INDIANA DEPARTMENT OF TRANSPORTATION

Intelligent Work Zone Design and Implementation Tool Kit

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INTRODUCTION

A traffic control device whether in a work zone or not should only be used if it addresses a certain need. Since work zones present challenging and often changing situations for the driver they present opportunities to use technologically based devices to enhance the operation of the work zone and reduce risk. This guide provides information on some of those technologies but certainly does not include all that might be available on the market.

Goals/Needs

This section provides a correlation between a need or concern and intelligent work zone technology options that can be considered to address.

Need: Reducing speeds/speed variation through the work zone

- Radar Speed Display Signs- these provide an alert to drivers that they are speeding and are advertised to be effective at reducing the amount of speeding, particularly excessive speeding.
- Variable Speed Limit Signs also known as dynamic speed limit signs, allow the speed limit to change based on real-time traffic, construction activity, or weather conditions. Variable speed limits may be used to provide road users with a safe speed limit through the work zone and to reduce abrupt braking as they approach a queue.

Need: Encouraging use of alternate routes

- Real Time Travel and Alternate Route Advisory signs include speed sensors and permanent or portable changeable message signs. If traffic congestion forms, the changeable message signs are triggered by the speed sensors and the travel times to approaching destinations are updated and/or an alternate route is advised.
- Portable Changeable Message Signs are a type of temporary traffic control device on a movable trailer that is capable of displaying one or more alternative messages. The portable changeable message signs may be used to provide travel times and suggest an alternate route.

Need: Raising driver awareness to potential or actual queuing

- Queue Warning Systems are a combination of speed sensors and permanent or portable changeable message signs that are upstream of the work zone. If traffic queues begin to form in the work zone, the speed sensors provide an alert and an appropriate message is displayed on the changeable message signs.
- Late Lane Merge Systems consist of speed sensors and permanent or portable changeable message signs that are placed in advance of a lane merge. As traffic queues begin to form, the speed sensors activate the changeable message signs that instruct drivers to use a late (zipper) merge method. Late lane merges are useful when there is an upstream interchange or intersection near the work zone that is impacted by the queues.
- Work Vehicle Entering Warning System include vehicle detection at the contractor ingress/egress point and a portable changeable message sign or a static truck entering sign

with a when flashing plaque and flashing beacons. The system may be useful when contractor equipment or material deliveries are a significant source of traffic queues.

- End of Queue Warning Vehicles are vehicles with truck mounted attenuators equipped with portable changeable message signs that warn drivers of an approaching queue and as a queue length increases will reposition so that they continue warning drivers of the approaching queue.

Need: Additional delineation for lane merge and shift tapers (reducing frequency of lane departure events)

- Sequential Warning Lights are mounted to channelizing devices and illuminate in a sequence that assists drivers in navigating a lane merge or shift. Sequential warning lights are useful in work zone tapers or shifts when the geometrics are unusual or there are low levels of ambient lighting at night.
- Smart Arrow Boards provide information to connected vehicles, the contractor, and highway agency of a lane closure which is particularly useful for any unexpected lane closures or rolling lane closures.

Need: Work zone will be unlighted or inadequately lighted, e.g., temporary crossovers that will be located where the existing lighting system does not provide coverage.

- Presence Lighting improves visibility approaching and in the work zone at locations without permanent highway lighting or where existing lighting cannot be maintained during construction or will not provide sufficient light levels. This device has also been shown to reduce travel speed as it increases driver awareness of the work zone.

Need: Contractor, Construction Staff, and TMC awareness of operational issues approaching or within a work zone where such issues are anticipated.

- Closed Circuit Television (CCTV) for surveillance of traffic and road conditions This information can be used to provide quicker response to incidents (crashes) or to improve scheduling of activities that cause operational issues such as queuing.

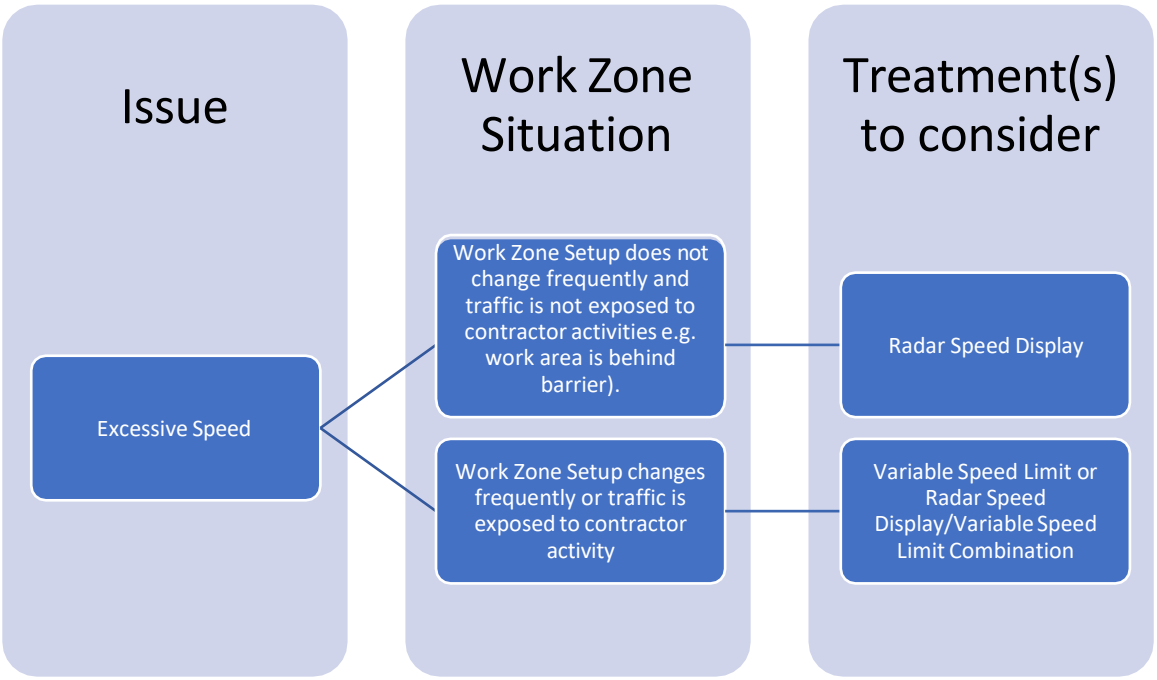
Need: Driver awareness of construction and emergency response vehicles within or approaching a work zone.

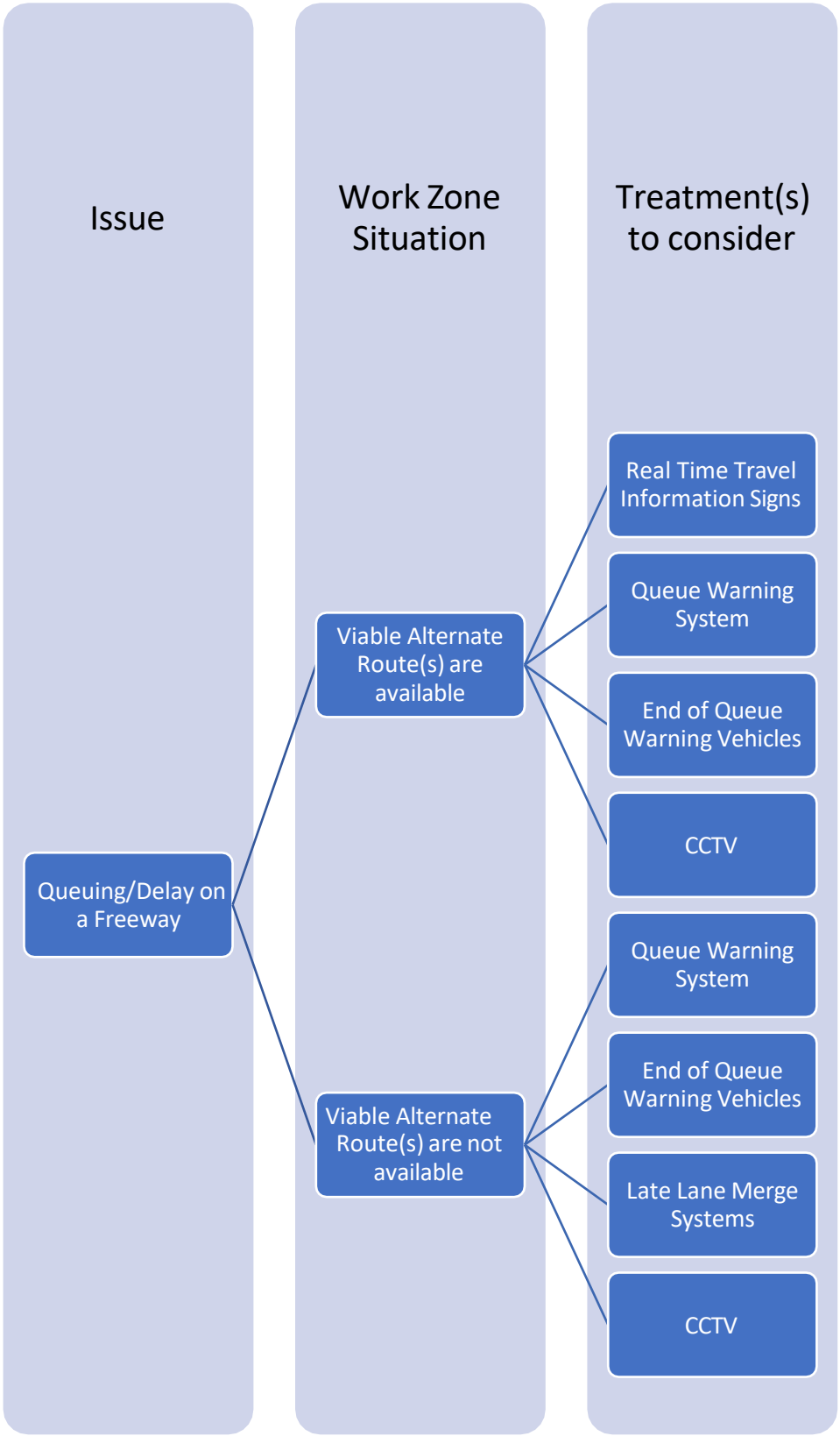
- A Digital Alert System informs drivers of the presence of work or emergency response vehicles. This enhances safety and facilitates operation for the contractors and emergency responders. A device (transponder) is installed on the work or emergency vehicle that sends a message about the presence of a work/emergency vehicle via an application programming interface to drivers of vehicles equipped with onboard navigation systems or through an app on a hands-free smart phone.

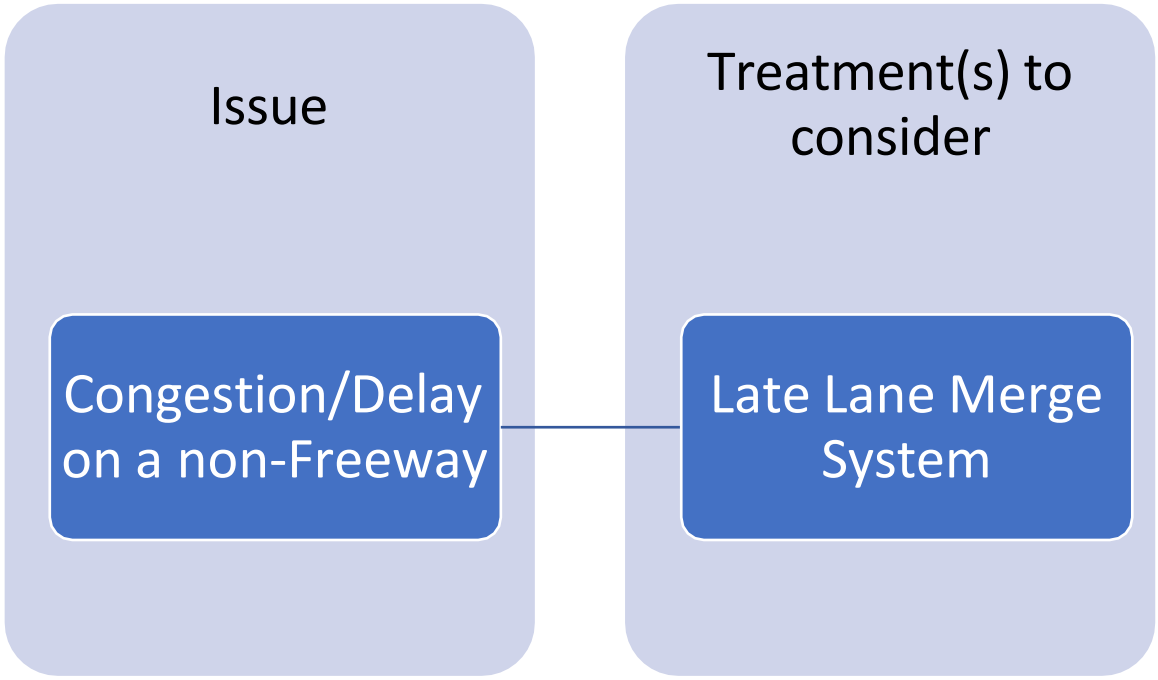
<u>Intelligent Work Zone Technologies</u>

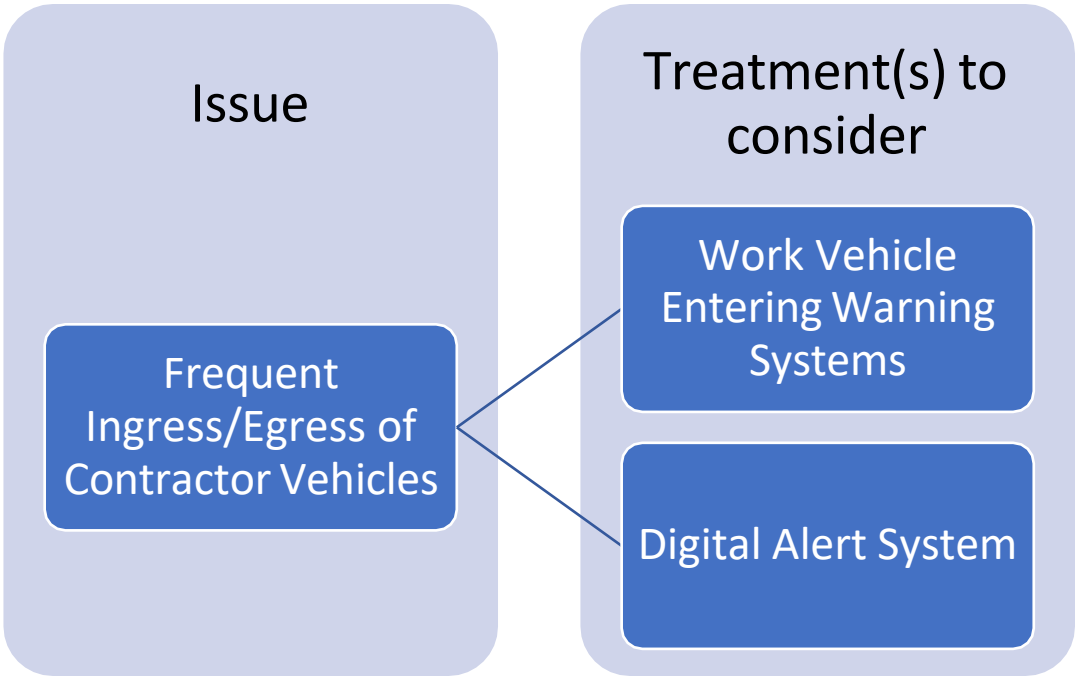
INDOT considers the devices described herein to be viable options to address the specific concerns and needs identified above. Additional information about the devices may be obtained from the manufacturers or the IMUTCD.

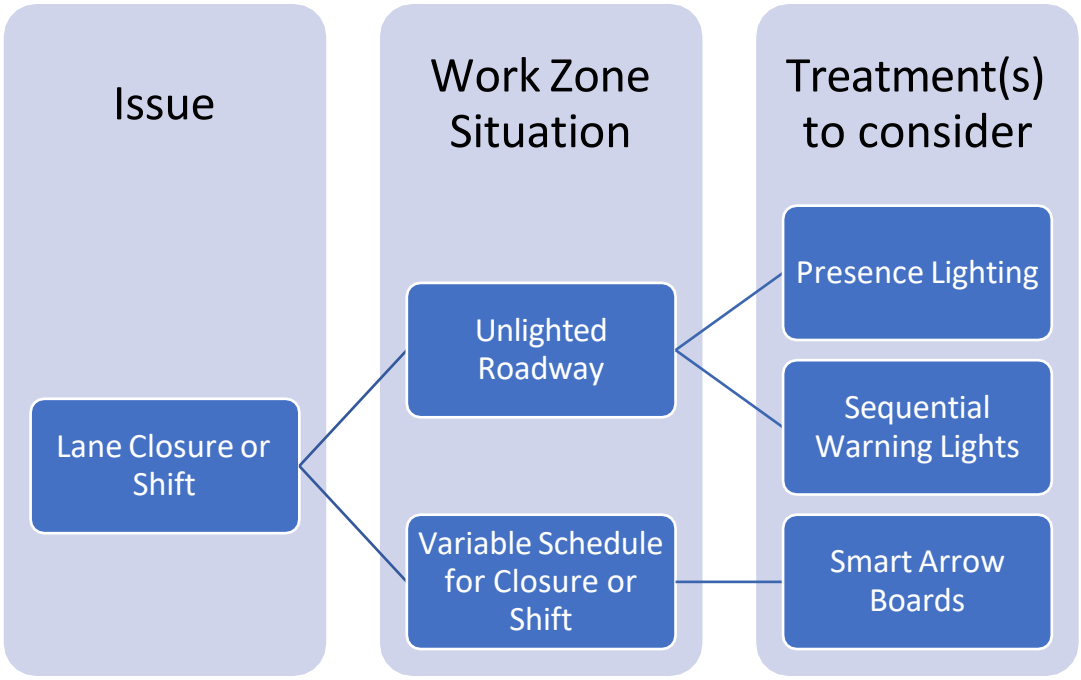
TREATMENT SELECTION GUIDE

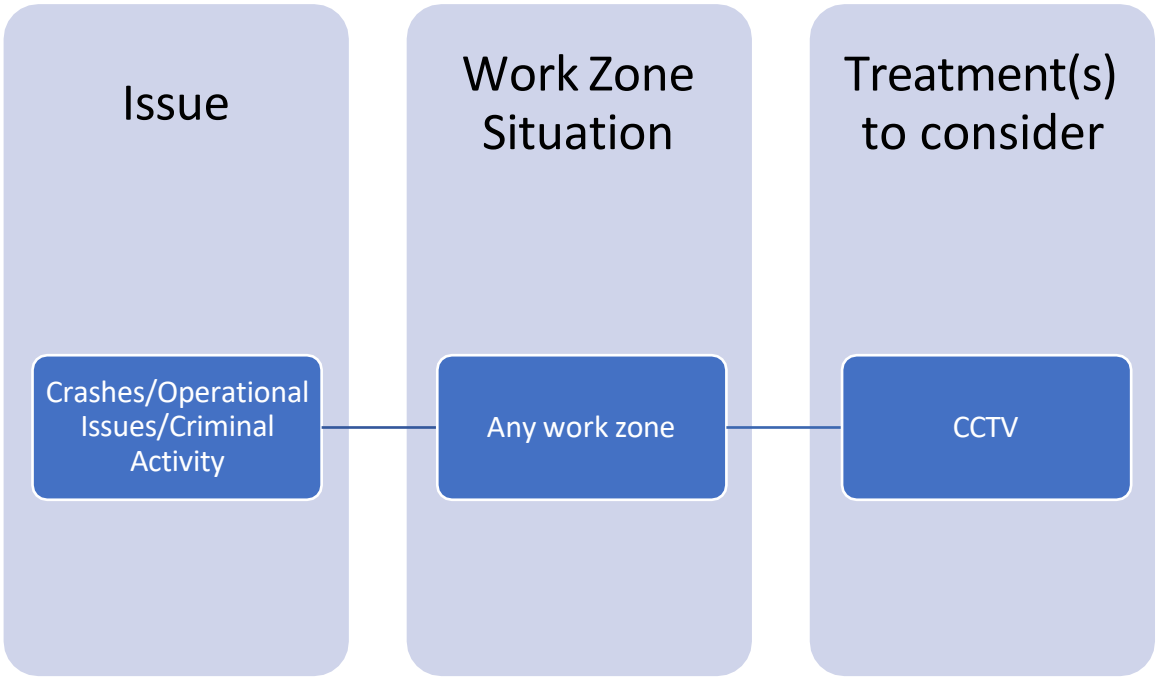



Issue
Work Zone Situation
Treatment(s) to consider
Queuing/Delay on a Freeway
Viable Alternate Route(s) are available
Viable Alternate Route(s) are not available
Real Time Travel Information Signs
Queue Warning System
End of Queue Warning Vehicles
CCTV
Queue Warning System
End of Queue Warning Vehicles
Late Lane Merge Systems
CCTV


Issue
Treatment(s) to consider
Congestion/Delay on a non-Freeway
Late Lane Merge System


Issue
Frequent Ingress/Egress of Contractor Vehicles
Treatment(s) to consider
Work Vehicle Entering Warning Systems
Digital Alert System


Issue
Work Zone Situation
Treatment(s) to consider
Lane Closure or Shift
Unlighted Roadway
Variable Schedule for Closure or Shift
Presence Lighting
Sequential Warning Lights
Smart Arrow Boards


Issue
Work Zone Situation
Treatment(s) to consider
Crashes/Operational Issues/Criminal Activity
Any work zone
CCTV

RADAR SPEED DISPLAY SIGNS

What is a Radar Speed Display sign? Also known as Driver Feedback signs, this device provides the driver with a reasonably accurate measure of their travel speed at a point along the roadway. Speed is measured by radar and then displayed on an electronic component (LEDs) of a sign. The sign also has a static component that contains the "Your Speed' part of the message. The speed displayed flashes when it is over the posted speed limit, providing an additional alert to drivers. These devices can be used in permanent applications in which case they are post or pedestal mounted. When used in temporary situations like in work zones, they are trailer mounted, dolly mounted units can be considered for urban roadways where the device will be set on sidewalk. They can be set to run 24 hours a day 7 days a week or to operate only at certain times through use of a built-in time clock. Electrical service is not needed in any application as they are battery powered, some are equipped with a solar panel charging system. The signs are available in several sizes/letter heights for varying types of roadways- for INDOT routes a minimum 11" letter height should be specified for the speed display component of the sign.

When are they recommended for use? While they can be used in any work zone they are particularly beneficial where speeds are expected or known to be significantly greater than the posted speed limit. One such circumstance is projects that are on urban or suburban interstate segments where traffic is known to exceed the posted speed limits on a regular basis. They should

also be considered for any project on a rural interstate or other high-volume route where a reduced, temporary work zone speed limit is in place.

Is there a standard or specification? INDOT has developed a recurring special provision that should be used: *See Appendix A*

What should be considered in developing the MOT plans? The designer should discuss the need for radar speed display signs with the TMP team or with the district if there is not a formal TMP team. When needed, their location should be shown in the plans. They should be located adjacent to the speed limit sign that is being reinforced – with continuous use work site speed limits it should be the first sign assembly the driver will encounter approaching the work zone, when there is no speed limit reduction for the work zone they should be located adjacent to the last permanent speed limit sign that will be encountered approaching the work zone. They can also be used with intermittent work site speed limits. If adequate lateral space is not available by the speed limit sign, then the radar speed display sign should be located directly after the speed limit, within 500 ft for freeway and high-speed rural highways and 200 ft for other routes.

What are the Operational Considerations? Should it be determined that they are only needed at certain times of the day or days of the week the device will need to be programmed (the time clock set) for activation at the proper time. The electronic component of the sign will remain blank when not activated. As normally configured the radar unit will detect speeds approximately 400 ft in advance of the sign. There is no need to cover the sign when not active but if they will not be used for an extended period of time- in excess of 1 week– they should be removed from the roadway. As with any trailer mounted device they should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical. If positive protection is not available, they should be delineated with drums at the corners of the trailer.

What type of Maintenance activities are needed? Batteries will occasionally need to be replaced or recharged per the manufacturers' recommendations. They will need to be recharged more frequently if in use over winter, typically November through February.

VARIABLE SPEED LIMIT SIGNS

What is a Variable Speed Display sign? As the name suggests, this device can display varying speed limits depending on prevailing conditions. For instance, a lower speed limit can be displayed when traffic congestion occurs. Traffic conditions are detected by radar. The device can also be programmed for speed limits specific to certain times of day. The numerical value of the speed limit is displayed on an electronic component (LEDs) of the sign. The sign also has a static component that contains the "Speed Limit' part of the message. Variable speed limits can be used in temporary or permanent applications- for permanent use they are post or pedestal mounted. When used in temporary situations generally they are trailer mounted although dolly mounted units can be considered for urban roadways where the device will be set on sidewalk. Typically, they are set to run 24 hours a day 7 days a week, but they are capable of being programmed to operate only at certain times through use of a built-in time clock. Electrical service is not needed in any application as they are battery powered, some are equipped with a solar panel charging system. Variable speed limits are allowable under the Indiana Code (*IC 9-21-5-12)* but an Official Action (OA) approved by the District Deputy Commissioner is required since this is a regulatory device. The minimum and maximum speed limits should be indicated on the OA.

When are they used? Variable speed limit signs should be considered when traffic congestion varies through the day or week, when traffic patterns change frequently, or when the proximity of the work area or contractor activity changes frequently.

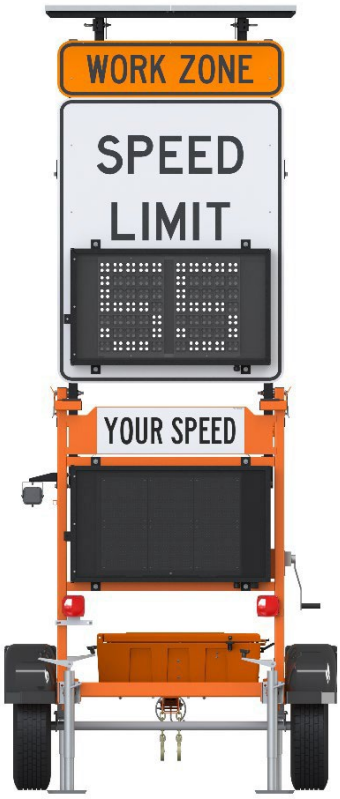
Is there a Standards Specifications or Special Provision? INDOT has developed a sample unique special provision that may be used, see Appendix B.

What should be considered in developing the MOT plans? The designer should discuss the need for variable speed limit signs with the TMP team or with the district if there is not a formal TMP team. When used, the location of the variable speed limit signs should be shown on the plans.

What are the operational considerations? Variable speed limits must include software that maintains a record of activity. If cellular communication fails, the activity record will indicate the period without cellular communication. The interstate highway system generally has good cellular signal coverage, but variable speed limits may not be suitable for locations on conventional highways in remote areas with poor cellular communication. As with any trailer mounted device they should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical. If positive protection is not available, they should be delineated with drums at the corners of the trailer.

What type of maintenance activities are needed? Batteries will occasionally need to be replaced or recharged per the manufacturers' recommendation. They will need to be recharged more frequently if in use over winter, typically November through February.

RADAR SPEED DISPLAY-VARIABLE SPEED LIMIT COMBINATION SIGNS



What is a Radar Speed Display and Variable Speed Limit sign combination? This device provides for varying speed limits and also gives the driver their travel speed at a point along the roadway. The speed limit varies according to changing traffic or work zone conditions and can also be programmed for certain limits at certain times of the day. Travel speed is measured by radar and then displayed on an electronic component (LEDs) of a sign. The sign also has static components that give the "Speed Limit" and the "Your Speed' part of the message. The speed limit and the actual travel speed are displayed in the electronic portion of the sign. The actual travel speed flashes when it is over the posted speed limit, providing an additional alert to drivers. These devices can be used in permanent applications in which case they are post or pedestal mounted. When used in temporary situations like in work zones, they are trailer mounted, dolly mounted units can be considered for urban roadways where the device will be set on sidewalk. They can be set to run 24 hours a day 7 days a week or to operate only at certain times through use of a built-in time clock. Electrical service is not needed in any application as they are battery powered, some are equipped with a solar panel charging system. The signs are available in several sizes/letter heights for varying types of roadways- for INDOT routes a minimum 11" letter height should be specified for the speed limit and the speed display components of the sign.

When are they used? They may be of particular benefit where traffic or work zone conditions are expected to vary frequently and where speeds are expected or known to be significantly greater than the posted speed limit.

Is there a standard or specification? INDOT has developed unique special provisions for both radar speed display signs and variable speed limit signs, see Appendix C.

What should be considered in developing the MOT plans? The designer should discuss the need for radar speed display-variable speed limit sign with the TMP team or with the district if there is not a formal TMP team. When used, the location of the radar and variable speed limit signs should be shown on the plans.

What are the operational considerations? Should it be determined that they are only needed at certain times of the day or days of the week the device will need to be programmed (the time clock set) for activation at the proper time. The electronic component of the sign will remain blank when not activated. As normally configured the radar unit will detect speeds approximately 400 ft in advance of the sign. There is no need to cover the signs when not active but if they will not be used for an extended period of time- in excess of 1 week– they should be removed from the roadway. As with any trailer mounted device they should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical. If positive protection is not available, they should be delineated with drums at the corners of the trailer. The combination of radar speed display signs and variable speed limit signs may not be suitable for remote areas on conventional state highways, as the variable speed limit signs require strong cellular communication signal strength.

What type of maintenance activities are needed? Batteries will occasionally need to be replaced or recharged per the manufacturers' recommendations. They will need to be recharged more frequently if in use over winter, typically November through February.

QUEUE WARNING SYSTEMS

Camera Based System

Sensor Based System

What is a Queue Warning System? Also referred as Smart Traffic Monitoring Systems (STMS) for temporary work zone purposes this is a trailer mounted system utilizing either cameras or microwave sensors that performs two primary functions- 1) it detects and measures queue in a real time as the queue develops and 2) it communicates information about the queue to motorists. Radar detection is generally used, communication is typically through radio signals, and the information typically is displayed on portable changeable message signs *(can permanent DMSs be used?)*.

When are they used? Queue Warning System improve safety when queuing occurs and so should be considered if the queuing is expected, especially on freeways and expressways (highways where drivers do not expect to stop) and if queuing will be frequent and at predictable locations.

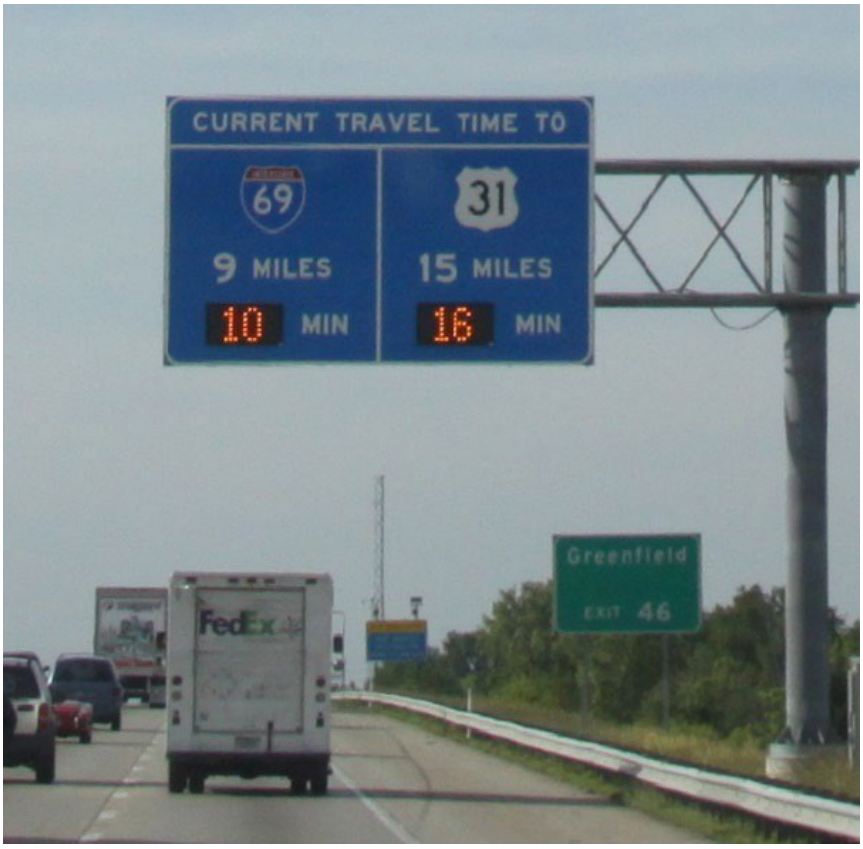
Are there Specifications or Special Provision? See Appendix D for a unique special provision that may be used.

What should be considered in developing the MOT plans? The need should be discussed as MOT plans are being developed and queuing analysis performed. They should be located approximately 800 ft downstream of the first Road Construction Ahead sign but in advance of the expected maximum queue length.

What are the operational considerations? Since these are trailer mounted devices they can be relocated should the original placement not be at an appropriate distance in advance of queuing. They should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical or at minimum should be delineated with drums at the corners of the trailer.

What type of maintenance activities are needed? Battery maintenance or replacement per the manufacturer's recommendations. They will need to be recharged more frequently if in use over winter, typically November through February.

REAL TIME TRAVEL AND ALTERNATE ROUTE ADVISORY SIGNS (TEMPORARY)



Permanent RTT Sign

What is a Real Time Travel sign? This type of sign provides motorists with actual travel times from the point of the sign to certain downstream locations- typically a major interchange or intersection, often more than one downstream location is provided on the sign. Vehicle speed sensors between the location of the sign and the selected downstream locations send information to a controller which calculates the travel time to the prescribed downstream locations. That time then is displayed on the electronic component of RTT sign along with the notice of the availability of an alternative route. The alternative route advisory message is programmed into the PCMS controller and activated when the determined threshold travel time is exceeded. The downstream locations may be given as a static sign message or may be variable as well- the real time travel and alternative route information may be displayed on the same portable changeable message sign rather than on separate devices. INDOT has permanent RTT signs in the Indianapolis and Lake County areas that can potentially be used as part of a project TMP if the signs are in a useful location- coordination with the TMC on their use is needed.

When are they used? RTTs should be considered when regular queuing or delay is expected and there are viable alternative routes available.

Are there Standards Specifications or Special Provisions? INDOT has developed a sample unique special provision that may be used, see Appendix E.

What should be considered in developing the MOT plans? Use of RTT signs should be discussed during plan development- district and TMC input on the threshold travel time and alternative route selection as these aspects are integral to each other, i.e., if the alternative route adds 10 minutes travel time to the normal trip through the work zone the threshold for activating the alternative route message should be at least 10 minutes. These signs should be located in advance of the alternative route, at least 1/2 mile for freeways and other high-speed highways.

What are the operational considerations? They should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical or at minimum should be delineated with drums at the corners of the trailer.

What type of maintenance activities are needed? Solar powered portable changeable message signs may require generators if used during winter months and speed sensor batteries may need to be replaced. The equipment for real time travel and alternate route advisory signs should be inspected before and after use.

DYNAMIC LATE LANE MERGE SYSTEMS

Portable Trailer for Sensor/Radar

What is a Dynamic Late Lane Merge System? This system decreases queue length at a lane merge by encouraging motorists to use any open lane including the lane that is being merged, up to the point of the merge taper during periods of traffic congestion. The system detects congestion as it develops with speed sensors and then changes the portable changeable message signs in advance of the work area through radio signals to display a message like "USE BOTH LANES TO MERGE POINT". Appropriate variations on this message may be used. During uncongested times the variable portion of the portable changeable message signs may be blank.

When are they used? They should be considered when a lane merge is expected to generate a queue (congestion) for at least several hours a day and there is an upstream interchange or intersection that may be affected by the queues. If congestion is expected through most of the day static signing may be just as effective and will be less expensive.

Are there Standard Specifications or Special Provision? INDOT has developed a sample unique special provision that may be used, see Appendix F.

What should be considered in developing the MOT plans? The designer should estimate the queues for the work zone, referencing the Interstate Highways Congestion Policy for interstate work zones, and if the results indicate periodic queuing, the design should discuss dynamic late lane merges with the TMP team or with the district if there is not a formal TMP team. When used, the dynamic late lane merge should be shown in the plans.

What are the operational considerations? A radio site survey and cellular signal strength check may be needed for locations in remote areas. As with any trailer mounted device the portable

changeable message signs for the dynamic late lane merges should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical. If positive protection is not available, the portable changeable message signs should be delineated with drums at the corners of the trailer.

What type of maintenance activities are needed? Solar powered portable changeable message signs may require generators if used during winter months and speed sensor batteries may need to be replaced. The equipment for the dynamic late lane merge should be inspected before and after use.

END OF QUEUE WARNING VEHICLE ("QUEUE TRUCK")

INDOTs Queue Truck Warning System

What is an End of Queue Warning Vehicle? This is a truck with extensive light packages and reflective warning wrapping designed to get driver's attention and let them know that they are approaching and the end of a queue. This message is displayed with both static and changeable message signs that are mounted on the back of the vehicle. The intent of this vehicle is to reduce the number of crashes and hard barking incidents.

When is it used? End of Queue Warning Vehicles are used when specified by the Work Zone Safety Office or the Director, Engineering and Research. They are considered when queueing and high approach speeds are expected, often this situation is identified through queuing analysis performed in conjunction with IHCP exception requests.

Are there Standard Specifications or Special Provision? See Appendix G for the special provision that is required.

What should be considered in developing the MOT plans? The pay item for end of queue warning vehicles should be included in the Engineer's Estimate, the item is code no 801-12652 "QUEUE TRUCK"

What are the operational considerations? Trucks will usually operate about ¼ mile in advance of the queue. For more information on this measure visit INDOT's website at: https://www.in.gov/indot/safety/protect-the-queue-indots-queue-awareness-program/

What type of maintenance activities are needed? Queue trucks require periodic maintenance. And should be inspected before and after use.

WORK VEHICLE ENTERING WARNING SYSTEM

What is a Work Vehicle Warning System? This system detects (or is activated by) work vehicles as they are entering the highway from the work or storage area. A camera or sensor usually mounted on a separate trailer detects a truck that will be entering the highway. A signal is sent that activates either a portable changeable message sign to display a "TRUCK ENTERING" warning message or the flashing beacons on a static truck entering sign.

When is it used? A Work Vehicle Warning System should be considered when it's expected that there will be regular and frequent egress/ingress of work vehicles to/from open travel lanes, for instance when materials will be stored proximate to traffic. The possible need should be discussed with the District Construction office.

Are there Standard Specifications or Special Provision? INDOT has developed a sample unique special provision that may be used, see Appendix H.

What should be considered in developing the MOT plans? The designer should discuss work vehicle entering warning systems with the TMP team or with the district if there is not a formal TMP team. When used, the work vehicle entering warning system should be shown on the plans.

What are the operational considerations? As with any trailer mounted device the portable changeable message signs for the work vehicle entering warning system should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical. If positive protection is not available, the portable changeable message signs should be delineated with drums at the corners of the trailer.

What type of maintenance activities are needed? Solar powered portable changeable message signs may require generators if used during winter months and vehicle detection sensor batteries may need to be replaced. The equipment for the work vehicle entering warning system should be inspected before and after use.

PORTABLE CHANGEABLE MESSAGE SIGNS

What is a Portable Changeable Message Sign? This device has been frequently used on INDOT projects for many years. Currently the technology involves an all-electronic (LED) display of three lines with eight characters per line. Some signs are capable of displaying graphics although use of graphics is limited/prohibited by the Manual on Uniform Traffic Control Devices. The signs are battery powered with solar charging and are trailer mounted, the trailers must be delineated if not placed behind guardrail or barrier wall. They can be used as a stand-alone device but are a component of a number of the systems described in this document.

When are they used? PCMSs should be considered for projects with varying conditions where static signing will not be sufficient. They are used on many projects to advise of closures, expected delays, and detour or alternative routes.

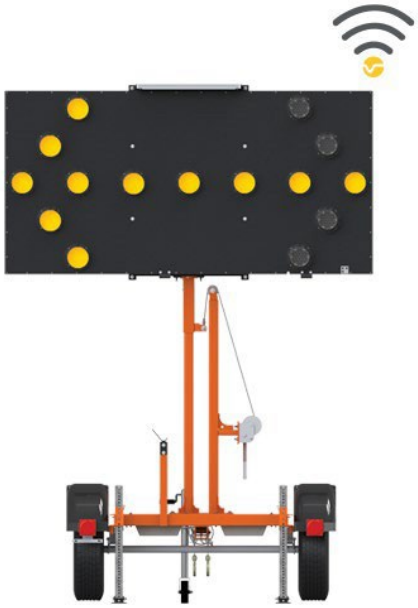
Are there Standard Specifications or Special Provisions? The Standard Specifications address PCMS and there is a qualified products list for contractors' reference, PCMSs utilizing smart technology for speed sensor compatibility are identified on this list.

What should be considered in developing the MOT plans? Messages and location should be shown on the MOT plans and a programming sheet for each of those messages provided in the special provisions. Please refer to the INDOT Guidelines for Portable Changeable Message Signs for recommendations on messaging and plan locations.

What are the operational considerations? They should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical or at minimum should be delineated with drums at the corners of the trailer. The diming feature should be set so that messages are brighter during the daytime but do not glare at night.

What type of maintenance activities are needed? Solar powered portable changeable message signs may require generators if used during winter months and speed sensor batteries may need to be replaced.

SMART ARROW BOARDS



What is a smart arrow board? This device provides the normal arrow board operation as required by INDOT Standards for lane closures, but it also sends real-time data to a vehicle's navigation system which will alert the motorist that they are approaching a work zone. Smart arrow boards also send the lane closure data to third party navigation apps- such as Waze - and notifies INDOT of the lane closure.

When is it used? A smart arrow board may be considered for any lane closure particularly those on high volume/high speed roadways.

Are there Standard Specifications or Special Provision? INDOT has developed a sample unique special provision that may be used, see Appendix I.

What should be considered in developing the MOT plans? The designer should discuss work vehicle entering warning systems with the TMP team or with the district if there is not a formal TMP team.

What are the operational considerations? As with any trailer mounted device the smart arrow boards should be placed to minimize the probability that they will be struck, e.g., behind existing guardrail or barrier wall if practical. If positive protection is not available, the smart arrow boards should be delineated with drums at the corners of the trailer.

What type of maintenance activities are needed? Solar powered arrow boards may require generators if used during winter months. Smart arrow boards should be inspected before and after use.

WORK ZONE PRESENCE LIGHTING

What is a Work Zone Presence Lighting? This is a temporary lighting system that enhances safety by providing drivers with better visibility approaching or within a work zone. Presence lighting has also been shown to reduce speeds. They are typically trailer mounted, battery or generator powered and use solid state technology (LEDs) for the light source.

When is it used? Work Zone Presence Lighting should be considered for any project in an unlighted location or where existing lighting cannot be maintained during construction and the project will involve lane closures or shifts, or contractor activity will be proximate to the travel way.

Are there Standard Specifications or Special Provision? INDOT has developed a sample unique special provision that may be used, see Appendix J.

What should be considered in developing the MOT plans? The location, number, spacing, and mounting height of the light assemblies should be shown on the plans, Typically, temporary presence lighting will start about ½ mile in advance of the first lane merge, lane shift, or contractor activity the driver will encounter and then may be extended through the work depending on the needs specific to each work zone (e.g. if the contractor will be working close to the open travel lanes, presence lighting through the work zone may be needed) Lumen (light) output varies from model to model and must be considered to determine number and spacing.

What are the operational considerations? The support stands may be more stable on paved surfaces rather than on ground. The contractor or construction staff should drive the work zone after the lighting is installed to check for hot or dark spots and glare and make necessary adjustments to placement.

What type of maintenance activities are needed? Batteries or generators should be maintained per manufacturers recommendations.

CLOSED CIRCUIT TELEVISION

What is Closed Circuit Television? For work zones, Closed Circuit Television (CCTV) provides real time information through video surveillance of traffic and roadway conditions to those involved in implementation or mitigation of adverse conditions. Trailer supported, solar/battery powered cameras are placed at locations of interest such as merge tapers or work vehicle ingress/egress points. Typically, these cameras have both daytime and nighttime light sensitivity and send video images through the internet to a laptop, tablet, smart phone, or TV monitor at one or more designated locations (offices).

When is it used? CCTV should be considered when queuing is expected approaching the work zone or when work vehicle ingress and egress within the construction limits will be frequent. CCTV may also be considered for protection of contractor's equipment and material storage areas.

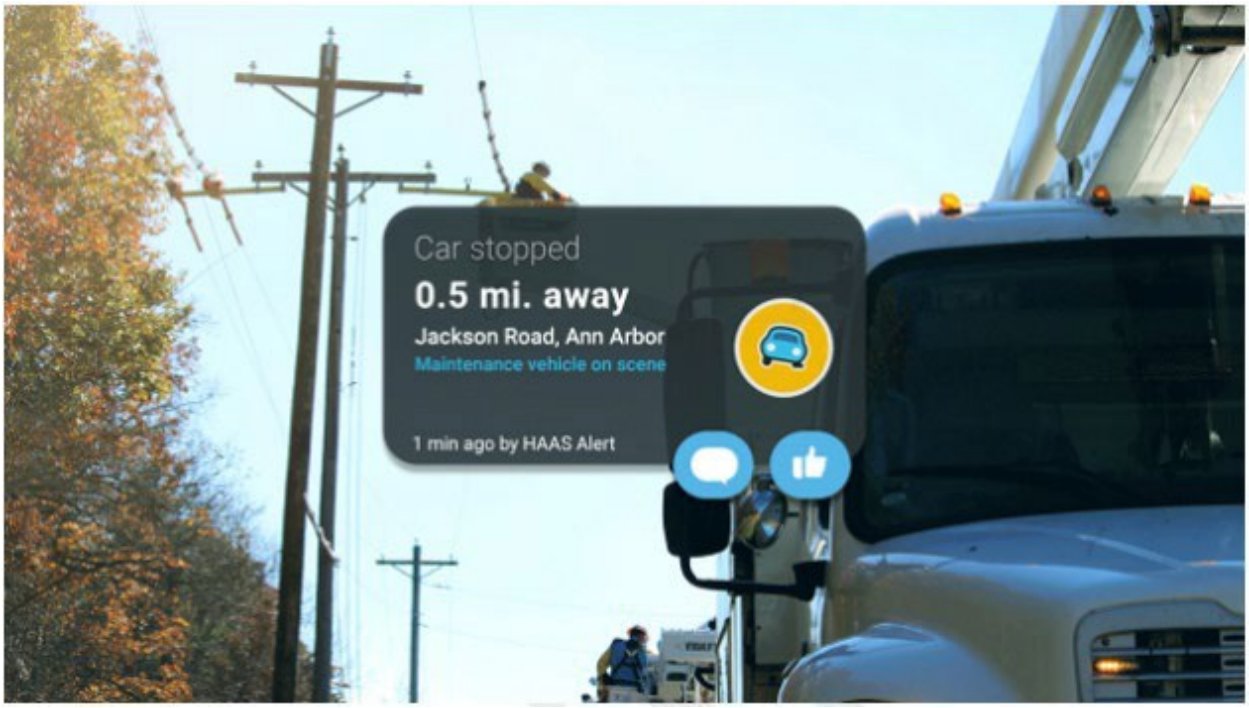
Are there Standard Specifications or Special Provisions? INDOT has developed a sample unique special provision that may be used, see Appendix K.

What should be considered in developing the MOT plans? The recipient(s) of the images should be identified, this may include the project managers for both the contractor and INDOT as well as INDOTs Traffic Management Center (TMC). The location of the trailer and orientation of the camera should be shown on the plans for each MOT phase. The designer should note that INDOT has permanent surveillance cameras in place at many interstate interchanges in the automated traffic management system (ATMS) areas (Greater Indianapolis, Lake Co, Falls City area) - pending work zone location and the prompting need use of these permanent cameras can be coordinated with the TMC.

What are the operational considerations? The trailers should be placed behind existing barrier if available or if not the corners of the trailer should be delineated with drums.

What type of maintenance activities are needed? Camera lenses may need to be periodically cleaned, typically this should occur every three or four months but the camera manufacturers recommendations on cleaning cycle and method should be followed. Battery maintenance or replacement per the manufacturer's recommendations. They will need to be recharged more frequently if in use over winter, typically November through February.

DIGITAL VEHICLE ALERT SYSTEM



What is a digital vehicle alert system? A Digital Alert System informs drivers of the presence of work or emergency response vehicles through a device (transponder) that is installed on the work or emergency vehicle. The transponder sends an alert message when a work or emergency vehicle is either approaching the work zone (within approximately 30 seconds) or is already in the work zone. The message is sent via the Cloud to drivers of vehicles equipped with onboard navigation systems or through an app on a hands-free smart phone.

When is it used? Digital vehicle alert systems should be considered when the work zone will experience high traffic volumes, unusual geometry, a high frequency of work vehicle ingress/egress or where there are numerous work vehicle access points.

Are there Standard Specifications or Special Provisions? INDOT has developed a sample unique special provision that may be used, see Appendix L.

What should be considered in developing the MOT plans? The designer should specify the number of transponders needed and should coordinate with the emergency responders - law enforcement, fire departments, ambulance services, towing providers, etc. - on their needs and willingness to use the system.

What are the operational considerations? Once the alert system is connected to a vehicle's warning lights, no further action is required to activate or deactivate the alert system.

What type of maintenance activity is needed? No maintenance or calibration of the alert system is needed.

Appendix A

801-T-2xx TEMPORARY SPEED DISPLAY ASSEMBLY

(Adopted xx-xx-21)

Description

This work shall consist of furnishing, installing, and maintaining a solar powered, temporary speed display assembly, at the locations shown on the plans or where directed by the Engineer, in accordance with 105.03.

Materials

Materials shall be in accordance with 801.02 and the Indiana MUTCD. The temporary speed display assembly shall be an all-weather, self-contained unit. The signs shall be installed on a mounted moveable stand or trailers in accordance with 910.14(f). Signs shall be in accordance with 919.01

Construction Requirements

Each temporary speed display assembly shall be installed in accordance with 801.15(c) and the manufacturer recommendations. Each unit installed shall consist of a driver speed feedback digital display and a static legend that reads "YOUR SPEED" or "YOUR SPEED IS". Each temporary speed display assembly shall require solar power and be normally dark. The display shall be illuminated and have reflective properties for day readability and automatic dimming for nighttime readability. Speed measurement shall be by radar and provide a detection distance of 1/4 to 1/2 mile. The radar speed display sign assembly shall be FCC Part 15 compliant.

The speed indicator display shall face approaching traffic and shall have a static sign legend of either "Your Speed" or "Your Speed is" above the speed display. The static sign legend and border shall he black on either white or yellow background. "The digital display between the fixed messages shall show two digits, 00 to 99. The minimum height of the numerals shall be 11 in. for conventional roads and 18 in. for freeways and expressways, and the nominal legibility distance shall be at least 750 ft. A R2-1-B sign displaying either the worksite speed limit with a "Worksite" plaque or the permanently posted speed limit shall be placed above the digital display.

The unit shall be programmable for the posted speed limit and threshold speed. The threshold speed shall be set at 10 mph above the posted speed for roadways with speeds under 45 mph and at 20 mph above the posted speed for roadways with speeds 45 mph or greater. The sign shall activate when the speed limit of the roadway is exceeded by one mph and flash the driver speed at a rate of 50 cycles per minute. When the detected speed exceeds the threshold speed the display shall go dark or display the message "SLOW DOWN". If the detected speed is less than or equal to the posted speed, the message "THANK YOU" may be displayed.

The speed indicator measurement and display functions shall be equipped with a power supply capable of providing 24 hours of uninterrupted service.

The Contractor shall provide all preventive maintenance effort in accordance with 107.12.

Method of Measurement

Temporary speed display assemblies will be measured by the number of units installed.

Basis of Payment

Temporary speed display assemblies will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Temporary Speed Display Assembly	EACH

The cost of materials, transportation, placement, and all incidentals to provide a working temporary worksite speed display assembly shall be included in the cost of the pay item.

Appendix B

VARIABLE SPEED LIMIT SIGN ASSEMBLY

Description

This work shall consist of furnishing, installing, and operating a Variable Speed Limit (VSL) Sign Assembly. The VSL Sign Assembly shall consist of the following components: signs, trailer, power supply and control. The VSL Sign Assemblies shall comply with the MUTCD.

Materials

Materials shall be in accordance with the following:

Portable Construction Sign Trailer ..... 910.14(f)
Traffic Signs..... 802

The VSL Sign Assembly shall consists of the following components: Signs, Mounting, Power Supply, Cellular Modem and Controls.

Signs

One 48” x 60” Speed Limit sign (R2-1) with a numerical digital display legend, and one 48” x 16” WORKSITE (XG20-5P) plaque shall be provided with the VSL Sign Assembly. The XG20-5P plaque shall be horizontally centered with and vertically above and immediately adjacent to the R2-1 sign.

The color of the digital display legend portion of the R2-1 sign shall be a white legend on a black background. The minimum pixels per character (numeral) on the digital display legend of the R2-1 sign shall be 5 wide by 7 high. The digital display legend portion of the R2-1 sign shall automatically adjust brightness under varying light conditions to maintain legibility. Speed limit values shown on the digital display legend shall continuously display without animation; however, the digital display legend may experience a brief blanking, up to 10 seconds, only during the digital display legend user input utilizing the hard-wired hand control.

The digital display legend of the R2-1 sign shall be wired so that it can be blanked out or changed between the original posted speed and the approved reduced speed limit(s) (and between two reduced speed limits) in conjunction with implementation of a work zone speed zone while using a hand control hard wired to the VSL Sign Assembly.

Sign mounting shall be in accordance with the MUTCD and shall be such that the bottom of the R2-1 sign shall be a minimum of 7 feet above the roadway.

All sign colors and sheeting types shall be in accordance with the MUTCD.

Trailer

The VSL Sign Assembly shall be trailer mounted. No portion of the trailer or attachments shall physically or visually block any portion of the sign assembly or Speed Limit from road users approaching the sign. The mounting

method shall be suitably stable such as to prevent movement due to high winds or passage of large vehicles.

The trailer shall support the VSL assembly during transportation on when placed into position under 80 mph wind loadings. The trailer shall be equipped with devices which shall provide leveling and stability during operation.

The trailer shall be equipped with a sight tube aiming device, installed parallel to the Speed Limit Sign and digital display legend beams, to ensure optimum VSL Sign Assembly positioning for oncoming driver visibility when scoped to be in alignment with oncoming target traffic.

Power Supply

The VSL Sign Assembly shall be solar powered. Solar powered battery units shall have a minimum no-charge-life of 30 days. No-charge-life is defined as the number of consecutive days that the system can continue to properly function starting with a full battery charge and with no additional charge provided by the solar cells.

The power supply and hand control enclosure shall be tamper and vandal resistant.

Controls

The VSL Sign Assembly shall be locked so that unauthorized users cannot tamper with the power supply and hand controls.

The VSL Sign Assembly shall have an on/off power switch that controls the power supply to the digital display.

The VSL Sign Assembly shall include a hand control hard wired to the unit capable of changing and blanking out the legend of the digital display legend portion of the R2-1 speed limit sign.

Software

Software shall be secure so that unauthorized users cannot tamper with the system or change the speed limits displayed.

The VSL Sign Assembly shall maintain an accurate clock, communicate via cellular connection and provide the following minimum functionality and Activity Record:

1. History of Activity and Location. For each VSL Sign Assembly, a record of all activity shall be automatically recorded with an electronic log. For each activity entry, include:

    a. Unique VSL Sign Assembly name/code relating to each activity Entry;
    b. Time/date stamp for each activity entry (legend display change, GPS position, etc.);
    c. GPS position (latitude/longitude) of the DSL Sign Assembly foreach activity entry;
    d. Directional orientation of the DSL Sign Assembly sign face (reported in quadrant bearing format from true north, example: N 35° E) for each activity entry;
    e. Description of the digital display legend on the R2-1 sign for each activity entry;
    f. Unique user name/code relating to each activity entry showing who

implemented each change.

The History of Activity and Location Log shall also include an automatic logging of the GPS (latitude/longitude) of the VSL Sign Assembly. This automatic logging of the GPS shall occur at a rate of once every 10 minutes, with capability to automatically log the data between 2 minutes to 30 minutes. Each automatic GPS activity entry shall also include items 1-6 above.

2. If the cellular communication fails, the log shall indicate "Cellular Communication Failed" within the area(s) relating to number 3 above. All entries relating to items 4, 5, and 6 above shall be blank when a cellular communication fails. Entries relating to items 1 and 2 above shall be appropriately logged.

3. All activity shall be logged from the date/time of initial power connection until the final power disconnection. The software shall capture and automatically produce (without manipulation and upon demand) the History of Activity and Location log with the required data in the Excel spreadsheet file that can be emailed (25 MB or less).

Construction Requirements

The Contractor shall install the VSL at the locations shown on the plans. The Contractor shall program and activate the VSL and keep all history and activation records. The speed displayed shall be to even 5 mph increment. At no time shall the speed displayed be greater than the normal speed limit. A reduced speed limit shall be displayed only when workers are present, traffic is queuing, when lane widths are less than 11 ft, shoulder widths are less than 2 ft, or as directed by the Engineer. The minimum speed displayed shall be 45 mph.

A minimum of three drums shall be placed in front of the trailers for delineation.

Method of Measurement

VSL will be measured by the number of units installed, maintained, and removed.

Basis of Payment

The accepted quantities of VSL will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Variable Speed Limit Sign Assembly	EACH

The cost of the sign, trailer, solar panel, controls, software, and all hardware required shall be included in the cost of the variable speed limit sign assembly.

Appendix C

VARIABLE SPEED LIMIT SIGN ASSEMBLY WITH SPEED FEEDBACK SIGN

Description

This work shall consist of furnishing, installing, and operating a Variable Speed Limit (VSL) Sign Assembly with a vehicle speed feedback sign. The VSL Sign Assembly shall consist of the following components: signs, trailer, power supply and control. The VSL Sign Assemblies shall comply with the MUTCD.

Materials

Materials shall be in accordance with the following:

Portable Construction Sign Trailer ..... 910.14(f)
Traffic Signs 802

The VSL Sign Assembly shall consists of the following components: Signs, Mounting, Power Supply, Cellular Modem and Controls.

Signs

One 48” x 60” Speed Limit sign (R2-1) with a numerical digital display legend, and one 48” x 16” WORKSITE (XG20-5P) plaque shall be provided with the VSL Sign Assembly. The XG20-5P plaque shall be horizontally centered with and vertically above and immediately adjacent to the R2-1 sign.

The color of the digital display legend portion of the R2-1 sign shall be a white legend on a black background. The minimum pixels per character (numeral) on the digital display legend of the R2-1 sign shall be 5 wide by 7 high. The digital display legend portion of the R2-1 sign shall automatically adjust brightness under varying light conditions to maintain legibility. Speed limit values shown on the digital display legend shall continuously display without animation; however, the digital display legend may experience a brief blanking, up to 10 seconds, only during the digital display legend user input utilizing the hard-wired hand control.

The digital display legend of the R2-1 sign shall be wired so that it can be blanked out or changed between the original posted speed and the approved reduced speed limit(s) (and between two reduced speed limits) in conjunction with implementation of a work zone speed zone while using a hand control hard wired to the VSL Sign Assembly.

Sign mounting shall be in accordance with the MUTCD and shall be such that the bottom of the R2-1 sign shall be a minimum of 7 feet above the roadway.

All sign colors and sheeting types shall be in accordance with the MUTCD.

Trailer

The VSL Sign Assembly with Speed Feedback Sign shall be trailer mounted. No portion of the trailer or attachments shall physically or visually block any portion of the sign assembly or Speed Limit from road users approaching the sign. The mounting method shall be suitably stable such as to prevent movement due to high winds or passage of large vehicles.

The trailer shall support the VSL assembly with speed feedback sign during transportation or when placed into position under 80 mph wind loadings. The trailer shall be equipped with devices which shall provide leveling and stability during operation.

The trailer shall be equipped with a sight tube aiming device, installed parallel to the Speed Limit Sign and digital display legend beams, to ensure optimum VSL Sign Assembly positioning for oncoming driver visibility when scoped to be in alignment with oncoming targettraffic.

Power Supply

The VSL Sign Assembly with Speed Feedback Sign shall be solar powered. Solar powered battery units shall have a minimum no-charge-life of 30 days. No-charge-life is defined as the number of consecutive days that the system can continue to properly function starting with a full battery charge and with no additionalcharge provided by the solar cells.

The power supply and hand control enclosure shall be tamper and vandal resistant.

Controls

The VSL Sign Assembly with Speed Feedback Sign shall be locked so that unauthorized users cannottamper with the power supply and hand controls.

The VSL Sign Assembly with Speed Feedback Sign shall have an on/off power switch thatcontrols the power supply to the digital display.

The VSL Sign Assembly with Speed Feedback Sign shall include a hand control hard wired tothe unit capable of changing and blanking out the legend of the digital display legend portion of the R2-1 speed limit sign.

Software

Software shall be secure so that unauthorized users cannot tamper withthe system or change the speed limits displayed.

The VSL Sign Assembly with Speed Feedback Sign shall maintain an accurate clock, communicate via cellular connection and provide the following minimum functionality and Activity Record:

1. History of Activity and Location. For each VSL Sign Assembly with Speed Feedback Sign, a record of all activity shall be automatically recorded with an electronic log. For each activity entry, include:

   a. Unique VSL Sign Assembly name/code relating to each activity Entry;
   b. Time/date stamp for each activity entry (legend displaychange, GPS position, etc.);
   c. GPS position (latitude/longitude) of the DSL Sign Assembly foreach activity entry;
   d. Directional orientation of the DSL Sign Assembly sign face (reported in quadrant bearing format from true north, example:N 35° E) for each activity entry;
   e. Description of the digital display legend on the R2-1 sign foreach activity entry;
   f. Unique user name/code relating to each activity entry showing who implemented each change.

   The History of Activity and Location Log shall also include an automatic logging of the GPS (latitude/longitude) of the VSL Sign Assembly with Speed Feedback Sign. This automatic logging of the GPS shall occur at a rate of once every 10 minutes, with capability to automatically log the data between 2 minutes to 30 minutes. Each automatic GPS activity entry shall also include items 1-6 above.

2. If the cellular communication fails, the log shall indicate "Cellular Communication Failed" within the area(s) relating to number 3 above. All entries relating to items 4, 5, and 6 above shall be blank when a cellular communication fails. Entries relating to items 1 and 2 above shall be appropriately logged.

3. All activity shall be logged from the date/time of initial power connection until the final power disconnection. The software shall capture and automatically produce (without manipulation and upon demand) the History of Activity and Location log with the requireddata in the Excel spreadsheet file that can be emailed (25 MB or less).

Construction Requirements

The Contractor shall install the VSL with speed feedback at the locations shown on the plans. The Contractor shall program and activate the VSL and keep all history and activation records. The speed displayed shall be to even 5 mph increment. At no time shall the speed displayed be greater than the normal speed limit. A reduced speed limit shall be displayed only when workers are present, traffic is queuing, when lane widths are less than 11 ft, shoulder widths are less than 2 ft, or as directed by the Engineer. The minimum speed displayed shall be 45 mph.

Each speed feedback sign shall be installed on the sign assembly in accordance with the manufacturer recommendations. The static legend of the speed feedback sign shall read "YOUR SPEED" or "YOUR SPEED IS". The display shall be illuminated and have reflective properties for day readability and automatic dimming for nighttime readability. Speed measurement shall be by radar and provide a detection distance of 1/4 to 1/2 mile. The speed feedback sign shall be FCC Part 15 compliant.

The speed indicator display shall face approaching traffic. The static sign legend and border shall he black on either white or yellow background. "The digital display between the fixed messages shall show two digits, 00 to 99. The minimum height of the numerals shall be 11 in. for conventional roads and 18 in. for freeways and expressways, and the nominal legibility distance shall be at least 750 ft.

A minimum of three drums shall be placed in front of the trailer for delineation.

Method of Measurement

Variable speed limit sign assembly with speed feedback sign will be measured by the number of units installed,maintained, and removed.

Basis of Payment

The accepted quantities of variable speed limit sign assembly with speed feedback sign will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Variable Speed Limit Sign Assembly with Speed Feedback	EACH

The cost of the signs, trailer, solar panel, controls, software,and all hardware required shall be included in the cost of the variable speed limit sign assembly with speed feedback sign.

Appendix D

DYNAMIC AUTOMATED QUEUE WARNING SYSTEM

Description

This work shall consist of furnishing, installing, relocating, operating, servicing, and removing all components of a dynamic automated queue warning system, DAQWS, in accordance with 105.03 and 801 and as specified herein. The Contractor shall furnish all labor, materials, equipment for a system capable of alerting traffic with the use of Portable Changeable Message Signs, PCMS, in accordance with 801.15, that provide specific real-time lane messages from real-time traffic data collected near the PCMS location.

Materials

Materials shall be in accordance with 801.02 and as follows. All materials used shall meet the manufacturer's specifications and recommendations. The Contractor shall maintain an adequate inventory of parts to support maintenance and repair of the DAQWS.

The DAQWS equipment shall be approved by the Engineer prior to deployment. The Department reserves the right to terminate the DAQWS at any time if it determines the Contractor has not met the responsibilities identified in this specification.

The Contractor shall provide a DAQWS that consists of the following field equipment: portable vehicle speed sensors and PCMS's. The Contractor shall provide a system capable of withstanding inclement weather conditions while continuing to provide adequate battery power. The system must calculate and notify drivers via PCMS's with the appropriate lane message based on real-time traffic data.

The speed sensor shall be capable of collecting traffic speed data. The processed data is used to remotely control PCMS's to display user definable, Engineer approved and locally stored messages. The message trigger state thresholds are user configurable. The PCMS shall be in accordance with 923.05, with the additional capability of supporting communications via modem/radio/CDMA/GPRS for remote message management. The DAQWS Operator local control functions and remote management operations shall be password protected.

Construction Requirements

The Contractor shall maintain this system and shall be readily available to service and maintain system components, move portable devices as necessary and respond to emergency situations. The Contractor shall have oversight responsibility for directing placement of devices in the project area. The Contractor shall be accessible seven days a week and twenty-four hours a day while the system is deployed. The Contractor shall designate an on-site System Coordinator responsible for monitoring the DAQWS throughout all periods of deployment. The Contractor shall provide contact information to the Engineer for the System Coordinator and others responsible for operation and maintenance of the DAQWS prior to installation of the system. The decision to deploy or relocate field equipment will be made by the Engineer and instrumented through the System Coordinator. The decision for equipment removal will be made by the Engineer.

The DAQWS shall be utilized when traffic queueing is anticipated. PCMS

and speed sensor spacing shall be 1 mile apart with a total of 4 speed sensors and 2 PCMS per deployment. When traffic is slow with an average travel speed of less than 45 mph, the PCMS message in advance of the queue shall be "SLOW TRAFFIC AHEAD" in phase 1 and "BE PREPARED TO STOP" in phase 2. When traffic is stopped with an average travel speed of less than 20 mph, the PCMS message in advance of the queue shall be "STOPEED TRAFFIC AHEAD" in phase 1 and "BE PREPARED TO STOP" in phase 2. Other message dialogs are to be approved by the Engineer prior to use. The location of the speed sensors and PCMS shall be as shown on the plans or as directed.

The Contractor shall assume all responsibility for any damaged or inoperative equipment due to crashes, vandalism, adverse weather or other condition that may occur during the contract period.

In the event communication with any field equipment is lost; the Contractor shall provide a means and staff to manually program a PCMS message. If communication is lost for more than 10 consecutive minutes, the system shall revert to a fail-safe ROAD WORK/ X MILES AHEAD message displayed on the PCMSs until communications is restored.

The DAQWS shall be capable of acquiring traffic information and selecting messages automatically without operator intervention after system initialization. The lag time between changes in threshold ranges and the posting of the appropriate PCMS messages shall be no greater than 60 seconds. The system operation and accuracy must not be appreciably degraded by inclement weather or degraded visibility conditions including precipitation, fog, darkness, excessive dust, and road debris.

The Contractor shall provide read only access to the Department to the system software. The Department will have access to the system status and to download recorded data. The Department will require a minimum of three individuals accessing the system.

The Contractor may be assessed damages for failure to maintain the required software access to the Department. For each day, or portion thereof, during which the Department does not have software system access, damages will be assessed at the rate of $1000 per day. Non-compliance caused by events beyond the control of the Contractor may not be assessed damages.

Equipment Maintenance

The Contractor shall maintain all system components in good working condition at all times. The Contractor shall repair or replace damaged or malfunctioning components, at no cost to the Department, as soon as possible and within 24 hours of notification by the Engineer. The Contractor shall periodically clean the PCMS.

The Contractor may be assessed damages for failure to maintain the DAQWS in good working condition. For each day, or portion thereof, during which the DLLMS is not functioning properly, damages will be assessed at the rate of $1000 per day.

Method of Measurement

The dynamic automated queue warning system including speed sensors, remote access software, doppler unit and all supporting field equipment will be measured by the number of the DAQWS units installed, maintained and removed.

Portable changeable message signs will be measured in accordance with

801.17.

Basis of Payment

The accepted quantities of the dynamic automated queue warning system will be paid for at the contract unit price per each. The accepted quantities of portable changeable message signs will be paid in accordance with 801.18.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Dynamic Automated Queue Warning System	EACH
Dynamic Automated Queue Warning System, Relocate	EACH

The cost of all materials including speed sensors, remote access software and all supporting field equipment shall be included in the cost of the dynamic automated queue warning system. The cost shall include furnishing all labor, equipment and materials for the installation, maintenance and removal of speed sensors and supporting field equipment.

The cost to relocate the dynamic automated queue warning system from one direction of traffic to the other shall be included in the cost of the dynamic automated queue warning system, relocate. The cost shall include furnishing all labor, equipment and materials for the installation, maintenance and removal of speed sensors and supporting field equipment. Relocation of the Dynamic Automated Queue Warning System will only be paid for when it is relocated to a different direction of travel.

Appendix E

TEMPORARY REAL TIME TRAVEL SIGNS

Description

This work shall consist of furnishing, installing, relocating, operating, servicing, and removing all components of a temporary travel time sign, TTTS, in accordance with 105.03 and 801 and as specified herein. The Contractor shall furnish all labor, materials, equipment for a system capable of providing traffic with real time travel information where delays are anticipated.

Materials

Materials shall be in accordance with 801.02 and as follows. All materials used shall meet the manufacturer's specifications and recommendations. The Contractor shall maintain an adequate inventory of parts to support maintenance and repair of the TTTS.

The TTTS equipment shall be approved by the Engineer prior to deployment.

The Contractor shall provide a TTTS that consists of the following field equipment: speed sensors to detect travel speeds and a portable changeable message sign, PCMS, equipped to receive data from the speed sensors and display relevant messages before traffic approaches the work zone. The TTTS shall be fully automated from detecting work vehicles to displaying messages on the PCMS.

Construction Requirements

The PCMS for the TTTS shall be located 2 miles upstream of the work zone. The speed sensors shall be located ½ mile apart so that they accurately detect average travel speeds and can provide the PCMS with current travel time information. The PCMS message shall be "TIME TO EXIT 123 XX MIN". Alternate route information shall be used with a message of "ALT RTE EXIT 121" in phase 2 and a message of "TO STATE ST" in phase 3. Other message dialogs are to be approved by the Engineer prior to use. The location of the speed sensors and PCMS shall be as shown on the plans or as directed.

The Contractor assumes all responsibility for any damaged or inoperative equipment due to crashes, vandalism, adverse weather or other condition that may occur during the contract period.

Method of Measurement

The temporary real-time travel sign will be measured by the number of the DLLMS units installed, maintained and removed.

Portable changeable message signs will be measured in accordance with 801.17.

Basis of Payment

The accepted quantities of temporary real-time travel sign will be paid for at the contract unit price per each. The accepted quantities of portable changeable message signs will be paid in accordance with 801.18.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Temporary Real-Time Travel Sign.....	EACH

The cost of all materials including speed sensors and all supporting field equipment shall be included in the cost of the temporary real-time travel sign.

Appendix F

DYNAMIC LATE LANE MERGE SYSTEM

Description

This work shall consist of furnishing, installing, relocating, operating, servicing, and removing all components of a dynamic late lane merge system, DLLMS, in accordance with 105.03 and 801 and as specified herein. The Contractor shall furnish all labor, materials, equipment for a system capable of allowing traffic to use both lanes approaching a lane reduction and then alternate into one lane at the merge point with the use of Portable Changeable Message Signs, PCMS, in accordance with 801.15, that provide specific real-time lane messages from real-time traffic data collected near the PCMS location.

Materials

Materials shall be in accordance with 801.02 and as follows. All materials used shall meet the manufacturer's specifications and recommendations. The Contractor shall maintain an adequate inventory of parts to support maintenance and repair of the DLLMS.

The DLLMS equipment shall be approved by the Engineer prior to deployment. The Department reserves the right to terminate the DLLMS at any time if it determines the DLLMS is not reducing the vehicle queuing, or the Contractor has not met the responsibilities identified in this specification.

The Contractor shall provide a DLLMS that consists of the following field equipment: portable vehicle speed sensors and PCMS's. The Contractor shall provide a system capable of withstanding inclement weather conditions while continuing to provide adequate battery power. The system must calculate and notify drivers via PCMS's of the appropriate lane message based on real-time traffic data.

The speed sensor shall be capable of collecting traffic speed data. The processed data is used to remotely control PCMS's to display user definable, Engineer approved and locally stored messages. The message trigger state thresholds are user configurable. The PCMS shall be in accordance with 923.05, with the additional capability of supporting communications via modem/radio/CDMA/GPRS for remote message management. The DLLMSS Operator local control functions and remote management operations shall be password protected.

Construction Requirements

The Contractor shall maintain this system and shall be readily available to service and maintain system components, move portable devices as necessary and respond to emergency situations. The Contractor shall have oversight responsibility for directing placement of devices in the project area. The Contractor shall be accessible seven days a week and twenty-four hours a day while the system is deployed. The Contractor shall designate an on-site System Coordinator responsible for monitoring the DLLMS throughout all periods of deployment. The Contractor shall provide contact information to the Engineer for the System Coordinator and others responsible for operation and maintenance of the DLLMS prior to installation of the system. The decision to deploy or relocate field equipment is made by the Engineer and instrumented through the System Coordinator. The decision for equipment removal is made by the Engineer.

The DLLMS shall be utilized when traffic lanes are reduced. PCMS and speed sensor spacing shall be 1 mile apart with a total of 2 speed sensors and

2 PCMS per deployment. When traffic is slow with an average travel speed of less than 45 mph, the PCMS message in advance of the merge point shall be "SLOW TRAFFIC AHEAD" in phase 1 and "USE BOTH LANES" in phase 2. The PCMS message at the merge point shall be "MERGE HERE" in phase 1 and "TAKE TURNS" in phase 2. When traffic is stopped with an average travel speed of less than 20 mph, the PCMS message in advance of the merge point shall be "STOPPED TRAFFIC AHEAD" in phase 1 and "USE BOTH LANES" in phase 2. The PCMS message at the merge point shall be "MERGE HERE" in phase 1 and "TAKE TURNS" in phase 2. Other message dialogs are to be approved by the Engineer prior to use. The location of the speed sensors and PCMS shall be as shown on the plans or as directed.

The Contractor assumes all responsibility for any damaged or inoperative equipment due to crashes, vandalism, adverse weather or other condition that may occur during the contract period.

In the event communication with any field equipment is lost; the Contractor shall provide a means and staff to manually program a PCMS message. If communication is lost for more than 10 consecutive minutes, the system shall revert to a fail-safe ROAD WORK/ X MILES AHEAD message displayed on the PCMSs until communications is restored.

The DLLMS shall be capable of acquiring traffic information and selecting messages automatically without operator intervention after system initialization. The lag time between changes in threshold ranges and the posting of the appropriate PCMS messages shall be no greater than 60 seconds. The system operation and accuracy must not be appreciably degraded by inclement weather or degraded visibility conditions including precipitation, fog, darkness, excessive dust, and road debris.

The Contractor shall provide read only access to the Department to the system software. The Department will have access to the system status and to download recorded data. The Department will require a minimum of three individuals accessing the system.

The Contractor may be assessed damages for failure to maintain the required software access to the Department. For each day, or portion thereof, during which the Department does not have software system access, damages will be assessed at the rate of $1000 per day. Non-compliance caused by events beyond the control of the Contractor may not be assessed damages.

Equipment Maintenance

The Contractor shall maintain all system components in good working condition at all times. The Contractor shall repair or replace damaged or malfunctioning components, at no cost to the Department, as soon as possible and within 24 hours of notification by the Engineer. The Contractor shall periodically clean the PCMS.

The Contractor may be assessed damages for failure to maintain the DLLMS in good working condition. For each day, or portion thereof, during which the DLLMS is not functioning properly, damages will be assessed at the rate of $1000 per day.

Method of Measurement

The dynamic late lane merge system including speed sensors, remote access software, and all supporting field equipment will be measured by the number of the DLLMS units installed, maintained and removed.

Portable changeable message signs will be measured in accordance with

801.17.

Basis of Payment

The accepted quantities of the dynamic late lane merge system will be paid for at the contract unit price per each. The accepted quantities of portable changeable message signs will be paid in accordance with 801.18.

Payment will be made under:

Pay Item	Pay Unit Symbol
Dynamic Late Lane Merge System	EACH
Dynamic Late Lane Merge System, Relocate	EACH

The cost of all materials including speed sensors, remote access software and all supporting field equipment shall be included in the cost of the dynamic late lane merge system. The cost shall include furnishing all labor, equipment and materials for the installation, maintenance and removal of speed sensors and supporting field equipment.

The cost to relocate the dynamic late lane merge system from one direction of traffic to the other shall be included in the cost of the dynamic late lane merge system, relocate. The cost shall include furnishing all labor, equipment and materials for the installation, maintenance and removal of speed sensors and supporting field equipment. Relocation of the dynamic late lane merge system will only be paid for when it is relocated to a different direction of traffic.

Appendix G

TRUCKS FOR ADVANCED QUEUE AWARENESS

Description

This work shall consist of strategic and ongoing placement, operation, and repositioning of Queue Trucks pursuant to INDOT's "Protect the Queue" Program in where queue is present in advance of work zones where stopped or slowed traffic presents risk to motorists and workers caused by the speed differential between approaching traffic and traffic traversing the work area. This work shall include a Queue Truck and operator who is actively assessing the queue, providing a designated graphic and message, and repositioning the vehicle to provide awareness of the traffic queue resulting from construction operations. This work shall be in accordance with 105.03and any stipulations listed in Interstate Highway Congestion Policy Exceptions associated with this contract.

Materials

Materials shall be in accordance with 801.02 and as described herein.

Traffic Quality Control Means and Methods Coordination Submittal (TQCMMCS)

For each phase, the Contractor and the Engineer shall meet to discuss the deployment of the queue truck for that phase. Subsequently, the Contractor shall provide a TQCMMCS as an acknowledgement of the means and methods that incorporates the Traffic Control Plan (TCP) in the Contract Documents or provided by the Engineer. This shall include initial start times, initial truck placements, the anticipated daily duration of queue truck deployment, and the planned schedule of deployment (calendar or workdays).

The TQCMMCS shall be prepared in acknowledgment of the MOT Plans and INDOT Standards and shall consider the predicted queue lengths and durations of queue listed in the Contract Information Book or the Interstate Highway Congestion Policy (IHCP) Exception. Additionally, the TQCMMCS shall address the configuration of the work zone including detour routes, and proposed initial locations for deployment, and staging of the Queue Truck(s). If queue predictions are not stated in the Contract Information Book or not provided in the IHCP Exception, queue predictions will be provided by the Engineer when requested. Finally, the TQCMMCS shall address interchange ramp control, the staging of vehicles in standby for cases when queue dissipates, and other specific concerns discussed between the Contractor and the Engineer prior to submittal. The Engineer will provide concurrence with the TQCMMCS or provide detailed guidance and request revision.

Construction Requirements

The implementation of Trucks for Advanced Queue Awareness shall be in accordance with the TQCMMCS for each phase of construction. The Contractor shall obtain from the Engineer concurrence with the TQCMMCS before beginning each phase of work. Start times and initial truck placement shall be confirmed either daily with the Engineer, as agreed at the Pre-Construction Meeting, or as agreed during the execution of the contract.

Queue Truck Operators shall complete the INDOT TRAINING VIDEO FOR QUEUE AWARENESS available on the INDOT Protect the Queue Website (https://wwwhttps://www.in.gov/indot/safety/protect-the-queue-indots-queue-awareness-program/) and register online with an affirmation that they have completed the training and shall adhere to the requisite queue awareness practices discussed herein. Queue Truck Operators shall reposition the Queue Truck(s) as necessary as the queue develops and diminishes in accordance with this specification and the TQCMMCS. Queues are considered present when either there is stopped or slowed traffic approaching the work zone. This is evident by the presence of brake lights denoting slowing of vehicles. Queue Truck Operators shall position their Queue Truck(s) on the shoulder of the side of the roadway where the work is performed or where directed by the Engineer. Queue Truck Operators shall actively monitor traffic flow approaching the work zone to maintain a position that is approximately 1/4 mile before the location where braking is observed approaching the queue.

When a second Queue Truck is designated, the TQCMMCS shall show the initial placement of the second Queue Truck approximately 2-miles in advance of the first. Both Queue Trucks shall continuously maintain a position for optimal placement relative to the queue. When the queue rapidly expands, overtaking the Queue Truck nearest to the queue, the overtaken Queue Truck shall discontinue messaging and the trailing Queue Truck shall move into the advance position. The overtaken Queue Truck shall drive-out, double-back, and reposition into the trailing position, approximately 2-miles in advance of the leading Queue Truck.

When no queue is present, the Queue Truck Operators shall position themselves in locations designated in the TQCMMCS. INDOT's "Protect the Queue" signing shall be stowed when no queue is present such that is not visible to motorists. Queue Truck Operators shall notify the Engineer and be available by phone to receive instruction from the Engineer. Queue Truck Operators shall monitor INDOT's DeltaSpeed website (https://deltaspeed.trafficwise.org/) and also Google Maps with the Traffic Layer activated (https://google.com/maps) from their Queue Truck to verify the progression of traffic to attempt to determine the development of a queue so they can redeploy to provide queue awareness.

Queue Truck Operators shall implement all aspects of the notification, warning, messaging, and vehicle awareness provided for in this specification and the TQCMMCS when deployed in their efforts to alert motorists of the queue. When no queue is present, Queue Truck Operators shall discontinue active notifications. Queue Trucks should only be conspicuous when a queue exists or is developing.

The Contractor shall provide Queue Trucks for each instance where the TCP calls for Queue Trucks in the quantities noted in the Contract Information Booklet.

The Contractor shall provide notice to the Department and the Indiana State Police (ISP) three working days prior to commencing work which may develop a queue, necessitating a need for Queue Trucks. The Contractor's notice shall include the general location, time, and date where a queue or queues may develop.

Equipment

Queue Truck: Queue Trucks shall consist of a commercial chassis truck (>= 16,000 LB GVWR).They shall include signing with INDOT's designated "Protect the Queue" imagery and lighting package for Queue Trucks including:

- A metal sign 96” wide and 48” tall, secured to the vehicle in a manner that ensures the safe operation of the vehicle at highway speeds, as provided for in the design of the Queue Truck.
- Four, Whelen Strip-Lite Plus Series SmartLED® WARNING DUO Model: PSD02FCR 12V RED/WHT flasher lights (or equivalent) shall be installed in accordance with the INDOT’s “Protect the Queue” Truck Detail. The operation of the flasher lights shall be managed by a Whelen ULF44, 4 Channel LED Flasher device. The lights shall be placed in solid mode to allow the flasher to operate properly using the ULF44 device. The ULF44 flasher shall be set to operate the Action Flash 41 pattern.
- The flasher lights shall be operable from inside the vehicle using conventional wiring or wireless devices. Lighting packages shall include a dawn-to-dusk dimmer operation, managed from the Whelen Flasher, to avoid excessive lighting during nighttime operations.
- 6” 3M™ Diamond Grade™ Emergency Vehicle Markings 983-72NL or equivalent, alternating red and yellow, shall be installed in an upside down “V” fashion in accordance with emergency vehicle marking schemes, at a 45-degree angle making a right angle and the vertical of the center of the sign in accordance with the Queue Truck Detail. Printed sign material shall not be used to ensure that the robust color desired is attained.
- A 30” W3-4 “BE PREPARED TO STOP” sign shall be mounted in the center of the image; the color shall be FLOURESCENT PINK in accordance with Chapter6I of the Indiana MUTCD and the Queue Truck Detail.
- These signs shall be configured in a manner that does not interfere with brake and reverse lighting ensuring safe operation.

These packages shall be integral to the Queue Truck and INDOT’s “Protect the Queue” imagery shall be placed in a conspicuous location in the bed of the truck when in use. They shall include a retractable truck mounted attenuator suitable for the commercial chassis, in accordance with the applicable attenuator manufacturer specifications. Trailer attenuators are prohibited because Queue Truck Operators shall not be able to reposition their vehicles in reverse using trailer attenuators. INDOT’s “Protect the Queue” imagery and lighting package may remain on the vehicle when not in use, but it shall be obfuscated by the retracted attenuator when not actively providing queue awareness.

Queue Trucks shall include a truck-mount message sign (WANCO Model WVMB Large Display, or equivalent) for messaging as directed by the Engineer. The message sign shall be positioned so that it does not the conspicuity of the “BE PREPARED TO STOP” sign and shall conform with the IMUTCD.

All queue trucks shall comply with length requirements designated in Indiana Code 9-20-3-4. All Queue Trucks shall be approved in advance by the Engineer prior to initial deployment on the Project.

The default message displayed on message boards during active queue awareness deployment shall be “SLOW TRAFFIC AHEAD”. Other messages or graphics (such as an arrow) shall be pre-programmed as options and may be used when directed by Engineer, as approved in the TQCMMCS, or as directed by the INDOT Traffic Management Center operations personnel.

All Queue Trucks shall be equipped with a HAAS Transmitter to report activity to the WAZE TRAFFIC APPLICATIONS. Other transmitters, such as iCone’s Connected tech product (used with their Arrow Panel Kits), may be used provided they are able to deliver data to WAZE and GOOGLE TRAFFIC

APPLICATIONS.

All Queue Trucks shall be equipped with a rear camera with a monitor capable of continuous operation, irrespective of transmission function, allowing the Queue Truck Operator to continuously monitor approaching traffic – even when INDOT's "Protect the Queue" imagery is deployed and visible to motorists.

Method of Measurement

Queue Trucks will be measured by the number of days each truck is deployed. A day, for purpose of payment, is an 8-hour continuous period, per truck. Each deployment shall be at a minimum duration of 4-hours for each truck in use. Additional time will be paid in 1/4-day (2 hour) increments. When queues exist for less than the designated time, Queue Trucks will remain in standby for the remainder of the approved period or until queues return.

Basis of Payment

The accepted quantity of Queue Trucks will be paid for at the contract unit price per day.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Queue Truck (ea)	DAY

The cost of all labor, equipment and all incidental work shall be included in the cost of the pay item.

Appendix H

TRUCK ENTRY WARNING SYSTEM

Description

This work shall consist of furnishing, installing, relocating, operating, servicing, and removing all components of a truck entry warning system, TEWS, in accordance with 105.03 and 801 and as specified herein. The Contractor shall furnish all labor, materials, equipment for a system capable of alerting traffic that work vehicles in a work zone are preparing to exit the work zone and merge with traffic.

Materials

Materials shall be in accordance with 801.02 and as follows. All materials used shall meet the manufacturer's specifications and recommendations. The Contractor shall maintain an adequate inventory of parts to support maintenance and repair of the TEWS.

The TEWS equipment shall be approved by the Engineer prior to deployment.

The Contractor shall provide a TEWS that consists of the following field equipment: sensor trailer to detect work vehicles leaving the work zone and a portable changeable message sign, PCMS, equipped to receive data from the sensor trailer and display relevant messages before work vehicles enter the travel way from the work zone. The TEWS shall be fully automated from detecting work vehicles to displaying messages on the PCMS.

Construction Requirements

The PCMS for the TEWS shall be located 1/2 mile upstream of the truck entry point. The sensor trailer for the TEWS shall be located so that it accurately detects work vehicles leaving the work zone and activate the PCMS before the work vehicles are in the travel lane. When activated, the PCMS message shall be "TRUCK ENTERING" in phase 1 and "MOVE LEFT" in phase 2 or "SLOW DOWN" in phase 2 during times when traffic is at or near capacity.

The Contractor assumes all responsibility for any damaged or inoperative equipment due to crashes, vandalism, adverse weather or other condition that may occur during the contract period.

Method of Measurement

The truck entry warning system including the sensor trailer, PCMS, and all supporting field equipment will be measured by the number of calendar days the system is in place.

Basis of Payment

The accepted quantities of truck entry warning system will be paid for by the number of calendar days the system is in place.

Payment will be made under:

Pay Item	Pay Unit Symbol
Truck Entry Warning System.....	DAY

The cost of all materials including sensor trailer, PCMS and all supporting field equipment shall be included in the cost of the truck entry warning system.

Appendix I

SMART FLASHING ARROW SIGN

Description

This work shall consist of furnishing, installing, relocating, operating, servicing, and removing a smart flashing arrow sign, in accordance with 105.03 and 801 and as specified herein. The Contractor shall furnish all labor, materials, equipment for a smart flashing arrow sign capable of providing lane closure information to the Department and road users with connected vehicles or technology.

Materials

The smart flashing arrow sign shall be in accordance with 801.02 and the following requirements.

The Contractor shall provide a smart flashing arrow sign with the ability to record activation history and provide GPS location along with the direction of the arrow and the side of the road where deployed to the Department, to third party location-based data or navigation companies, and to any compatible connected vehicles.

The activation history shall be capable of displaying where the smart flashing arrow sign is deployed, which mode it is in, and the direction of the arrow and side of the road where deployed.

Construction Requirements

The smart flashing arrow sign shall provide real-time activation information to the Department and at least one third party location-based data or navigation company.

The Contractor may be assessed damages for failure to maintain the required software access to the Department. For each day, or portion thereof, during which the Department does not have software system access, damages will be assessed at the rate of $500 per day. Non-compliance caused by events beyond the control of the Contractor may not be assessed damages.

Method of Measurement

The smart flashing arrow sign, remote access software, and all supporting field equipment will be measured by the number of calendar days each unit is operated.

Basis of Payment

Smart flashing arrow signs will be paid for at the contract unit price per day per each.

Payment will be made under:

Pay Item	**Pay Unit Symbol**
Flashing Arrow Sign, Smart.....	EACH

The cost of all materials including, remote access software and all supporting field equipment shall be included in the cost of the smart flashing arrow sign. The cost shall include furnishing all labor, equipment and materials for the installation, maintenance and removal of the smart flashing arrow sign.

Appendix J

WORK ZONE PRESENCE LIGHTING

Description

This work shall consist of furnishing, placing, and maintaining work zone presence lighting on the approaches to and at lane merges, median crossovers, lane transition areas, or at other locations shown on the plans in accordance with 105.03.

Materials

Materials shall be in accordance with 801.13 and the following:

Work zone presence lighting shall be portable – either stand or trailer mounted – and powered by either a generator or battery that is solar charged. The support shall be capable of providing an 18 ft mounting height at minimum. The trailer or support base shall have leveling mechanism that allows the mast to be plumb. The trailer shall be orange

The luminaires may be either flood or balloon type, shall provide a minimum output of 14,000 lumens, and shall be designed to limit glare. Flood style luminaires shall be dimmable. The light source shall provide a Correlated Color Temperature between 4000°K and 6000°K.

Construction Requirements

The work zone presence lighting system shall be installed and activated a minimum of one-half hour prior to the closure of the lane.

The first work zone presence light shall be placed approximately 1- 1/2 miles in advance of the beginning of the lane marge taper, the spacing of the other units shall be noted in this table Area 1 is the farthest from the lane merge:

Light Output (lumens)	Area 1		Area 2	
	No of Lights	Spacing (ft)	No. Of Lights	Spacing (ft)
14,000 – 35,000	6	640	8	480
35,100 – 60,000	5	800	6	640
>60,000	4	1000	5	800

The mounting height shall be a minimum of 18 ft. The luminaires shall be aimed perpendicular to the travel lanes.

Trailers that are not located behind barrier wall or guardrail shall be delineated by a drum at each corner.

Method of Measurement

The work zone presence lighting will be measured by the number of units installed, maintained, and later removed.

Basis of Payment

The work zone presence lighting will be paid for at the contract unit price per each.

Payment will be made under:

Pay Item **Pay Unit Symbol**

Work Zone Presence Lighting..... EACH

Appendix K

TEMPORARY CCTV SURVEILLANCE

Description

This work shall consist of providing closed-circuit television, CCTV, surveillance using one or more portable camera trailers to remotely monitor work zones in accordance with 105.03

Materials

The temporary CCTV surveillance equipment shall be in accordance with 801.02 and the following requirements.

The camera for the temporary CCTV surveillance shall include light sensitivity for operation during the day and at night and the ability to record video.

The portable camera trailer shall have a minimum telescopic mast height of 30 ft and shall be designed to withstand a 60 mph wind loading with a 1.3 gust factor when the temporary CCTV is operating. The trailer shall be painted or powder coated safety orange, SAE-AMS-STD-595, color No. 12300. The trailer shall include a minimum of two leveling jacks for stabilization.

Construction Requirements

The temporary CCTV surveillance shall provide real-time work zone information to the Department.

The Contractor may be assessed damages for failure to maintain the required software access to the Department. For each day, or portion thereof, during which the Department does not have software system access, damages will be assessed at the rate of $500 per day. Non-compliance caused by events beyond the control of the Contractor may not be assessed damages.

Method of Measurement

Temporary CCTV Surveillance will not be measured for payment.

Basis of Payment

The accepted quantities of temporary CCTV surveillance will be paid for at the contract lump sum price.

Payment will be made under:

Pay Item	Pay Unit Symbol
Temporary CCTV Surveillance.....	LS

Payment of the temporary CCTV surveillance will be administered as follows: 40% paid following a successful operational field test of the installation, 20% paid after Phase X, and 40% paid upon final acceptance.

Cost of the work involving system continuity and allowable down time will not be paid for separately and shall be included in the cost of the temporary CCTV surveillance

All labor, equipment, incidentals, and materials for the installation, maintenance, operation, verification, and coordination with the Indiana Traffic Management Centers, and the Department shall be included in the cost of the temporary CCTV surveillance.

Appendix L

DIGITAL VEHICLE ALERT SYSTEM

Description

This work shall consist of including a transponder in contractor work vehicles and emergency vehicles for first responders in the vicinity to send digital alerts to connected vehicles when the work vehicle lights are flashing.

Materials

The smart flashing arrow sign shall be in accordance with 801.02 and the following requirements.

The transponder for the digital vehicle alert shall be customizable to only send alerts based on a work vehicle warning light pattern selected by the vehicle operator and the transponder shall automatically send digital alerts to connected vehicles approaching the work zone when the designated work vehicle warning light pattern is active.

Construction Requirements

The digital vehicle alert system shall be capable of delivering alerts to the Work Zone Data Exchange, WZDx, feed in accordance with Version 4.0 or later of the WZDx Specification so that the transponder data on the work zone activity is available for third party use.

Method of Measurement

The digital vehicle alert system will be measured by the number of calendar days the system is in place.

Basis of Payment

The accepted quantity of the digital vehicle alert system will be paid by the number of calendar days the system is in place.

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Payment will be made under:

Pay Item	**Pay Unit Symbol**
Digital Vehicle Alert System.....	DAY

The cost of all transponders, system testing, and all supporting field equipment shall be included in the cost of the digital vehicle alert system.