) Report 230 crash test and evaluation procedures published in 1981. The importance and need for ISPEs was reiterated by Ross *et al.* in NCHRP Report 350 as well as by AASHTO in the *Manual for Assessing Safety Hardware* (MASH).

The laboratory performance of roadside safety hardware is tested and evaluated using criteria published in MASH. The site location and installation of roadside safety hardware is guided by criteria published in the AASHTO Roadside Design Guide (RDG). In-Service Performance Evaluation (ISPE) criteria has only just now become available under NCHRP Project 22-33. Guidelines are needed, at the national level, for defining acceptable field performance.

National guidelines which define acceptable field performance, for each of the evaluation criteria developed under NCHRP 22-33, will provide States with the ability to establish crashworthiness without having to conduct endless crash tests. Furthermore, the performance thresholds established by this research could be used to determine when (if) updates to MASH are necessary rather than simply updating MASH when the vehicle fleet changes.

This research is supported by the Technical Committee on Roadside Safety's (TCRS) Strategic Plan. The objective of the Strategic Plan is to "critique and improve the underlying assumptions within the RDG and MASH through the analysis of field performance and assessment of available data."

The AASHTO/FHWA joint implementation plan called for MASH testing to be required for the development of new hardware beginning January 1, 2011. As these MASH systems are placed into service, adequately planned and conducted in-service performance evaluations (ISPEs) will allow determination of field performance of roadside safety hardware. The performance thresholds established under this research will facilitate in the development of actionable conclusions for each ISPE conducted.

#### **3. LITERATURE SEARCH SUMMARY**

There are several research projects which are currently underway or were recently completed which will directly contribute to this effort in one way or another. A few of the more important projects have been highlighted here, including: TRB and FHWA pilot studies of data collection, NCHRP 22-33, and NCHRP Project 22-44. A TRB special study was completed which includes "... exploratory work in selected states" on collecting data for ISPEs. The FHWA office of Safety Research and Development recently completed a pilot data collection program which documented good practices for real-time crash data collection and interagency communication.

Past ISPE criteria for data collection and analysis were published under NHCRP Report 490. State funded ISPEs have been ongoing for more than 40 years. These various studies are too voluminous to list here. In addition to ISPEs, some states have begun developing mobile data collection apps for the purpose of asset management and/or assessing the field performance of roadside hardware. Examples of these states include Texas, Iowa, and Minnesota.

NCHRP Project 22-44, "A Transportation Agency Data Collection Practice for Use with In-Service Performance Evaluations (ISPEs)" is progressing to Phase II and is scheduled to complete on June 30, 2023. NCHRP Project 22-44 will provide nationally standardized ISPE data collection techniques. NCHRP Project 22-33 developed national ISPE evaluation criteria. NCHRP Project 22-33 has just finished a pilot test and the final report is anticipated this year. These national ISPE data collection protocol and evaluation criteria are two major steps toward realizing the long-sought goal to conducting ISPEs. The research proposed under this effort would provide the final piece for the conduct of national ISPEs to establish crashworthiness.

#### **4. RESEARCH OBJECTIVE**

The objective of this research is to develop national guidelines which define acceptable field performance thresholds for roadside hardware. Performance thresholds defining acceptable performance should be developed for each of the evaluation criteria established under the NCHRP 22-33 ISPE Guidelines Document. Guidelines for the use of ISPEs for establishing or updating existing guidelines and for establishing crashworthiness should be developed.

The following tasks are proposed:

- a. Assemble ISPEs conducted using the NCHRP 22-33 criteria;
- b. Recommend additional hardware to be evaluated using the NCHRP 22-33 criteria;
- c. Through consultation with the panel and based on a review of available data, determine which additional ISPEs should be conducted;
- d. Conduct additional ISPEs;
- e. Tabulate the results of the available and newly conducted ISPEs. Using the tabulated results, recommend national thresholds for acceptable performance which can be implemented across the states; and
- f. Develop recommendations for the use of ISPEs:
  - to establish and/or update existing guidelines on the crash testing and placement of roadside hardware.
  - to establish the crashworthiness of existing hardware such that new crash testing is not required for federal-aid eligibility.

## **5. URGENCY AND POTENTIAL BENEFITS**

**Urgency** – MASH was published in 2009. The AASHTO/FHWA joint implementation plan called for MASH testing to be required for the development of new hardware beginning January 1, 2011. Without in-service performance evaluations of roadside safety hardware it will not be possible to determine how well crash test performance translates into field performance. Making informed decisions about future crash testing requires that in-service performance evaluations be performed. National criteria which establishes acceptable field performance will provide a mechanism for agencies to assess field performance, establish crashworthiness of existing hardware, and establish federal-aid eligibility rather than continually updating to the latest crash testing standard.

**Potential Benefits** – The primary payoff is a means to better understand and more consistently evaluate the field performance of roadside hardware. This information can be used in updating existing standards and to establish the crashworthiness of roadside hardware absent of crash testing. The cost of this research is a tiny fraction of what a whole-sale technology replacement would cost if a particular device type proved unacceptable in a crash test without any knowledge of the acceptable field performance.

### 6. IMPLEMENTATION CONSIDERATIONS

This research would result in an improved understanding of the field performance of roadside hardware. A portion of the project should be dedicated to disseminating the results to interested agencies. It is anticipated that the improved guidelines would better support state DOT personnel charged with maintaining State standards. Outreach to the TRB AKD20 and AASHTO TCRS is recommended.

#### 7. RECOMMENDED RESEARCH FUNDING AND RESEARCH PERIOD

48 months and \$400,000

## REFERENCES

- Carrigan, C., C. Plaxico and E. Ray (2022 expected). In-Service Performance Evaluation of New England Transportation Consortium (NETC) Steel Bridge Railings, New England Transportation Consortium (NETC).
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