ENTERPRISE Transportation Pooled Fund Study TPF-5 (231)

Crashworthiness and Protection of ITS Field Devices

PROJECT SUMMARY REPORT

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Project Champion

Bill Legg, Washington State Department of Transportation and Jon Jackels, Minnesota Department of Transportation, were the ENTERPRISE Project Champions for this effort.

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Executive Summary

Agencies wishing to deploy ITS devices within the clear zone are responsible for ensuring that the supporting structure and ITS device are crashworthy. The ENTERPRISE Pooled Fund Program completed a research project to document available resources to assist state, provincial, and local agencies in the process of designing and deploying crashworthy devices. This report summarizes the large number of resources available from federal and state agencies. As depicted in the illustration below, a guideline was developed to support engineers and planners in finding and utilizing available resources.

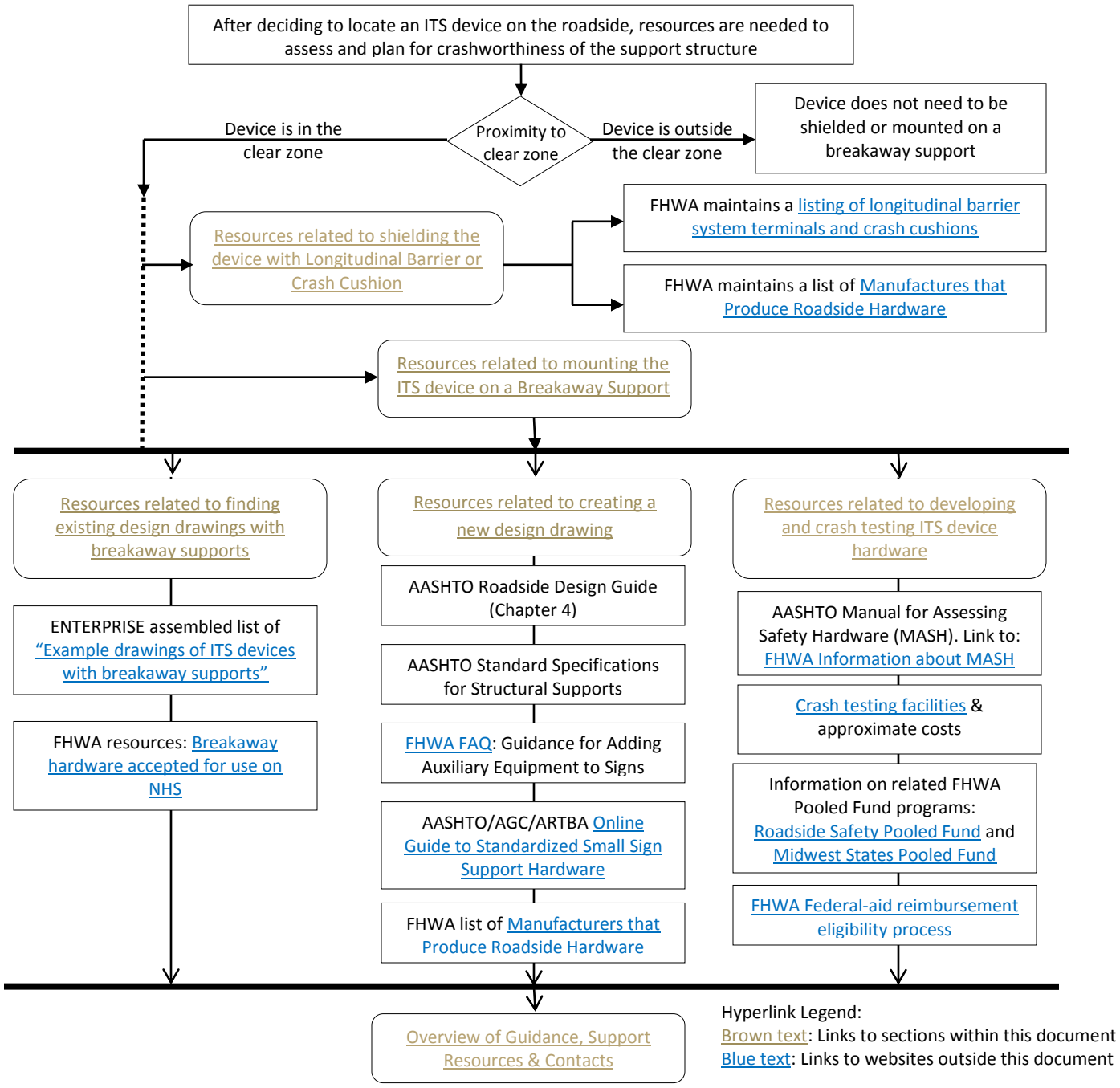

Figure ES-1: Guideline to Resources Available for Deploying Crashworthy ITS Supports

1.0 Background and Introduction

State and local transportation agencies often deploy technology solutions that are commonly referred to as Intelligent Transportation Systems (ITS). Examples of ITS deployments range from traffic management centers to on-line traveler information websites to "smart" traffic control devices to in-vehicle deployments of driver assist systems. Many ITS deployments include the deployment of a roadside device that is intended to be viewed by drivers on the road network (e.g. dynamic signs, static signs with flashing beacons, ramp meter lights). Other ITS deployments are intended to gather information from the roadside (e.g. cameras or road weather monitoring systems). With systems such as these examples, there is often the need to locate ITS devices close to the road, and therefore within the clear zone. The AASHTO Roadside Design Guide defines a clear zone as the total roadside border area, starting at the edge of the traveled way, available for safe use by errant vehicles. For devices located within the clear zone, the Manual on Uniform Traffic Control Devices (MUTCD)[1] requires these devices to be breakaway or shielded by a barrier.

For agencies wishing to deploy ITS devices within the clear zone, the engineers responsible for designing the structure to hold the ITS device(s) must ensure the supporting structure is breakaway, if the devices is not shielded by a barrier. Unlike static signs that are often the same dimensions and weights as other similar signs, the placement of ITS devices on the roadside is not always a reproducible activity. For example, one dynamic message sign might be connected to a 2'x2' solar panel while another dynamic message sign might be connected to power cables and not rely on solar. For these reasons, there are multiple parameters to consider when designing the crashworthiness of the ITS device and supporting structure.

The objective of this project was to research available documentation to help ENTERPRISE member states understand if there are existing appropriate crashworthy supports for ITS Field Devices (signs, detectors, solar panels, control cabinets, etc.), that meet federal MUTCD and American Association of State Highway Transportation Officials (AASHTO) standards and guidelines for crashworthy roadside appurtenances. This includes roadside appurtenances that have been successfully crash tested in accordance with a national standard such as the National Cooperative Highway Research Program Report 350, "Recommended Procedures for the Safety Performance Evaluation of Highway Features" or the Manual for Assisting Safety Hardware (MASH).

A secondary objective of the research was to determine if additional crashworthy supports are required to meet the needs of ITS deployments. During the course of the project, a third objective emerged. This objective was to create a summary of resources to support decision-making when designing and deploying ITS devices in the clear zone.

[1] Weblink: http://mutcd.fhwa.dot.gov/

2.0 Summary of Research

A series of five overall steps were performed to complete the project. Figure 1 illustrates these steps as well as the milestone deliverables and key decisions. The remainder of this section describes the activities performed to complete each step.

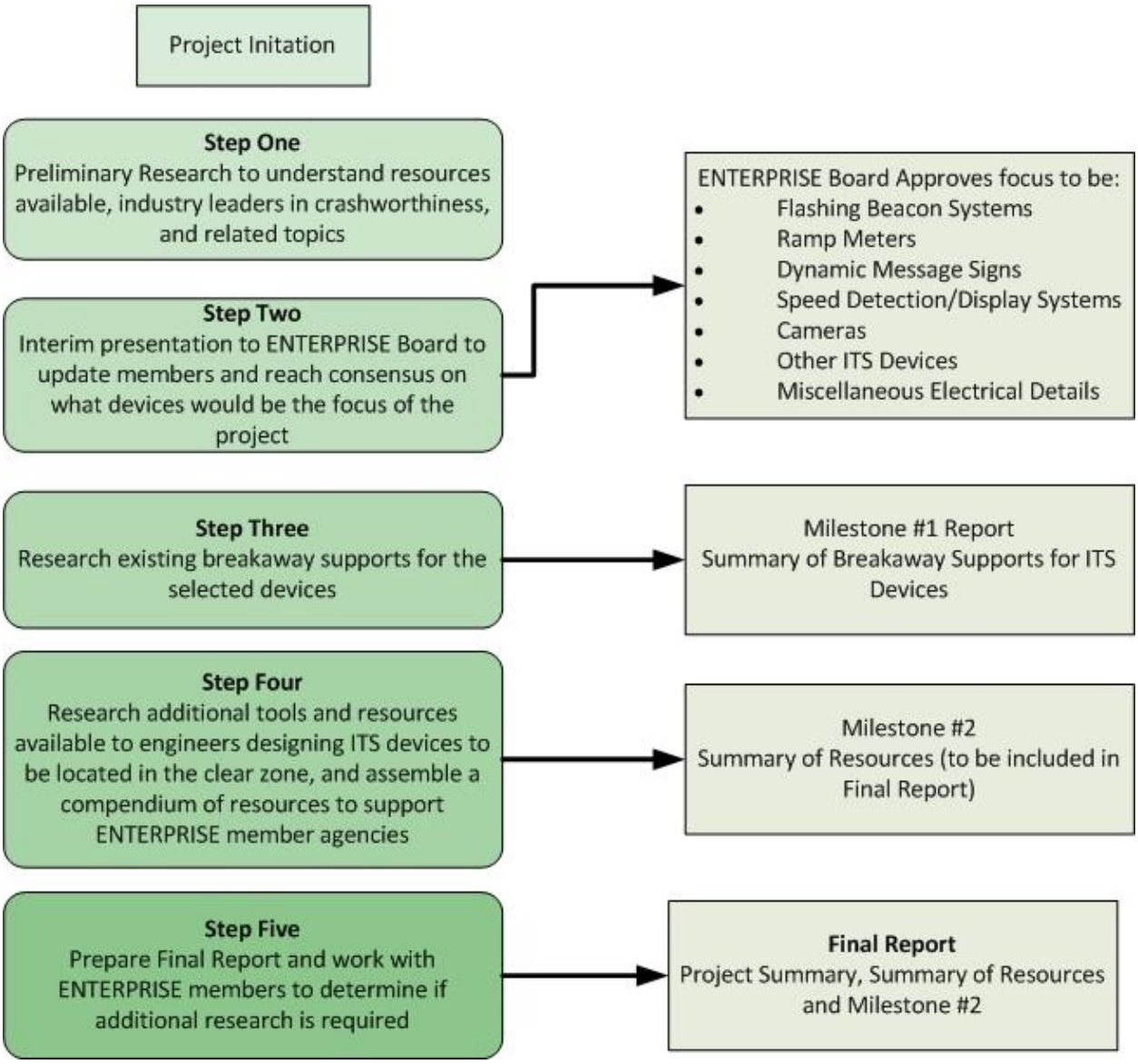

Figure 1: Summary of Project Steps, Outcomes, and Deliverables

2.1 Summary of Step One – Preliminary Research

In Step One, the project began with the contractor and project champion working together to research and explore the resource available related to crashworthiness of ITS devices. Outreach was extended to a representative from the Federal Highway Administration (FHWA) with expertise in crashworthiness of devices and structures on the roadside. Outreach was also conducted to ENTERPRISE member agencies,

who were asked to forward any design drawings for ITS devices and structures within the clear zone. Resources gathered from the various contacts were reviewed and summarized as part of Step One, and a detailed presentation was prepared to update ENTERPRISE members at the August, 2013 Board meeting.

2.2 Summary of Step Two – Interim Update & Selection of Project Focus

Step Two of the project involved sharing a detailed presentation of the early research findings to the ENTERPRISE Board in August, 2013. During this presentation, discussion was facilitated to enable Board members to select the ITS devices to be the focus of the remainder of the project. Based on the feedback received, ITS devices to be the focus of the project were categorized into the following:

- Flashing Beacon Systems
- Ramp Meters
- Dynamic Message Signs
- Speed Detection/Display Systems
- Cameras
- Other ITS Devices
- Miscellaneous Electrical Details

Note that ITS configurations such as Intersection Conflict Warning Systems (ICWS), Curve Warning Systems, and other unique ITS systems would typically fall into one of the above categories.

2.3 Summary of Step Three – ITS Devices with Breakaway Supports

Once the ITS devices were selected for the focus of this project, Step Three of the project researched and documented material summarizing crashworthy supports for ITS field devices (signs, detectors, solar panels, control cabinets, etc.) that have been successfully crash tested in accordance with NCHRP Report 350 and/or the AASHTO Manual for Assessing Safety Hardware (MASH)[2].

To accomplish Step Three, the following sources were searched (online literature searches, surveys, and email/phone communications) to determine the existence of breakaway supports for ITS devices:

- FHWA;
- ENTERPRISE member State DOTs;
- Crash Testing Facilities; and
- Selected Equipment Manufacturers.

It is important to note that the search identified design drawings for breakaway supports (e.g. breakaway posts and foundations) in addition to supports that have been successfully crash tested. For example, breakaway supports found on FHWA's web site were accompanied by documentation of successful crash testing. However, design drawings found online or collected from ENTERPRISE member

[2] The AASHTO Manual for Assessing Safety Hardware (MASH) is available for purchase from AASHTO at: https://bookstore.transportation.org/collection_detail.aspx?ID=34

DOTs were not verified as being successfully crash tested for the exact configurations shown on the drawings. This is likely because crash testing is not necessarily required to be conducted for every design configuration. Breakaway supports should be designed in accordance with the MUTCD, the AASHTO Roadside Design Guide[3] (Chapter 4), and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals[4]. As explained in FHWA's Frequently Asked Questions, devices such as lights, batteries, and solar panels may be added to breakaway signs if they meet mass, height, and other thresholds, as specified in the AASHTO Design Guidance Documents listed above.

2.3.1 FHWA Resources for Crash Tested Roadside Hardware

A search of FHWA's website was conducted, to locate ITS devices with breakaway supports. FHWA posts acceptance letters for breakaway hardware that have been successfully crash tested and accepted by the FHWA for use on the National Highway System (NHS) at the following web pages:

- Overview: Breakaway Hardware
- Luminaire Supports: Accepted Breakaway Luminaire Supports
- Sign Supports: Accepted Breakaway Sign Supports

Several ITS device configurations with breakaway supports, along with verification of successful crash testing, were discovered on the FHWA website. The ITS devices with breakaway supports found through this search, with web links to acceptance letters and design drawings, are tabulated in Appendix A.

2.3.2 Online Search and Targeted Request - ENTERPRISE State DOTs

This investigation consisted of the following:

- Online search of online design standards of ENTERPRISE State DOTs; and
- A request for information, sent to ENTERPRISE Board members, to collect design drawings for ITS configurations that have breakaway supports. This call for information was conducted to collect relevant drawings that may have been created for specific projects and therefore not included in standard plans/drawings that are utilized on a regular basis.

Several design drawings for ITS devices with breakaway supports were collected from State DOTs through this search. The ITS devices with breakaway supports found through this search, along with web links to design drawings, are tabulated in Appendix A.

The outcome of Step Three was Milestone #1: Summary of Breakaway Supports for ITS Devices, delivered December, 2013.

2.4 Summary of Step Four – Research Additional Tools and Resources

During Step Four of the project, the contractor and project champion agreed that the number of resources available to assist engineers in location ITS devices in the clear zone is large and difficult to

[3] The AASHTO Roadside Design Guide,
[4] and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals are available for purchase from AASHTO at: https://bookstore.transportation.org/collection_detail.aspx?ID=34

navigate. Therefore, rather than Milestone #2 simply consisting of a matrix comparing crash tested supports to ITS Device needs, the breadth of Milestone #2 was increased to be a resource tool that engineers and planners could use to navigate the process to mount ITS devices on breakaway supports. It was agreed that this would help ENTERPRISE member states benefit from the large number of national and state resource that already exist. It was also agreed that Milestone #2 would be included in the Project Summary Report, rather than a stand-alone document.

As part of Step Four, additional research was conducted to further understand the FHWA and AASHTO resources. Additionally, research was conducted into crash test facilities and device manufacturers, as described below.

2.4.1 Research into Crash Testing Facilities

The sources identified for this search were found on FHWA's website listing laboratories with experience in testing roadside hardware. A questionnaire requesting the following information was sent to the 11 U.S. crash testing facilities listed at this website:

- Responder name and contact information;
- Crash testing criteria used;
- Experience in testing ITS devices with breakaway supports (a list of ITS devices of interest was provided); and
- A request to provide design drawings, along with the organization requesting crash testing, for each ITS configuration that successfully met NCHRP 350 or MASH criteria.

Five crash testing facilities responded to the request. A summary of the responses is as follows:

- Four facilities indicated they did not have experience with testing breakaway ITS devices. One facility indicated that they had previously conducted crash testing on a red light camera. However, they did not provide design details for this device, citing client confidentiality.
- All five facilities indicated that they conduct crash testing per NCHRP 350 and MASH criteria.
- In addition to survey response, a representative from the Midwest Roadside Safety Facility at the University of Nebraska – Lincoln agreed to discuss their relevant experience via a phone conversation. This representative noted that their facility's most recent experience with testing breakaway supports for ITS devices was with the Minnesota DOT, on work zone devices, approximately 8-10 years ago, and she did not have design details to share.

2.4.2 Summary of Findings from Contacting Device Manufacturers

When the project was initiated, a potential approach for obtaining relevant information (e.g. design drawings for crash-tested devices) from ITS device manufacturers was to request names and contact information from the American Traffic Safety Services Association (ATSSA) and send a request to a subset of manufacturers who produce roadside devices. Per discussions with the project champion, it was determined that this approach would not likely produce relevant information, as it is common for device manufactures to provide only specifications for their device (e.g. weight, dimensions of a camera or a sign), and it is the responsibility of the agency deploying the device to design the support structure. Phone conversations with representatives with two manufacturers of dynamic message signs

(Daktronics and SES America) were consistent with this understanding. Both manufacturers indicated that only provide specifications for their actual devices and do not provide design guidance or design drawings for structural supports to which the devices are mounted.

2.5 Summary of Step Five – Preparation of Project Summary Report

As noted earlier, the overall intent of this project was to support ENTERPRISE member agencies as they navigate the process of determining the best approach for protecting ITS devices and structures deployed in the clear zone. This Project Summary Report was prepared to summarize the project and present the results. This report and the example design drawings of ITS devices with breakaway supports are available on the ENTERPRISE Crashworthiness Project Web Page[5].

A summary of the project and its results were presented at the February 2014 ENTERPRISE Board meeting. ENTERPRISE Board members were asked whether there was a need/role for an additional future ENTERPRISE project related to crashworthiness of ITS devices (e.g. one example of a candidate of a future project might involve collaboration with one or more crash testing facilities to test some frequently used combinations of ITS devices that all members might benefit from). Feedback from Board members indicated that the final products (online links to ITS device drawings and the summary of resources) will serve as helpful tools for designers, and that additional projects on this topic were not needed at this time.

[5] Weblink: http://www.enterprise.prog.org/Projects/2010_Present/crashworthiness.html

3.0 Project Findings

3.1 Summary of Findings - Available Resources for Crashworthiness

This section provides an overview of potential steps and resources to help guide decision-making when deploying crashworthy ITS devices in the roadway clear zone. For the purposes of the steps listed in this section, it is assumed that ITS devices of interest are mounted on structural supports with a sign or luminaire "base configuration." For example, an intersection conflict warning system (ICWS) alert sign may be comprised of a sign, a beacon, and a solar panel mounted on a sign post. In this example, the "base configuration" of the ICWS alert sign is the sign and post support, with the beacon and solar panel mounted on the sign/post system as auxiliary equipment.

Figure 2 illustrates an overview of the major steps an agency may take to help guide decision-making when deploying ITS devices in the roadway clear zone. In the sub-sections that follow, relevant resources within each major step are provided.

The Manual on Uniform Traffic Control Devices (MUTCD) states that "Ground-mounted sign supports shall be breakaway, yielding, or shielded with a longitudinal barrier or crash cushion if within the clear zone." Therefore, two options exist:

1) Option #1 - Shield the ITS device with a longitudinal barrier or crash cushion; or
2) Option #2 - Mount the ITS device on a breakaway support.

Section 3.2 provides resources for shielding ITS devices with longitudinal barriers or crash cushions.

Section 3.3 outlines options for mounting ITS devices on breakaway supports. Note that Chapter 4 of the AASHTO Roadside Design Guide states that "The term breakaway support refers to all types of sign, luminaire, and traffic signal supports that are designed to yield, fracture, or separate when impacted by a vehicle. The release mechanism may be a slip plane, plastic hinge, fracture elements, or a combination of them." Therefore, for the purposes of this section, all types of breakaway supports, including yielding and base-bending types, will be referred to as "breakaway supports."

Section 3.4 provides a summary of general resources and contact information for information regarding breakaway supports.

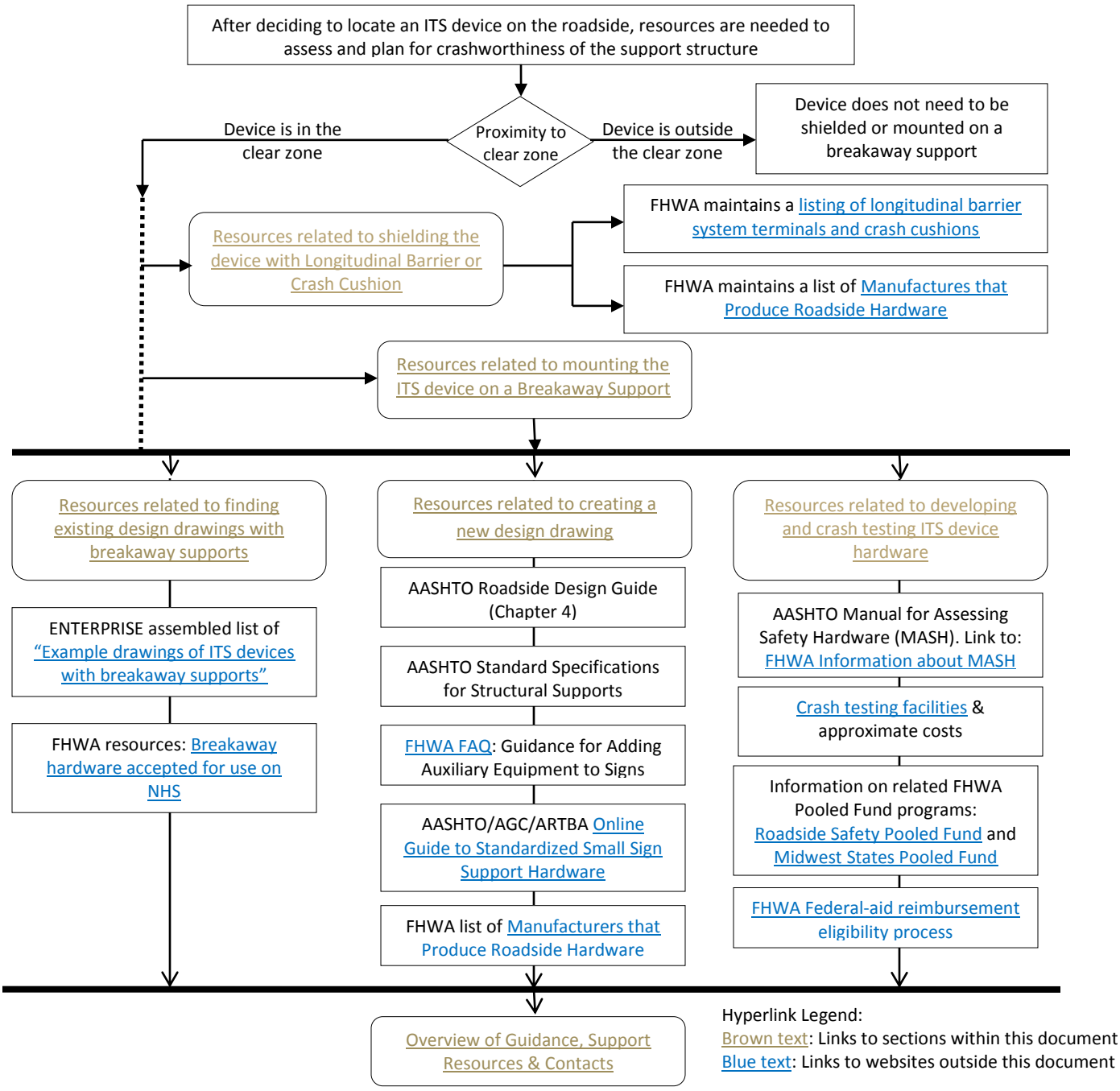

Figure 2: Major Steps to Guide Decision-Making when Installing ITS Devices in the Clear Zone

3.2 Resources Related to Shielding Devices within the Clear Zone

One approach to protecting the ITS device and supporting structure is to shield the device with a longitudinal barrier or a crash cushion. The resources summarized in Table 1 provide online mechanisms to assist agencies with selecting these shielding devices.

Table 1: Summary of Resources Related to Shielding ITS Devices

Longitudinal Barriers and Crash Cushions	
FHWA Acceptance Letters for Longitudinal Barriers and Crash Cushions	FHWA maintains a listing of longitudinal barrier system terminals and crash cushions[6] that have been crash tested and/or determined to meet the criteria of NCHRP Report 350 or the AASHTO Manual for Assessing Safety Hardware.
Manufacturers	FHWA maintains a list of Manufacturers that Produce Roadside Hardware[7] on its website. This list includes manufacturers of sign and/or luminaire supports as well as those who produce protection devices such as barriers, crash cushions, and attenuators.

3.3 Resources Related to Installing Breakaway Supports in the Clear Zone

Agencies that choose not to shield the ITS device with a longitudinal barrier or crash cushion would typically pursue options for mounting the ITS device on a breakaway support. This section describes the three optional 'tracks' of resources that could be investigated and pursued to select the best option for the local deployment, as illustrated in Figure 2:

- 'Track 1' – Search existing design drawings for ITS devices with breakaway supports;
- 'Track 2' – Create a new design drawing; and
- 'Track 3' – Develop and test the ITS hardware configuration.

The remainder of this section provides an overview of each 'track', together with the resources and references available to support each activity.

When considering which "Track" to pursue, a resource that may help guide initial decision-making can be found in the Frequently Asked Question (FAQ) section of FHWA's Roadside Hardware Policy and Guidance website.[8] This FAQ directly pertains to ITS devices, as it asks whether adding auxiliary equipment, such as lights, batteries, solar panels to signs, requires crash testing for the combined configuration. The resource indicates that "The addition of flashing lights and solar panels or other auxiliary equipment will not likely affect the change in velocity experienced by the vehicle…unless it becomes substantial compared to the mass of the pole. Additional equipment must be mounted at or above sign height (at least 7 ft. above support). The overall mass of the pole, sign, and auxiliary equipment should not exceed 600 pounds." As described in the FAQ, this guidance applies only to breakaway features that are slip base, frangible coupling system, or a cast aluminum transformer base. Base bending or yielding systems such as u-channel posts, perforated square steel tube posts, or

[6] Web Link: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/barriers/term_cush.cfm
[7] Web Link: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/manufacturers/
[8] Web Link: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/qa_bsls.cfm#q6

composite posts require full scale crash testing. The *AASHTO Roadside Design Guide* should be referenced for specific guidance related to adding auxiliary equipment to sign or luminaire supports.

3.3.1 Track 1: Search Existing Design Drawings for Breakaway Supports

Step Three of this project conducted a search for design drawings for ITS devices with breakaway supports. In addition to searching FHWA's web site for breakaway supports accepted for use on the National Highway System, a request was made to ENTERPRISE member agencies to share any available design drawings for breakaway supports used to mount ITS devices. Design drawings for the following categories of ITS devices with breakaway supports were collected:

- Flashing Beacon Systems
- Ramp Meters
- Dynamic Message Signs
- Speed Detection/Display Systems
- Cameras
- Other ITS Devices
- Miscellaneous Electrical Details

The online resources listed in Table 2 can be searched in order to locate example design drawings for specific ITS devices of interest. In addition to the links to example drawings provided on the ENTERPRISE web page, FHWA continues to post documentation of crash-tested devices on their website.

Table 2: Summary of Resources for Existing Design Drawings for ITS Devices with Breakaway Supports

Existing Design Drawings for ITS Devices with Breakaway Supports	
ENTERPRISE "Example Drawings of ITS Devices with Breakaway Supports"	The ENTERPRISE Example Drawings for ITS Devices with Breakaway Supports[9] web page provides links to example design drawings from ENTERPRISE State DOTs and FHWA.
FHWA: Breakaway Hardware Accepted for Use on the National Highway System	Acceptance letters for breakaway hardware that has been successfully crash tested and accepted by the FHWA for use on the National Highway System (NHS) can be accessed at the following FHWA web pages: • Overview: Breakaway Hardware[10] • Luminaire Supports: Accepted Breakaway Luminaire Supports[11] • Sign Supports: Accepted Breakaway Sign Supports[12] Acceptance letters typically include design details showing dimensions/weights of signs and other equipment mounted to hardware, post details, and foundation type.

[9] Weblink: http://www.enterprise.prog.org/Projects/2010_Present/crashworthy/example_drawings.html
[10] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/breakaway/
[11] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/listing.cfm?code=lumin
[12] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/listing.cfm?code=signs

3.3.2 Track 2: Create a New Design Drawing

If the specific ITS device configuration of interest is not found by searching existing design drawings, it may be necessary to create a new design. The process of creating a new design drawing typically requires a structural analysis to determine loadings on the support, based on the signs and other equipment mounted to the support. This process also typically includes selecting a manufactured breakaway support. ***With this approach, is recommended that structural engineers and/or signing experts within an agency be consulted for assistance when creating a new design drawing.***

The design guidance resources in Table 3 include relevant specifications used when creating a new design with a breakaway support. Table 4 provides online resources to assist with selection of appropriate manufactured breakaway supports, based on requirements as determined through a formal design process conducted using relevant design specifications.

Table 3: Breakaway Support Design Guidance Resources

Design Guidance	
AASHTO Roadside Design Guide	The AASHTO Roadside Design Guide (Chapter 4) provides engineering guidance for placement of sign/luminaire/traffic signal supports, breakaway supports, and protection of such devices. This publication is available for purchase from AASHTO. State DOTs often own copies of AASHTO publications.
AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals	This publication provides structural design guidance, including design loads (e.g. wind/ice, dead load) and criteria for determining acceptable breakaway performance, for sign and/or luminaire supports. This publication is available for purchase from AASHTO. State DOTs often own copies of AASHTO publications.
FHWA FAQ: Guidance for Adding Auxiliary Equipment to Signs	This FHWA Frequently Asked Question (FAQ)[13] asks if adding auxiliary equipment, such as lights, batteries, solar panels to signs, requires crash testing for the combined configuration. This resource indicates that: • "The addition of flashing lights and solar panels or other auxiliary equipment will not likely affect the change in velocity experienced by the vehicle…unless it becomes substantial compared to the mass of the pole." Additional equipment must be mounted at or above sign height (at least 7 ft. above support). The overall mass of the pole, sign, and auxiliary equipment should not exceed 600 pounds. • This guidance applies only to breakaway features that are slip base, frangible coupling system, or a cast aluminum transformer base. Base bending or yielding systems such as u-channel posts, perforated square steel tube posts, or composite posts require full scale crash testing. Reference the AASHTO Roadside Design Guide for specific guidance related to adding auxiliary equipment to sign or luminaire supports.

[13] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/qa_bsls.cfm#q6

Table 4: Resources for Locating Manufactured Breakaway Supports

Manufactured Breakaway Supports	
AASHTO/AGC/ARTBA Online Guide To Standardized Small Sign Support Hardware	The AASHTO/AGC/ARTBA Joint Committee Task Force 13 has developed an Online Guide to Standardized Hardware.[14] This resource serves as a content management system for standardized small sign supports and luminaire supports. The resource organizes supports by type, provides links to FHWA acceptance letters, and provides manufacturer information. • Small Sign Supports[15] • Luminaire Supports[16]
Manufacturers	FHWA maintains a list of Manufacturers that Produce Roadside Hardware[17] on its website. This list includes manufacturers of sign and/or luminaire supports as well as those who produce protection devices such as barriers, crash cushions, and attenuators.

3.3.3 Track 3: Develop & Crash Test the ITS Device Hardware Configuration

If an appropriate design cannot be achieved by selecting a manufactured breakaway support using design guidance resources and an existing manufactured breakaway support, it may be necessary to develop a new hardware configuration and initiate crash testing. This scenario may be required if the ITS device for a particular configuration does not meet the requirements of the applicable specifications. For example, the mass of the device(s) and/or mounting heights do not meet the stated thresholds for adding auxiliary equipment to a previously crash-tested sign/support configuration.

If a new hardware configuration is needed, agencies could choose to work with a crash testing facility to initiate development and testing. This could involve structural design and computer simulation to optimize and refine the design, full-scale crash testing, and submittal of testing results to the FHWA through its "Federal-aid Reimbursement Eligibility Process."

Table 5 summarizes resources developing and crash-testing new roadside hardware configurations with breakaway supports.

[14] Weblink: http://guides.roadsafellc.com/
[15] Weblink: http://guides.roadsafellc.com/signGuide/index.php?action=home
[16] Weblink: http://guides.roadsafellc.com/luminaireGuide/index.php?action=home
[17] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/manufacturers/

Table 5: Resources for Developing and Testing New Roadside Hardware with Breakaway Supports

New Hardware Configurations: Development and Crash Testing	
AASHTO Manual for Assessing Safety Hardware (MASH)	MASH presents uniform guidelines for crash testing permanent and temporary highway safety features and recommends evaluation criteria to assess test results. It updates and replaces NCHRP Report 350[18] as the state of practice for crash testing of roadside hardware. • According to FHWA Information about MASH:[19] "Any new or revised highway safety hardware under development as of October 15, 2009, when the MASH was published, may continue to be tested using the criteria in NCHRP Report 350. However, FHWA will not accept or review requests for new or revised highway safety hardware tested using NCHRP 350 criteria which are received after January 1, 2011. The AASHTO / FHWA MASH Implementation Plan states that all highway safety hardware accepted prior to adoption of MASH using criteria contained in NCHRP Report 350 may remain in place and may continue to be manufactured and installed. Hardware tested under MASH should be considered for use within your State as it becomes available, but there is no requirement to replace hardware that has been accepted under Report 350." • MASH is available for purchase from AASHTO. State DOTs often own copies of AASHTO publications.
Crash Testing Facilities & Approximate Cost of Crash Testing	• FHWA's website includes a list of certified Laboratories with Experience Testing Roadside Safety Hardware,[20] which can be used to find a facility to conduct crash tests on roadside hardware with breakaway supports. • According to the FHWA Federal-aid Reimbursement Eligibility Process web page,[21] "As the full development of roadside safety hardware may require eight or more full-scale crash tests (at approximately $50,000 each), a developer may use computer simulation during hardware development/refinement to optimize the design in order to minimize the expense of crash testing."

[18] Weblink: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_350-a.pdf
[19] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/ctrmeasures/mash/
[20] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/laboratories/
[21] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/acceptprocess/#s2

New Hardware Configurations: Development and Crash Testing	
FHWA Pooled Fund Programs	Two FHWA pooled fund programs specialize in pooling resources to design and test roadside hardware configurations of interest to multiple agencies: • The Roadside Safety Pooled Fund[22] conducts design, analysis, testing, and evaluation of crashworthy structures. The work of this pooled fund is primarily conducted at the Texas A&M Transportation Institute.[23] • The Midwest States Pooled Fund[24] specializes in designing and testing roadside hardware configurations of interest to member agencies. The work of this program is primarily conducted at the Midwest Roadside Safety Facility[25] at the University of Nebraska-Lincoln.
FHWA Federal-aid Reimbursement Eligibility Process	After crash testing is complete and certified as meeting the appropriate evaluation criteria, documentation is submitted to the FHWA Office of Safety for review, to determine eligibility for reimbursement under the Federal-aid highway program. FHWA's Federal-aid Reimbursement Eligibility Process[26] outlines requirements for this process. This process replaces FHWA's "acceptance of roadside hardware for use on the National Highway System."

[22] Weblink: http://www.roadsidepooledfund.org/
[23] Weblink: http://tti.tamu.edu/group/crashtesting/research-areas/#area1
[24] Weblink: http://mwrsf-qa.unl.edu/
[25] Weblink: http://mwrsf.unl.edu/
[26] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/acceptprocess/

3.4 Overview of Guidance and Support Resources

The FHWA Office of Safety offers significant resources on requirements for and design of roadside hardware installed in the roadway clear zone. These resources, which include web pages focused on roadside hardware policy/guidance and a contact person with relevant experience, provide an excellent starting point for becoming familiar with the requirements of deploying roadside hardware such as ITS devices mounted on sign or luminaire supports. These resources are listed in Table 6.

Table 6: Summary of Guidance and Support References

Guidance and Support Resources	
FHWA's "Roadside Hardware Policy and Guidance" website	The FHWA Office of Safety maintains several resources on its website: • Roadside Hardware Policy and Guidance[27] • FAQs on Breakaway Sign and Luminaire Supports[28] • Breakaway Features for Sign Supports, Utility Poles and Other Roadside Features[29]
FHWA Office of Safety Contact	FHWA's Office of Safety contact for the use of and requirements for signs/luminaires with breakaway supports: Nicholas Artimovich FHWA Office of Safety, Roadway Departure Team nick.artimovich@dot.gov 202-366-1331

[27] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/
[28] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/qa_bsls.cfm
[29] Weblink: http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/ctrmeasures/breakaway/

4.0 Conclusions

This project produced a number of resources that agencies can use to help navigate and guide decision making for assessing crashworthiness and deploying ITS devices in the roadway clear zone. Several design drawings for specific ITS device configurations with breakaway supports were located and summarized for easy reference by ENTERPRISE members. In addition, a summary of options and relevant resources for shielding or installing ITS devices in the clear zone was compiled. These options and resources are predominately structured around design principles contained in AASHTO specification and guidance provided by the FHWA.

A summary of the project and its results were presented at the February 2014 ENTERPRISE Board meeting. ENTERPRISE Board members were asked whether there was a need/role for an additional future ENTERPRISE project related to crashworthiness of ITS devices (e.g. one example of a candidate of a future project might involve collaboration with one or more crash testing facilities to test some frequently used combinations of ITS devices that all members might benefit from). Feedback from Board members indicated that the final products (online links to ITS device drawings and the summary of resources) will serve as helpful tools for designers, and that additional projects on this topic were not needed at this time.

Appendix A: Example Design Drawings for ITS Devices with Breakaway Supports

During this project, a number of design drawings for breakaway supports were researched and identified. A summary of these design configurations, along with example drawings collected via this search, is included in Tables A1-A7. All example drawings can also be found at the ENTERPRISE Crashworthiness Project Website[30].

Table A1: Example Design Drawings for Flashing Beacon Systems with Breakaway Supports

State/Agency	Design Detail	Source	Breakaway Support
Georgia	Flashing School Assembly – Post Mounted (TS-12B)	Georgia DOT Construction Standards	Aluminum Pole with Pedestal Base (Footing Foundation)
Michigan	Sign Mounted Beacon	Michigan DOT Standards and Special Details	Perforated Steel Square Tube Posts (Ground-Driven)
	Rectangular Rapid Flashing Beacon (Pedestrian Crossing)		Aluminum Pole with Frangible Square Aluminum Base (Footing Foundation)
Minnesota	Advance Warning Flasher Design	MnDOT Traffic Engineering Signal Plans	Pedestal Pole with Breakaway Pedestal Base (Footing Foundation)
Washington	Flashing Beacon Type 1 Signal • Flashing Beacon Type 1 Signal Standard Details • Electrical Details • Foundation Details (slip-base) • See WS DOT Standard Plans for related standard details	Washington State DOT Standard Plans	Tapered Steel Shaft with Slip Base (Footing Foundation)
Texas	Roadside Flashing Beacon Assembly	Texas DOT Traffic Standards	Aluminum Pole with Pedestal Base (Footing Foundation)
	Solar Powered Roadside Flashing Beacon Assembly		Aluminum Pole with Pedestal Base (Footing Foundation)

[30] Weblink: http://www.enterprise.prog.org/Projects/2010_Present/crashworthy/example_drawings.html

State/Agency	Design Detail	Source	Breakaway Support
FHWA	Flashing Light Warning Apparatus FHWA SS-112 Acceptance Letter	Breakaway Hardware Accepted for Use on the National Highway System	Aluminum Pole with Cast Aluminum Breakaway Transformer Base (Footing Foundation) OR U-Channel Steel Posts with Lap Splice Breakaway System (Ground-Driven)
	School Zone Flashing Beacon System SS-161 Acceptance Letter		Galvanized Steel Pole with Pelco 5300 Series Breakaway Base *(Foundation type not shown)*

Table A2: Example Design Drawings for Ramp Meter Systems with Breakaway Supports

State/Agency	Design Detail	Source	Breakaway Support
Georgia	Ramp Meter Signal Support Structures Detail (ITS-54)	Georgia DOT Construction Standards	Aluminum Pole with Pedestal Base (Footing Foundation)
Minnesota	Ramp Meter (one way) Detail with Standard Plate 8122F Pedestal and Pedestal Base (for Traffic Control Signals Support)	MnDOT ITS Project Management Design Manual and MnDOT Standard Plans	Aluminum Pole with Pedestal Base (Footing Foundation)
Washington	Ramp Meter Signal: Ramp Meter Standard Details Ramp Meter Electrical Details Foundation Details (slip-base) See WS DOT Standard Plans for related standard details	Washington State DOT Standard Plans	Tapered Steel Shaft with Slip Base (Footing Foundation)

Table A3: Example Design Drawings for Dynamic Message Signs (DMS) with Breakaway Supports

State	Design Detail	Source	Breakaway Support
Michigan	LED Changeable Message "Open-Closed" Sign	Michigan DOT Standards and Special Details	Steel I-Beam Posts with Slip Base (Footing Foundation)
Pennsylvania	Post-Mounted Dynamic Message Signs	Publication 647 – Civil and Structural Standard Drawings for ITS	Steel Posts – Post Selection Tables Provided on Plan Sheets (Footing Foundation)

Table A4: Example Design Drawings for Speed Detection/ Display Systems with Breakaway Supports

State	Design Detail	Source	Breakaway Support
FHWA	Radar Speed Display on a Slip Base Support SS-135 Acceptance Letter	Breakaway Hardware Accepted for Use on the National Highway System	4" Diameter Pole with Generic Four-Bolt Slip Base or Comparable Base using Crashworthy Frangible Couplings (Ground-Driven base shown)
	IDC Speed Check Radar Speed Display Devices FHWA SS-163 Acceptance Letter	Breakaway Hardware Accepted for Use on the National Highway System	Aluminum Pole with Pedestal Base *(Foundation type not shown)*

Table A5: Example Design Drawings for Cameras with Breakaway Supports

State	Design Detail	Source	Breakaway Support
FHWA	Red Light Camera Mounted on Pelco Pole FHWA SS-158 Acceptance Letter	Breakaway Hardware Accepted for Use on the National Highway System	Pelco GS-11 Aluminum Pole and Base (Footing Foundation)

Table A6: Example Design Drawings for Other ITS Devices with Breakaway Supports

State	Design Detail	Source	Breakaway Support
Idaho	Non-Invasive Pavement Sensor Pole & Foundation Detail I-7-C	Robert Koberlein Robert.Koeberlein@itd.idaho.gov	Steel Pole with Slip Base (Footing Foundation)

Table A7: Example Design Drawings for Electrical Details used with Breakaway Supports

State	Design Detail	Source	Breakaway Support
Idaho	Dynamic Message Signs Breakaway Electrical Details	Robert Koberlein Robert.Koeberlein@itd.idaho.gov	N/A
Pennsylvania	Highway Advisory Radio System Electrical Details	Publication 647 Civil and Structural Standard Drawings for ITS	N/A