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| Sponsor | Nominations must be submitted by an AASHTO member DOT willing to help promote the technology | 1. Sponsoring DOT (State): Arizona DOT
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| 1. Name and Title: Dave Riley, PE, PTOE, Intelligent Transportation Systems Engineer
 |
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| 3. Is the sponsoring State DOT willing to promote this technology to other states by participating on a Lead States Team supported by the AASHTO Innovation Initiative? Yes or No: yes |
| **Technology Description (10 points)** | The term “technology” may include processes, products, techniques, procedures, and practices. | 4. Name of Technology:Wrong Way Driver System using thermal cameras |
| 1. Please describe the technology.

The ADOT Wrong Way Driver (WWD) system consists of 4 major elements:  1. Thermal cameras located on exit ramps detecting initial entry of WWD  2. Thermal cameras located at 1-mile spacing on the freeway to track the location of the WWD  3. Internally-illuminated WRONG WAY sign with flashing lighted border, and 4. Decision support software to confirm WWD and activate countermeasures.The WWD system uses thermal cameras to accurately detect WWD’s entering the freeway system and track their location on the freeway. Upon a WWD detection, the system (i) immediately triggers an oversized and highly visible internally-illuminated WRONG WAY sign with flashing lighted border, (ii) immediately streams CCTV feeds of adjacent cameras, (iii), immediately alerts law enforcement officers and dispatchers, and (iv) decision support software immediately alerts and provides video recording of WWD detection to operators in the ADOT Traffic Operations Center to confirm detection is actual WWD and quickly active countermeasures with “one click”. Countermeasures activated through the decision support software consist of posting DMS waring messages to right-way drivers, and changing traffic signal timing and turning ramp meters red to limit new vehicles entering the affected freeway. |
| 6. If appropriate, please attach photographs, diagrams, or other images illustrating the appearance or functionality of the technology. (If electronic, please provide a separate file.) Please list your attachments here.Attachments: 1. Graphic: ADOT WWD System overview 2. Video: ADOT's Wrong Way sign (upper left) & conventional sign with LED's (lower right) 3. Video: Thermal Video of WWD detection 4. Thermal Camera Details: Traffisense data sheet |
| **State of Development** **(30 points)** | Technologies must be successfully deployed in at least one State DOT. The AII selection process will favor technologies that have advanced beyond the research stage, at least to the pilot deployment stage, and preferably into routine use. | 1. Briefly describe the history of its development.

The technology applied to the WWD system has been routinely used for decades as stand-alone components in the transportation industry. This WWD system takes these time-proven and mature components and assembles them into a single system, using them in a new and innovative way. The core component of the WWD system is the Flir thermal camera. ADOT performed several years of research on crash statistics, best practices, and available sensors to determine the best technology to apply to WWD. Available sensor technologies were compared and the most viable options were field tested, which include: inductive loops, radar, and thermal cameras. Thermal cameras proved outstanding in field tests and approximately 30 sites throughout ADOT’s phoenix-metro freeway system are outfitted with Flir thermal camera WWD detection. As of August 2017, ADOT has several interchanges outfitted with thermal cameras which will become part of a 15-mile continuous WWD system that will be completed December 2017. Thermal cameras have been commonly used by the military and law enforcement for many decades. Within the past couple decades, thermal cameras have been used for traffic signal presence detection. And within the past decade a wrong way driving algorithm was added by Flir into their thermal cameras. At this point, the technology and wrong way detection algorithm is considered mature technology. However until recently, Flir did not market their thermal camera as a WWD solution as much as other technology vendors and thermal cameras may have been overlooked. ADOT is the first and only agency known in the United States to utilize thermal cameras for WWD detection. The internally illuminated WRONG WAY sign with flashing lighted border are an assembly of commercially available off-the-shelf components and is MUTCD compliant. Internally illuminated signs showing street names have been used for many decades at traffic signals. The component of the sign used to flash the border of the sign is routinely used to enhance visibility of roadway signs, including stop signs and wrong way signs. |
| 1. For how long and in approximately how many applications has your State DOT used this technology?

ADOT has been using thermal cameras for traffic signal presence detection for several years. The first thermal camera for WWD testing was installed in December 2016. Since then, approximately 29 more thermal cameras have been turned on with WWD detection and alerts are being monitored through a central software system. |
| 1. What additional development is necessary to enable routine deployment of the technology?

ADOT currently has separate software systems that centrally control DMS, CCTV, traffic signals, and ramp meters. ADOT is currently developing decision support system software that will create a link between these separate software systems, allowing activation of countermeasures with “one click” to reduce response time and the risk of crashes involving wrong way drivers.  |
| 1. Have other organizations used this technology? Yes or No: No If so, please list organization names and contacts.

Many organizations have used these components individually for applications other than WWD. No organizations are known to use these components in this way for WWD.  |
| Organization | Name | Phone | E-mail |
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| **Potential Payoff****(30 points)** | Payoff is defined as the combination of broad applicability and significant benefit or advantage over other currently available technologies. | 1. How does the technology meet customer or stakeholder needs in your State DOT or other organizations that have used it?

This system is expected to reduce wrong way crashes on Freeways. Wrong way crashes are often tragic and a major concern of the public, media, and ADOT. The use of thermal cameras provides excellent performance considering: false-detections, missed-detections, maintenance, and cost. This WWD system provides a way to reduce WWD crashes through faster response and provides a way to track WWD statistics so that roadway improvements can be identified and made to deter and prevent drivers from driving the wrong way before it happens.  |
| 12. What type and scale of benefits has your DOT realized from using this technology? Include cost savings, safety improvements, transportation efficiency or effectiveness, environmental benefits, or any other advantages over other existing technologies.ADOT is currently collecting safety data to specifically quantify benefits. ADOT expects safety benefits and reduced WWD related crashes as a result of faster interception of WWD’s by law enforcement, and faster alerting to right-way drivers. Also, ADOT is tracking WWD entry statistics to identify geometric improvements that can be implemented now and in future design to discourage inadvertent wrong way entry onto freeways. Thermal cameras provide a specific advantage compared to other detection technologies due low frequency of false detections. A false detection is a trigger of an alert when a WWD is not actually there. Increased frequency of false detections can lead to alerts being ignored or put at low priority by those monitoring and responding to the system. Because thermal cameras are very accurate, alerts are responded to quickly, reducing the risk for crashes and improving safety.The Internally-illuminated WRONG WAY sign with flashing lighted border was designed for exit ramps and with the goal of having WWD’s recognize their mistake and turn around before entering the freeway. The state of mind of WWD’s was carefully considered in designing the sign, and address shortcomings of other lighted WRONG WAY signs current available. Other lighted signs typically use an array of LEDs on the border of the sign or use RRFB’s to enhance conspicuity. However, other available products are not very bright and they are somewhat noticeable at night, but not noticeable during under daylight. Given a high percentage of WWD’s are impaired, the sign used in this system solves this problem with a very bright light source which can be dimmed at night if desired. Another, issue addressed by the sign in this system is that at night when the border lights are on, it can make the WRONG WAY legend difficult to read due to glare, especially if a driver is impaired. This is solved by this sign by using an internally illuminated sign which greatly increases the sign panel brightness and readability compared to standard retro-reflective sign sheeting. Also, because the sign is internally illuminated, it is legible at night even if headlights are inadvertently left off, another potential issue if the driver is impaired. The cost of the Internally-illuminated WRONG WAY sign with flashing lighted border is less than or about equal to currently available lighted WRONG WAY sign assemblies and it provides increased safety benefits.Latency of the WWD system to provide the alert to the operator is less than 5 seconds. The ADOT WWD system utilizes existing fiber optic communication infrastructure and servers are designed to be reliable and fast. Other currently available WWD technologies can have latency of up to 60 seconds. Latency of other systems can be attributed to using cellular communications, private cloud servers, and email for alerts. Low latency of the ADOT WWD system results in better location and tracking of WWD using existing CCTVs, faster posting DMS waring messages to right-way drivers, faster changing of traffic signal timing and ramp meter timing to limit new vehicles entering the affected freeway, and faster WWD interception time by law enforcement. Often WWD’s crash within only a couple minutes of driving the wrong way on the freeway, and low latency and immediate response is critical.The decision support system is designed so that the response is immediate and can reduce the risk of a crash. Upon a WWD detection, the system (i) immediately triggers an oversized and highly visible internally-illuminated WRONG WAY sign with flashing lighted border, (ii) immediately streams CCTV feeds of adjacent cameras, (iii), immediately alerts law enforcement officers and dispatchers, and (iv) decision support software immediately alerts and provides video recording of WWD detection to operators in the ADOT Traffic Operations Center to confirm detection is actual WWD and quickly active countermeasures through “one click”. Countermeasures activated through the decision support software consist of posting DMS waring messages to right-way drivers, and changing traffic signal timing and ramp meter timing to limit new vehicles entering the affected freeway. The decision support system reduces the response time from minutes to seconds, improving safety and allowing the operator and law enforcement to focus on what is important rather than unnecessary manipulation of several software systems controlling various devices. |
| 1. Please describe the potential extent of implementation in terms of geography, organization type (including other branches of government and private industry) and size, or other relevant factors. How broadly might the technology be deployed?

State, county, and city DOT’s can apply this technology to any divided two-way roadway including freeways, rural highways and arterials with median. Thermal sensors are not affected by fog, ice, dust, sun glare, night, day, and other environmental factors that many other sensor technologies can experience reduced detection performance. |
| **Market Readiness (30 points)** | The AII selection process will favor technologies that can be adopted with a reasonable amount of effort and cost, commensurate with the payoff potential. | 1. What actions would another organization need to take to adopt this technology?

All the hardware used for the WWD system is commercially-available off-the-shelf products commonly used for traffic signals, ITS, and transportation. All components and applications are MUTCD compliant.The make and model of the primary components are (i) thermal cameras: Flir Traffisense, (ii) internally illuminated WRONG WAY sign: Temple Edge Lit, and (iii) flashing lighted sign border: Trafficalm Sign Alert. The remaining networking, mounting hardware, and electronic components are all commonly available from transportation equipment vendors for purchase by transportation agencies. Installation of the equipment uses standard methods of construction and any construction contractor who specializes in ITS or traffic signals can install the equipment without special training.Software development efforts will vary depending on the agencies desired level of automation. Off-the-shelf software from Flir can be installed with minimal effort to perform the primary WWD system functions: receive WWD alerts, view a recorded video of the WWD detection, and manage and maintain the thermal cameras. If an agency chooses to use decision support software to provide “one-click” activation of WWD countermeasures, software development may be needed to integrate the WWD system with the software packages the agency uses to post messages on DMS, and change traffic signal and ramp meter operation.Adoption of this technology is further made easier and cost-effective considering that a single Flir thermal camera can perform both WWD detection and traffic signal presence detection with accuracy and reliability which ADOT commonly finds outperforms inductive loops, optical video, and radar based detection. Also, thermal cameras can be installed utilizing existing inductive loop detector or video detection cable, which greatly simplifies and reduces the resources needed for installation. If an agency decides to use thermal cameras for any new traffic signal detection needs, the agency will subsequently be able to create WWD detection for no additional cost. For agencies that already use Flir thermal cameras for traffic signals, they would simply need to create wrong way detection zones using the camera’s internal software user interface.  |
| 1. What is the estimated cost, effort, and length of time required to deploy the technology in another organization?

WWD hardware costs vary depending on the utilization of existing infrastructure. The following costs include the internally-illuminated WRONG WAY sign with flashing border, conduit, conductors, and other components typically needed. At sites where Flir thermal cameras are already used for traffic signal presence detection, the estimated cost for the WWD system hardware is $10,000 per site. At sites where a new thermal detection camera is installed at a traffic signal, the estimated cost for the WWD system hardware is $16,000 per site. WWD software costs are a one-time purchase that covers all WWD sites. Software costs only about $6,000 which performs the primary WWD system functions: receive WWD alerts, view a recorded video of the WWD detection, and manage and maintain the thermal cameras. Decision support software to provide “one-click” activation of WWD countermeasures varies widely depending on the software packages the agency uses to post messages on DMS, and change traffic signal and ramp meter operation. If an agency uses the same software packages as ADOT does, the cost would be much less because ADOT already paid for necessary enhancements to these software packages which another agency could receive with future version releases at no cost.  |
| 1. What resources—such as technical specifications, training materials, and user guides—are already available to assist deployment?

Because the components of the ADOT WWD system use off-the-shelf products, device user guides and specifications are readily available on manufacturer websites. ADOT has prepared system architecture diagrams, construction specifications, and design plans, and these are provided to agencies who make the request. Also, because the individual components of this technology have been used for many years, vendor representatives located throughout the country can provide product training. |
| 1. What organizations currently supply and provide technical support for the technology?

All the components and software used for the WWD system are provided by companies who provide technical support for their products. ADOT believes many aspects of this WWD system will be adopted by other agencies, further increasing the knowledge of the system throughout the country.  |
| 1. Please describe any legal, environmental, social, intellectual property, or other barriers that might affect ease of implementation.

There are no known barriers that might affect ease of implementation. All components and applications are MUTCD compliant. All components are commercially available off-the-shelf.  |
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