AASHTO
AASHTO INNOVATION INITIATIVE

AASHTO Innovation Initiative

[Proposed] Nomination of Innovation Ready for Implementation

Sponsor

Nominations must be submitted by an AASHTO member DOT willing to help promote the innovation. If selected, the sponsoring DOT will be asked to promote the innovation to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative.

1. Sponsoring DOT (State): Delaware

2. Name and Title: Peter Haag, Chief of Traffic Engineering

Organization: Delaware DOT

Street Address: 169 Brick Store Landing Road

City: Smyrna

State: DE

Zip Code: 19977

Email: peter.haag@delaware.gov

Phone: 302-659-4084

Fax: Click or tap here to enter text.

Innovation Description (10 points)

The term "innovation" may include processes, products, techniques, procedures, and practices.

3. Name of the innovation:

All-Way Stop Control (AWSC) at Low-Volume Unsignalized Intersections

4. Please describe the innovation.

From 2015 through 2019 nearly 40 percent of fatalities and serious injuries in Delaware occurred at an intersection. Of those, 51% occurred at unsignalized intersections, including many at low-volume

intersections. Some of those locations have such low volumes that, despite experiencing fatal or injury crashes, they do not meet the minimum crash thresholds currently outlined in the 2009 edition of the Manual of Uniform Traffic Control Devices (MUTCD) for All-Way Stop Control (AWSC) implementation. In support of Delaware's objective to reduce intersection fatalities and serious injuries by 15% over the next five years, DelDOT studied the potential benefits of installing All-Way Stop Control (AWSC) at low-volume intersections (AADTs less than approximately 7,500 vehicles per day on the major road) to determine if the use of reduced crash thresholds for AWSC conversion could improve safety. Specifically, DelDOT implemented AWSC at 25 low-volume intersections across the state as a potential safety countermeasure between 2017 and 2021. Locations included 13 intersections that met the 2009 MUTCD crash warrant threshold for AWSC, and 12 that did not, which were implemented based on engineering judgement, consistent with Delaware's Strategic Highway Safety Plan. Three years of "before" crash data and between one and three years of "after" crash data were obtained for each intersection. On average, the annual reduction in crashes after conversion to AWSC were as follows: 57% reduction in total crashes, 66% reduction in angle crashes, 82% reduction in injury crashes, and 100% reduction in fatal crashes.

Traffic control devices needed to implement AWSC are low cost, minimally invasive, and can be installed quickly. Improvements typically consist of new stop signs, advance warning signs, plaques, solar powered beacons, stop lines, and in-lane pavement markings that read STOP AHEAD and STOP. Depending on the location, either portable digital message boards or static temporary traffic control signs are installed at least one week in advance to warn motorists of the upcoming traffic pattern change. Construction can typically be completed in a single day.

5. What is the existing baseline practice that the innovation intends to replace/improve?

The existing baseline practice is using the guidance in Section 2B.07 of the 2009 edition of the MUTCD (adopted in the 2011 edition of the Delaware MUTCD) to evaluate AWSC as a potential intersection safety improvement. The crash history listed in Section 2B.07, paragraph 4, item B, includes the threshold of "five or more reported crashes in a 12-month period that are susceptible to correction by a multi-way stop installation."

6. What problems associated with the baseline practice does the innovation propose to solve?

For many low-volume intersections with volumes less than approximately 7,500 vehicles per day on the major street, AWSC would be a potential low-cost option to reduce the number of fatal and injury crashes; however, many of these locations do not meet the volume or crash thresholds in Section 2B.07 of the 2009 MUTCD. A strict adherence to the criteria outlined in the 2009 MUTCD would serve as a barrier for improvement at those locations where no other safety treatments were identified due to costs, environmental impacts, or other constraints.

7. Briefly describe the history of its development.

Similar to the criteria for Warrant 7, Crash Experience, contained in Section 2C.08 for traffic signal control studies, the threshold of five or more crashes in a 12-month period has been in use for AWSC

evaluations for a long time. However, the original basis for this threshold is unknown. In 2017, FHWA issued Interim Approval for Optional Use of an Alternative Signal Warrant 7 – Crash Experience (IA-19). The interim approval allows the use of new research-based thresholds that consider both the three-year and one-year crash history, the area type (urban or rural), the number of lanes on each approach, and the number of legs at the intersection in signal warrant analyses. Noting the similarities between the MUTCD crash warrants for both traffic signals and AWSC, DelDOT used the reduced thresholds in IA-19 to identify low-volume intersections in Delaware that could potentially benefit from AWSC being used as a safety countermeasure. DelDOT implemented AWSC at 25 low-volume intersections, 13 of which satisfied the AWSC crash warrant in the 2009 MUTCD (five or more crashes that are susceptible to correction in a 12-month period); while the other 12 intersections did not. Six of these 12 intersections met the reduced crash warrants in IA-19. DelDOT then performed before/after crash analyses at each location and estimated crash modification factors (CMFs) using the empirical Bayes method. The resulting CMFs and 95% confidence intervals indicate that AWSC implementation at low-volume intersections is expected to result in 28% fewer total crashes and 50% fewer fatal and injury crashes. Similar levels of crash reductions were observed at the locations that met the 2009 MUTCD AWSC crash warrants and those that did not. DelDOT monitors the crash trends at low-volume intersections that are converted to AWSC and updates the CMFs annually using the most recent available crash data.

8. What resources—such as technical specifications, training materials, and user guides—have you developed to assist with the deployment effort? If appropriate, please attach or provide weblinks to reports, videos, photographs, diagrams, or other images illustrating the appearance or functionality of the innovation (if electronic, please provide a separate file). Please list your attachments or weblinks here.

The most recent memorandum summarizing crash trends at new AWSC intersections in Delaware is available on the DelDOT website here: https://deldot.gov/Programs/DSHSP/pdfs/Emphasis-Areas/intersections/AWSC%20Research%20Memo%20with%20Appendices.pdf?cache=1694621133658

Attach photographs, diagrams, or other images here. If images are of larger resolution size, please provide as separate files.

State of Development (40 points)

Innovations must be successfully deployed in at least one State DOT. The AII selection process will favor innovations that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use.

9. How ready is this innovation for implementation in an operational environment? Please select from the following options. Please describe.

☐ Prototype is fully functional and yet to be piloted

☐ Prototype has been piloted successfully in an operational environment

☒ Technology has been deployed multiple times in an operational environment

☐ Technology is ready for full-scale implementation

In addition to the 25 low-volume intersections that were converted to AWSC between 2017 and 2021 for the most recent before-and-after study, DelDOT has implemented AWSC at 18 additional low-volume intersections in 2022 and 2023. AWSC has also been approved for 11 more intersections, which are scheduled for installation in late 2023 or early 2024. Crash trends at all new low-volume AWSC intersections continue to be evaluated on an annual basis.

10. What additional development is necessary to enable implementation of the innovation for routine use?

There is no additional development necessary to enable implementation of AWSC at low-volume intersections. Traffic control devices needed to implement AWSC (signs and, in some cases, pavement markings and solar powered beacons) are low cost, minimally invasive, and can be installed quickly. Construction can typically be completed in a single day. Consistent and proper installations will make this treatment more common and further increase safety.

11. Are other organizations using, currently developing, or have they shown interest in this innovation or of similar technology?? ☐ Yes ☒ No

If so, please list organization names and contacts. Please identify the source of this information.

Organization	Name	Phone	Email
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.
Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.	Click or tap here to enter text.

Potential Payoff (30 points)

Payoff is defined as the combination of broad applicability and significant benefit or advantage over baseline practice .

12. How does the innovation meet customer or stakeholder needs in your State DOT or other organizations that have used it?

The installation of AWSC at low-volume, unsignalized intersections meets customer and stakeholder needs in Delaware in terms of both safety performance and cost. At the 25 low-volume intersections where AWSC was implemented and evaluated between 2017 and 2021, there were 57% fewer total crashes, 66% fewer angle crashes, 82% fewer injury crashes, and 100% fewer fatal crashes after implementation, on average. CMFs and 95% confidence intervals indicate that AWSC implementation at low-volume intersections is expected to result in 28% fewer total crashes and 50% fewer fatal and injury crashes compared to no treatment, even if the 2009 MUTCD volume and crash thresholds for AWSC are not satisfied. The conversion of low-volume intersections to AWSC is a safety improvement that can be implemented cost-effectively. For the 25 intersections evaluated, improvements typically consisted of new stop signs, advance warning signs, plaques, solar powered beacons, stop lines, and in-lane pavement markings that read STOP AHEAD and STOP. The implementation cost for these improvements is typically between $20,000 and $25,000 per intersection. The annual crash cost savings before-and-after AWSC implementation ranged from approximately $18,000 to over $1.2 million, with an average crash cost savings of approximately $330,000 per intersection per year (in 2021 dollars).

13. Identify the top three benefit types your DOT has realized from using this innovation. Describe the type and scale of benefits of using this innovation over baseline practice. Provide additional information, if available, using quantitative metrics, to describe the benefits.

Benefit Types	Please describe:
Improved Safety	Of the 25 low-volume unsignalized intersections converted and studied between 2017 and 2021, the reductions in annual crashes after conversion to AWSC were as follows: • Total crashes were reduced by 57% • Angle crashes were reduced by 66% • Injury crashes were reduced by 82% • Fatal crashes were reduced by 100%
Improved Customer Service	DelDOT receives numerous requests from citizens and legislators each year to address safety concerns at unsignalized intersections. AWSC can be implemented both quickly and cost-effectively, while alternative

	improvements could take several years or even decades to plan, fund, design, and construct. By implementing AWSC at low-volume, unsignalized intersections, DelDOT is able to both evaluate and implement improvements to address stakeholder concerns in a timely fashion, often in a single construction season.
Cost Savings	The implementation cost for AWSC is typically between $20,000 and $25,000 per intersection and includes stop signs, advance warning signs, plaques, solar powered beacons, stop lines, and in-lane pavement markings that read STOP AHEAD and STOP. In most locations, alternative improvements would be much more likely to impact ROW, drainage, and utilities, resulting in higher costs for planning, design, and construction. The crash cost savings is approximately $330,000 per intersection per year, on average (in 2021 dollars).

Provide any additional description, if necessary:

Click or tap here to enter text.

14 How broadly might this innovation be deployed for other applications. In the transportation industry (including other disciplines of a DOT, other transportation modes, and private industry)?

This treatment can be immediately implemented at low-volume intersections by other transportation agencies, both at the state DOT level and at the local level. DelDOT provides the most recent available crash trends at new low-volume AWSC locations on their website and is actively disseminating the results in a variety of forums, such as at regional ITE events.

Market Readiness (20 points)

The AII selection process will favor innovations that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential.

15. What specific actions would another organization need to take along each of the following dimensions to adopt this innovation?

Check boxes that apply	Dimensions	Please describe:
☐	Gaining executive leadership support	Click or tap here to enter text.
☐	Communicating benefits	Click or tap here to enter text.
☐	Overcoming funding constraints	Click or tap here to enter text.
☐	Acquiring in-house capabilities	Click or tap here to enter text.
☐	Addressing legal issues (if applicable) (e.g., liability and intellectual property)	Click or tap here to enter text.
☒	Resolving conflicts with existing national/state regulations and standards	The 2009 MUTCD guidance in Section 2B.07 indicates a threshold of five or more crashes susceptible to correction in a 12-month period. The 2017 FHWA Interim Approval for the Optional Use of an Alternative Warrant 7 – Crash Experience (IA-19) has currently only been approved as it applies to signal warrant studies in Section 4C.08. DelDOT's research has found significant safety benefits from applying the same reduced crash thresholds presented in IA-19 for AWSC studies.
☐	Other challenges	Click or tap here to enter text.

16. Please provide details of cost, effort, and length of time expended to deploy the innovation in your organization.

Cost: The implementation cost for AWSC is typically between $20,000 and $25,000 per intersection.

Level of Effort: AWSC is routinely implemented at low-volume, unsignalized intersections in Delaware. There is minimal additional effort required to compare the crash history to the reduced crash thresholds in the 2017 FHWA Interim Approval for the Optional Use of an Alternative Warrant 7 – Crash Experience (IA-19) as part of an AWSC evaluation. The effort required to develop plans and work orders to install AWSC is similar for other signage and pavement marking improvements.

Time: During the study phase, there is minimal additional time required to compare the crash history to the reduced crash thresholds in the 2017 FHWA Interim Approval for the Optional Use of an Alternative Warrant 7 – Crash Experience (IA-19) as part of an AWSC evaluation. Where it is deemed appropriate, the time required to develop plans and work orders to implement AWSC is similar for other signage and pavement marking improvements. Finally, once plans have been developed and implementation has been scheduled, either portable digital message boards or static temporary traffic control signs are installed at least one week in advance to warn motorists of the upcoming traffic pattern change. Construction can typically be completed in a single day.

17. To what extent might implementation of this innovation require the involvement of third parties, including vendors, contractors, and consultants? If so, please describe. List the type of expertise required for implementation.

The implementation of AWSC requires similar involvement of third parties as other signage and pavement marking improvements. Consultants or contractors may be used to perform the initial study to determine whether AWSC is appropriate and/or to design, fabricate, and install signs and pavement markings; however, consultant or contractor support is not strictly required. In Delaware, the initial study may be completed by DelDOT staff or a traffic engineering consultant through an on-call contract. DelDOT staff fabricate the signs, procure solar powered beacons from a traffic control supply company, schedule the AWSC implementation, and install the signs and solar powered beacons. A contractor installs the pavement markings (stop lines, STOP AHEAD and STOP word markings) through an on-call contract.

Based on the before-and-after research that has demonstrated significant safety benefits from implementing AWSC at low-volume intersections, and specifically applying the reduced crash thresholds in the 2017 FHWA Interim Approval for the Optional Use of an Alternative Warrant 7 – Crash Experience (IA-19) when evaluating AWSC as a potential safety countermeasure, FHWA should consider revising the guidance in MUTCD Section 2B.07, paragraph 4, item B, during future updates to the MUTCD, or issue supplemental interim approval to apply the reduced thresholds to AWSC evaluations. Updated guidance from FHWA can contribute toward consistent and proper installation of AWSC at low-volume intersections, which will make this treatment more common and further increase safety.