Smart Work Zone (SWZ) Technical Concept Study
Phase No. 1
Working Paper 2 – Challenges to Implementation

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A. Overview

1 - Background

As part of Arizona Department of Transportation's (ADOT) Implementation Guidelines for Work Zone Safety and Mobility process review, ADOT is continually looking at ways to expand/enhance existing practices within work zones (WZ). Therefore, ADOT sought assistance to help develop and implement Smart Work Zone (SWZ) operational concepts. These concepts use a combination of intelligent transportation system (ITS) technologies in real-time that improve the safety of highway workers and the traveling public by optimizing WZ traffic operations. In addition, SWZ are deployed to minimize congestion by reducing delays to the motoring public within work zone areas.

As part of the development of Working Paper #1 (WP#1) the project stakeholders identified some of the major challenges and issues with ADOT WZ and then reviewed the results of the Nationwide Review of SWZ Technologies to see how other State Department of Transportation (DOT) agencies applied SWZ technologies to help improve WZ operations and safety. An ADOT SWZ Operational Concepts workshop was then facilitated with the project stakeholders to select which SWZ operational concepts should be included within ADOT roadway construction projects. These Arizona SWZ system operational concepts include the following subsystems, which are described in greater detail in WP#1:

- Traffic data collection and GPS;
- Queue warning system;
- Dynamic lane merge;
- Travel delay/times;
- Traffic monitoring camera system; and
- Variable speed limits.

2 - WP#2 Introduction

Using the information obtained from WP#1, a *Challenges to Implementation* workshop was facilitated with the project stakeholders to discuss the various types of challenges that ADOT may encounter when implementing the Arizona SWZ system operational concepts. The challenges to implementation were grouped into the following categories:

- Procurement Considerations;
- SWZ System Integration; and
- Other Challenges to Implementation.

At the *Challenges to Implementation* workshop, the project stakeholders discussed possible solutions for overcoming each challenge and consensus was obtained on what the appropriate course of action should be. The results of these decisions are presented within this WP#2.

B. Procurement Considerations

1 - SWZ Equipment Ownership and Deployment Responsibility

ADOT is not interested in owning any SWZ equipment that is to be deployed within a roadway construction project. ADOT may procure and deploy some SWZ technologies as part of their roadway maintenance activities, but ADOT has decided that all SWZ equipment deployed within a roadway construction project shall be provided by the roadway construction contractor. With this approach ADOT achieves some consistency with how other types of non-intelligent Temporary Traffic Control (TTC) are covered within the

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roadway construction contract documents; and it provides ADOT the ability to require the roadway construction Contractor to include the SWZ field devices as part of the overall roadway construction Traffic Control Plan (TCP).

2 - Types of Contract Documents Needed

Because ADOT is not going to own any of the SWZ equipment that is to be deployed within a roadway construction project, and ADOT is not at this time going to require any SWZ system vendors to integrate their system software with existing ADOT software platforms (see Section C. - SWZ System Integration), there is no current need for ADOT to develop a Request for Proposal (RFP) to purchase the SWZ system components or establish an approved Qualified Products List (QPL) of SWZ systems that have successfully integrated with existing systems. To effectively administer the SWZ systems within a roadway construction project, the following two types of contract documents are needed:

a. SWZ System Standard Specifications

ADOT does not want to revise Section 701 - Maintenance and Protection of Traffic of the existing Standard Specifications. A new section of the Standard Specifications for SWZ systems should be included as part of DIVISION VII - TRAFFIC CONTROL FACILITIES using one of the "Blank" sections (i.e., 710 – 729) or section number 738 which is the next undefined section within this division. This new SWZ system Standard Specifications section should complement and supplement Section 701, but it should not duplicate nor conflict with it.

The SWZ system Standard Specifications section should include the following standard subsections:

- 7xx - 1 Description,
- 7xx - 2 Materials,
- 7xx - 3 Construction Requirements,
- 7xx - 4 Method of Measurement, and
- 7xx - 5 Basis of Payment for Elements of Work.

It was decided that the new SWZ system Standard Specifications section should be limited providing general functional requirements of the SWZ system and the associated operational concepts of each subsystem. The SWZ system Standard Specifications section should avoid having specific requirements about current SWZ technologies that may become obsolete as these technologies evolve over the next 5-10 years. This approach will require the development of performance specifications rather than method specifications.

b. Special Provisions to the SWZ System Standard Specifications

During the design phase of each roadway construction project that will require a SWZ system, a Project Special Provisions section may need to be developed to add project specifics to the SWZ system section of the Standard Specifications. This is a typical process undertaken by designers to add project specific details that are needed beyond the performance requirements identified within the Standard Specifications. It is anticipated that Standard Specifications will be created to minimize the additional work required when developing the project Special Provisions for incorporating SWZ into the specific projects. These SWZ system special provisions will be needed to define the following types of project specific and/or technology specific requirements:

- When and where each type of SWZ subsystem is required on the project;
- What are the specific minimum requirements of the SWZ technologies that can be used;

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- What non-WZ deployments are required, if any, for proof of concept evaluations or acceptance testing;
- What additional data needs to be collected/submitted for evaluating the SWZ subsystem performance or for archiving general traffic data within WZ of a specific type or location;
- What types of system testing/data is required to demonstrate that system is fully functional and operating as intended; and
- What type of training will be required for ADOT representatives accessing the SWZ system software and/or observing the field deployments for proper implementation and field device deployment methods.

Over time as the use of various types of SWZ subsystems become more common to ADOT and Construction personnel, it is anticipated that the need for Special Provisions covering system training of DOT representatives, system acceptance testing, and system performance evaluations will become less frequent. However, it is anticipated that SWZ system Special Provisions will be needed on all projects requiring the use of SWZ subsystems to define when and where different types SWZ subsystems will be required, and what the SWZ technology minimum requirements are.

3 - SWZ System Configuration and Field Operations

The deployment of SWZ systems is relatively new to many of the General Contractors and TTC device subcontractors' employees that have a long history of performing roadway construction work on ADOT projects. It is safe to assume that many do not currently possess the required skills and knowledge to properly deploy, configure, and operate a SWZ system. As such, the responsibility of training roadway Contractor field personnel ultimately falls to the manufacturers of the field devices, a vendor that owns the field devices and furnishes it for use under some form of rental agreement, or the vendor/developer of the SWZ system software that is used to control the "smart" functionality and collect/archive the required system/traffic data.

As ADOT develops SWZ system requirements and administers contract documents that require the use of SWZ systems, it is important that ADOT design and construction administration representatives understand the following three (3) different types of subcontractors that the General Contractor may need on their team to perform the required SWZ system work:

a. Vendor Providing the SWZ System Software

Many of the current SWZ system software platforms do not reside on a DOT or General Contractor server or network. The SWZ System typically uses a remote server or cloud-based environment that often require the services of the SWZ system software developer to set-up and configure the SWZ application for each individual project area that is going to have SWZ field devices deployed. Any cloud-based services will need to be AZRamp certified prior to use. The logic used to provide the "smart" functionality, how/when data is collected from the field devices, the rules/safeguards for field device controls, and how data is archived/reported, is often part of the "system configuration" services that are provided by the SWZ system software vendor. The services of the SWZ system software vendor are also, typically, used to provide Contractor and/or DOT representative training on how to access and use the system software and associated data collected.

The General Contractor typically negotiates a lump sum amount for these types of "system configuration" services, on a project by project basis. The majority of costs for these services are typically realized by the General Contractor towards the beginning of the project. An effective way to compensate the General Contractor for these SWZ software configuration and training costs is to establish a SWZ system mobilization pay item with percent-based payment milestones.

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To verify that the General Contractor's employees and subcontractors are properly trained on the SWZ system software the Contract Documents should require the Contractor to submit some sort of certification from the proposed system software vendor stating that its staff has completed the necessary training needed to fully understand how to use all the software functionality being provided for the project. This certification will need to be completed in a verifiable manner such as DocuSign.

b. Vendor Furnishing the SWZ Field Devices

Most manufacturers of SWZ field devices do not offer rental agreements for temporary use of the equipment they manufacture. Their business model is more geared toward selling their SWZ field devices to companies that specialize in renting equipment and Contractors that have a frequent need to deploy these types of SWZ field devices on their projects. Because construction projects within Arizona have historically not required the use of SWZ field devices, the number of local companies that currently offer these types of field devices is limited or when they are offered the associated costs are often inflated to help cover equipment purchases, shipping and training of local employees. As SWZ system requirements become more common on municipal roadway construction projects within Arizona, it is anticipated that these types of SWZ devices will subsequently be more readily available from various sources within the state and the associated project costs will start to decrease.

The vendors furnishing the SWZ field devices to the project are often considered the equipment experts and are responsible for training field personnel on proper equipment deployment and providing equipment testing/troubleshooting services. This is especially true for vendors that specialize in furnishing portable SWZ field device trailers that can support multiple types of technologies integrated into the trailer power distribution assembly (PDA) and communications gateway. The vendors furnishing the SWZ field devices also provide the integration necessary for these devices to communicate with the SWZ system software platforms. This type of integration requires some sort of agreement with the SWZ system software vendor which may limit the types of field device manufacturers that can be supported by the SWZ system software vendor. Therefore, there is a chance that the operators of the SWZ system will need to learn and operate multiple software platforms from different vendors to achieve all the functionality being provided by the various field devices. Coordination with IT for access to these potentially multiple software platforms will be required.

The vendors furnishing the field devices for use on the project typically charge some sort of mobilization fee to help cover their upfront costs for integration, shipping, portable trailer equipment assembly, storage, and training. These upfront costs will be included within the bid price for the SWZ system mobilization pay item that is also compensating the SWZ system software vendor's system configuration and software training costs.

To verify that the General Contractor's employees and subcontractors are properly trained on proper field device deployment procedures and preventative maintenance activities the Contract Documents should require the Contractor to submit some sort of certification from the SWZ field device vendor stating that its staff has completed the necessary training needed to fully understand how to transport, deploy, and operate the field devices. This certification will need to be completed in a verifiable manner such as DocuSign.

c. Subcontractor Deploying the Field Devices within the WZ

If the training and experience requirements of the SWZ system field personnel are not clearly stated within the Contract Documents, the General Contractor will typically ask the subcontractor deploying the other non-technical TTC devices to also be responsible for deploying the SWZ field devices. The manner

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in how these SWZ and non-technical TTC devices need to be handled and deployed can be vastly different depending on the SWZ technology and could impact the overall SWZ system performance if not deployed correctly. Therefore, it is recommended that the Contract Documents require the SWZ system field personnel to be trained on proper SWZ field device deployment procedures and as an operator of the SWZ system software so field personnel can confirm the SWZ field devices are working as part of a fully functional system. As SWZ systems become more common on projects within Arizona over the next few years, the requirements placed upon the SWZ system field personnel should start to include some minimum level of project experience deploying SWZ field devices.

It may not be necessary to require the Contractor to submit training certifications and experience documentation on all field personnel that will be helping to deploy, adjust, and maintain the SWZ field devices, but the Contract Documents should at a minimum require the Contractor to identify one lead person, per shift, that has the proper training and experience to deploy the SWZ field devices. Depending on the field device technology used, it is also recommended to have this lead person certify that the SWZ system field devices are fully functional and operating as intended. This certification should be required upon initial deployment and every time a SWZ field device is relocated or the operation or configuration changes, such as when additional devices are added to the system or a faulty device is replaced.

A SWZ system is only as useful as the data that it generates and processes and therefore data accuracy is crucial to the success of the deployment. ADOT does not have the resources to verify the vast amounts of data that are transmitted to and from SWZ systems daily. ADOT should require the TTC subcontractor or SWZ vendor to certify that the deployed equipment is operating as expected.

The Contractor should be required to verify the system in coordination with the Inspector each time it is relocated or the operation changes, such as when additional devices are added to the system. ADOT should be provided with account and login information that enables them to access the SWZ system's controlling software. With some initial guidance from the vendor, ADOT can learn to read system reports and confirm that key portions of the system are operational.

4 - Measurement and Payment

Once the Method of Measurement and Basis of Payment subsection of the new SWZ system Standard Specifications section is developed, ADOT will need to establish new pay item numbers for each element of Work identified within the SWZ system Standard Specifications section and may also need to establish some additional open ended pay item number descriptions that could be used during the design phase of each project for any additional project specific elements of Work that are defined within the SWZ system section of the project Special Provisions.

It was decided that ADOT will establish a LUMP SUM pay item to cover all the various upfront mobilization, training, system configuration, testing, and other upfront costs associated with deploying a SWZ system; and establish PER DAY pay items for each type of field device, device location, or data collection frequency. The PER DAY units of measurement should not start until the device passes the acceptance test procedures. Because one malfunctioning device component can have a potential impact on the overall performance of the entire SWZ system, it is also recommended that the PER DAY units of measurement payment be dependent on the overall system being fully functional.

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C.   SWZ System Integration

1 - Archiving and Submitting Data

While ADOT does have in place archival systems and processes for other types of statewide data, ADOT does not have an existing system in place for the storage, archival, and retrieval of work zone data. ADOT desires that the storage of SWZ data be archived separately from other data storage efforts. ADOT also desires for the Contractor to provide a hard drive of all project SWZ system data at the conclusion of each project. Formatting best practices are still being determined. ADOT will require that the Contractor's submittal of the hard drive containing the SWZ system data be tied to a pay item, so final payment is withheld until this data is received and approved.

2 - Integration at the System Level

The ADOT Freeway Management System (FMS) is comprised of multiple software platforms, each performing different functions, and all are monitored and/or controlled by the Traffic Operations Center (TOC) operators. The following are some existing systems at the TOC that could help to play a role in managing work zones:

- **Highway Condition Reporting System (HCRS)** – central database for real-time roadway restriction information from work zones, incidents, and special events. Entries into HCRS populate the AZ511.gov website, which provides comprehensive and real-time motorist information for the state of Arizona.
- **Variable message central system (Camera Cameleon [DCAM])** – system used to manage FMS variable message signs (VMS) to provide in-route, real-time information to travelers about roadway and operational conditions. These types of VMS are also commonly referred to as dynamic message signs (DMS) and changeable message board (CMB).
- **Closed-circuit camera television (CCTV) central system (Camera Cameleon [CamCam])** – central system where real-time camera feeds from FMS CCTV cameras are collected and made viewable by TOC operators, the public, and the media.

Most SWZ software vendors have their own proprietary systems that offer limited to no interoperability with other SWZ software vendor systems or with ADOT's TOC systems. To create that interoperability will require significant time that may not be practical on a roadway construction project and the software vendors of each system will want to be compensated for their integration efforts. It will likely be more cost-effective for ADOT to allow the SWZ system industry to mature and create more open-sourced applications before pursuing system-level integration between ADOT's systems and any SWZ system software.

At some point in the future, when the new HCRS system is in place and when the FHWA defines the desired parameters of the work zone data that agencies need to collect and archive, it may be possible to add a Specification or Special Provision section that requires the SWZ software vendor to provide an Application Programming Interface (API) that ADOT could use to pass the SWZ system data to the HCRS system. However, a separate contract would be needed with the HCRS software vendor to develop the interfaces needed to receive information from a new standardized API or from each individual SWZ software vendor's unique API.

3 - Integration at the Operational Level

The Contract Documents will require the roadway construction Contractor to be responsible for operating the SWZ system, but ADOT representatives will need to be involved in the SWZ system configuration and deployment process. The following are some types of ADOT construction administration activities that may be needed:

- Approve the messages that can be posted on the portable trailers;

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- Approve the system logic and associated thresholds for triggering different CMB messages, variable speed limits, etc.;
- Defining what types of SWZ system alerts/notifications are desired;
- Providing a list of ADOT representatives that need/want access to the SWZ software application to view/download the data being collected/generated by the system, to view CCTV cameras, etc.;
- Providing a list of ADOT representatives that want various types of system generated alerts or notifications;
- Verifying that the SWZ system is fully functioning as intended and documenting when it is not, so the Contractor pay item requests can be approved/rejected accordingly; and
- Observing how the field devices are deployed and reporting any associated concerns with safety, traveling public mobility, and potential impacts to the SWZ system performance.

For each roadway project requiring SWZ systems, it is important to identify the needs and desires of all stakeholders involved with the SWZ and TTC operations and establish explicit channels of communication between all of them. The following list is not comprehensive, but rather identifies key ADOT stakeholders that will be involved on most projects using SWZ systems:

a. Resident Engineer

- The RE should have the ability to disable the SWZ system but not necessarily to make changes to it. The RE should communicate directly to the Contractor a request to make any changes, similar to a change in the TTC plan.
- The RE should have full and final control of the TTC plan and the SWZ system. This includes the activities of the Contractor related to the messages that are being displayed, where devices are located, and whether the system is deployed or not.

b. Region Traffic and/or District Engineer

- The Region Traffic Engineer (RTE) and/or District Engineer (DE) should be able to access the SWZ data and pan, tilt, zoom (PTZ) camera feeds in a read-only and view-only manner. This can be accomplished by providing the RTE/DE access to the system software.
- The RE/RTE/DE should receive notification of traffic anomalies only in certain circumstances, such as when a crash occurs in the work zone. Minor incidents, such as a brief loss of connectivity to SWZ devices may not need to be sent to the RTE/DE but can be requested at the discretion of the RTE/DE.

c. Traffic Operations Center

- The TOC should be able to access the SWZ data in a read-only manner and desires to have secondary access control of PTZ cameras. There are SWZ systems that can communicate their generated data with minimal setup required.
- The TOC should receive notification of traffic anomalies, such as speeds dropping substantially or a camera losing communications connectivity. At the operational level, this notification will likely take the form of a text or email alert to the TOC operators.
- The SWZ standard specification should require the RE and/or the Contractor to disseminate traffic information to the TOC, when applicable. Example cases include a crash in the work zone or unexpected changes in the TTC plan that will result in unusual congestion during peak travel demand.

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D.   Other Challenges to Implementation

1 - Public Interest Findings (PIF)

A Public Interest Finding (PIF) is required by FHWA and ADOT whenever an agency specifies the use of a proprietary device or product on a project that uses FHWA or state funds. Given the specialized nature of many SWZ systems, it can be expected that some systems will be available from only one vendor or will require a device that is available from a single vendor or manufacturer. An example of this is the portable variable speed limit (PVSL) system deployed by the Utah DOT, which is the only system of its kind currently. To use this PVSL system, ADOT would need to prepare a PIF letter during the design phase of the project. Not all SWZ systems will require a PIF, so each project requiring SWZ technology must be assessed separately to determine if the requirements within the Contract Documents can be provided by multiple vendors. If only one vendor can achieve all the desired functionality, then a PIF letter will need to be prepared and approved, before the project goes to bid.

2 - Crashworthiness

Currently there are no known trailer-mounted SWZ devices that are compliant with MASH 2016. After interviewing SWZ industry leaders, it is unlikely that there will be any such devices in the near future. As such, the Contract Documents will need to require the Contractor to be responsible for protecting the SWZ field devices in a manner similar to other non-crashworthy devices that are deployed as part of the roadway construction project. The associated pay items and quantities for that protection will need to be coordinated during the design phase of the project.

3 - System Communications

A key component of any SWZ is the ability to communicate between the SWZ field devices, SWZ system software, and the field personnel operating the system while it is deployed within the work zone. To do this, some manner of wireless communications must be available at all times during the deployment. Whether this is cellular coverage, satellite coverage, or some other method should not be specified but rather left up to the Contractor to decide what communications method would work best for the system the proposing and the associated project limits. ADOT project development staff and local staff will have a good understanding of project locations with poor cellular service and any such locations should be discussed during the design phase of the project development process.

4 - Design Phase Considerations

The design phase of a project will include many points where decisions regarding the SWZ system need to be made. The first decision is the one whether to use SWZ or not during a work zone project, which should be made as early as possible. Making that decision to use a SWZ system at Project Scoping is ideal, but required by Stage II (60% design). The decision should be made by a committee made up of the DE, RTE, design engineers, TOC representative (if necessary), and others as appropriate.

The design of SWZ systems and the design process will be a new process for many engineering firms and contractors. It should be expected that the first few projects that ADOT deploys a SWZ system on will be a learning process for all stakeholders, and ADOT should document lessons learned and best practices as those projects progress.