KANSAS DEPARTMENT OF TRANSPORTATION
SPECIAL PROVISION TO THE
STANDARD SPECIFICATIONS, EDITION 2015

SMART WORK ZONE

1.0 DESCRIPTION

A Smart Work Zone System is a group of devices that work together, using software to automatically detect traffic conditions and respond using preprogrammed response algorithms. The purpose of this system is to provide advance traffic condition information to motorists at key decision points due to construction activity.

Provide, install, relocate, operate, and maintain an automated, portable, stand-alone, real-time Smart Work Zone System meeting the requirements noted herein, for the duration of the project.

Provide a real-time, automated Smart Work Zone System that calculates and displays travel time and slowed/stopped traffic messages through the work zone using Traffic Management Software that automatically displays traffic data on a website and displays messages based on traffic data to drivers approaching the work zone.

The goal of this system is to monitor this project's work zone traffic operations and disseminate real-time information to KDOT and the traveling public.

Deploy the Smart Work Zone System according to the Contract Documents.

BID ITEMS	**UNITS**
Smart Work Zone System Deployment	Lump Sum
Smart Work Zone System	Each per Day

2.0 MATERIALS AND SYSTEM OPERATIONAL REQUIREMENTS

a. General. These specifications cover the general operational requirements for the Smart Work Zone System, to be constructed in accordance with and at locations indicated in the contract or designated by the Engineer. Provide physical and electronic protections for all components of the system and processes pertaining to implementation of the system to aid in preventing access to system components by unauthorized parties.

Provide the following equipment for this project:

- 15Traffic Sensors
- 10 Changeable Message Signs
- 5 Video Cameras;
- Customized Website integrated with the SWZ System for KDOT and project partners;
- Traffic Management Software capable of analyzing data and accurately supplying the indicated information; and
- Communication equipment for all above devices to include all components and communication methods necessary to allow each device to send and receive data or images to and from a website and Traffic Management Software.

b. System Documentation. Provide a set of complete specifications and literature on the selected Smart Work Zone System. Take care to address all the requirements of the Contract Documents in the submittal. Provide documents for each device which contain all information necessary to determine product specification compliance. Provide to the Engineer for Approval, at least 10 days prior to delivery of the Smart Work Zone System devices, the detailed security plan and protocol used to protect data, video and communications that are part of the Smart Work Zone System. Include in this plan and protocol physical locking mechanisms where the locks are unique for this Smart Work Zone and a key will be shared with KDOT, password handling techniques, and limited static IPs for remote access to equipment.

c. Power Source. Provide power for devices for continuous operation, as defined in **subsection 2.0k.** below. All utility hookups, solar panels, batteries and other power sources are subsidiary.

d. Installation. Use materials to mount and aim devices which allow the devices to be installed in a crashworthy manner and location and allow devices to meet data accuracy requirements. Coordinate installation locations and details with the Traffic Engineering Consultant prior to installation.

e. Traffic Sensor. Provide sensors for which the accuracy is not degraded by inclement weather and visibility conditions including sunlight, light precipitation, temperature, light, fog, darkness, excessive dust and road debris.

Provide sensors which:

- collect and report individual vehicle data and data on a per lane basis;
- collect speed, volume, and lane occupancy data, for the required direction(s) of traffic and;
- communicate data to the Traffic Management Software at least once per minute.

Install and maintain sensors to continuously detect all public traffic on northbound and southbound I-235 and eastbound K-96. Configure equipment to allow active and inactive collection zones so that construction traffic is differentiated from public traffic. At a minimum, detect speed, volume, and occupancy levels in each lane, each minute. Summarize data in 5 minute bins for data storage and transfer. Do not block or shield critical locations from the sensor. Test each sensor and re-test as needed to confirm the accuracy of the data reported. Collect and report data to the Traffic Management Software which meets or exceeds the following percentages at any given time during testing and operation:

- Per direction volume accuracy: greater than 90%;
- Per lane volume accuracy: greater than 90%; and
- Per direction average speed accuracy: greater than 90%

It is the responsibility of the Contractor to detect data malfunctions. Monitor, inspect, and maintain sensors so that malfunctions in data collection can be detected as soon as possible. Causes of malfunction may include high winds, shifting earth beneath or around the device, or interference by construction equipment. Monitoring, at a minimum, includes evaluation and documentation of power levels, communication connections, and accuracy of data provided to the Traffic Management Software. Monitoring data accuracy may include re-calibration and aiming of the device or retesting accuracy using human observers. Monitor as needed and when requested by the Engineer.

f. Changeable Message Signs (CMS). Provide and maintain Changeable Message Signs, which may be Portable (PCMSs), which are capable of displaying length of traffic queue and travel time advisories to motorists. Provide message signs that meet or exceed the material and functional requirements of PCMS as described in the Contract Documents and are capable of communicating with and being controlled by the Traffic Management Software. Provide signs which display messages and log the date, time and message text for messages when being controlled by the Traffic Management Software.

Install and maintain CMS and allow no more than 1 pixel illumination failure on the board at any given time during testing and operation. Continuously monitor changeable message sign status. Include in the monitoring procedure evaluation of power levels, communication connections, and the number of unlit pixels. Also include the periodic use of a human observer to document that the correct message is displayed at the correct date and time.

g. Camera. Provide and maintain cameras with pan, tilt, and zoom (PTZ) capabilities, and which are capable of collecting streaming video and still images in H264 and MPEG formats and communicating with, sending data to and being controllable through the project website. Provide cameras capable of saving and executing configurable preset views and of providing streaming video to the project website. Cameras may also be mounted on portable trailers.

Monitor camera status, including evaluation of power levels and communication connections.

h. Traffic Management Software (Software). The software has two main functions: Queue Warning and Travel Time Display, in addition to reporting and operational requirements. Use software that meets or exceeds the following requirements for each function:

(1) Queue Warning. The intent of the Queue Warning function is to detect traffic congestion and queue formation and notify approaching drivers of the conditions. Queue Warning is the most critical function of the system. Continuously monitor traffic and report the required operational characteristics to the software each minute. Use a combination of real-time speed and percent lane occupancy information reported by traffic sensors, compared

with configurable thresholds, to initiate a slow or stopped message. Display configurable messages on message signs located upstream of sensors that detect changes in speed and lane occupancy, in such a way that approaching drivers see a slow message before a stopped message and include accurate information on the distance to the condition. Round distances to the nearest ½ mile. Message examples include "STOPPED/TRAFFIC/1 MILE" and "SLOW/TRAFFIC/2 MILES." Configure Queue Warning messages to override all other messages on a CMS. Send texts and emails to project personnel when traffic conditions violate predetermined thresholds. Data collected by the Smart Work Zone System will be owned by KDOT and capable of being transferred in a file format compatible with Oracle.

Include in the monitoring procedure the use of human observers documenting posted messages and times during an actual event and comparing those messages with the information available from the software. Complete software monitoring as needed and when requested by the Engineer.

(2) Travel Time Display. The intent of the Travel time function is to calculate and display travel time for each appropriate message sign location. Travel Time is the secondary function and serves as the default function when Queue Warning is not activated. Use speed information from sensors in a given direction to calculate rolling average speeds and, using known distance information, calculate an estimated time to traverse that distance at the average speed. Calculate travel times either through the work zone or from a message board location to a predetermined highway junction, as directed by the Engineer. Update messages every 2 minutes, and be accurate at time of update to within 1 minute. Message examples include "TIME TO/K-96/3 MIN" or "6 MIN/THRU/WORKZONE."

Include in the monitoring procedure the use of a human observer documenting posted messages and times when a Queue Warning event is not occurring. Compare those messages with the information available from the software and information calculated by the human observer. Complete software monitoring as needed and when requested by the Engineer.

(3) Reporting and Operational Requirements. Communicate with and/or control all of the devices belonging to the Smart Work Zone System. Poll the sensors and CMS a minimum of once per minute. Collect from each device, as applicable, and store in configurable bins the following data: device name and location, 50^{th} percentile and 85^{th} percentile speeds, volume, lane occupancy, message sign history, and travel times as well as battery status and communication status. Make historical data available to KDOT staff at all times for the duration of work zone activity. Provide an electronic copy of all data, including date and duration of system malfunctions, to KDOT staff after all work zone activity is completed and the SWZ System has been removed.

i. Website. The purpose of the website is to be a real time traffic operations dashboard showing current traffic conditions, real time speeds, posted messages, and streaming video to the nearest minute. Display a full color map of the project area, using Google Maps or equivalent, which shows roadways impacted by project activities and for which data is being collected. Display current average speed at each traffic sensor for which data is available. Display a representation of each device in its approximate location, relative to the roadway and other nearby features, and indicate the operational status of each device. Display the messages posted on the message signs. Refresh information at least once per minute. In the event devices are moved to a new location in the field, automatically reflect these changes to the system layout on the website.

Display streaming video from each camera and allow users to control each camera and use preset views. Provide the video in a format capable of being displayed on the website while allowing at least 20 users to access the video without having the frame rate drop to less than 1 frame per second. Frequently monitor the Website for functionality and performance.

j. Traffic Control Devices. Provide traffic control devices as needed to set up, operate, maintain and tear down Smart Work Zone System as shown in the Contract Documents. Coordinate device placement with other Contractors as needed to meet or exceed placement requirements in the Contract Documents.

k. Malfunctions, Maintenance, and Inspection. Operate the Smart Work Zone System, including all components listed above, continuously (24 hours per day, 7 days per week) when deployed on the project, until project completion.

Continuously operate the Smart Work Zone System with no major malfunctions throughout the entire contract. Malfunctions include, but are not limited to; the inability of the equipment to provide accurate, real-time traffic data, video feeds, or travel time information; inability to withstand a construction roadside environment or normal weather conditions; or interference from construction equipment. Monitor and inspect equipment and data,

on a regular basis to avoid malfunctions. Upon discovery or notification of malfunction, make all necessary corrections to the components of the system such that system malfunctions are corrected within a 24 hour period through repair or replacement of the equipment. Components include sensors, message signs, cameras, communications equipment and all hardware and software required to place the real time information on the devices to operate according to Contract Documents.

l. Complete and Operational System. The Contract Documents describing the Smart Work Zone System form a guide for a complete and operable Smart Work Zone System. Where an item is reasonably necessary for a complete and operational system, but not specifically mentioned, provide these items as if they were specified. Direct and indirect costs associated with operating the Smart Work Zone System are subsidiary to this bid item and may include FCC licensing, cellular communication, wireless data networks, satellite and internet subscription charges, solar power system support and battery charging and maintenance.

3.0 CONSTRUCTION

a. System Manager. Provide one person, available 24 hours per day, as the System Manager for the Smart Work Zone System. This person may be the same person as the TMP Manager required by Special Provision 15-WZ0003. Provide this person's 24 hour contact information to the Engineer. Provide a system manager who is locally available to supervise, monitor and maintain the system components including the website, relocate devices as necessary and respond to emergency situations.

b. Smart Work Zone System Deployment. Deliver all of the required devices to the place and time designated by the Engineer and confirm they are in good condition and in working order. Coordinate with the Engineer to determine final sensor locations, then deploy and install sensors. Complete stand-alone tests, system operational test, final deployment, and system initiation prior to impacting traffic.

(1) Stand-alone Testing. Conduct stand-alone tests of each device. Sensors will be tested from their installed locations, and cameras and CMS may be tested in other locations. Turn all CMS away from traffic during testing.

Complete a stand-alone test for each sensor after installation, and use human observers to document the speed and volume of vehicles during 15 minute intervals. Calibrate sensors. Use a trained and experienced operator using a radar gun to measure the speeds of individual vehicles in each lane. Measure as many vehicles as possible in a 15 minute period and average the results. Calculate an average speed for the same period based on data from the sensor data. If vehicles in the closest lane interfere with measurements in other lanes, provide a means of safely elevating the observer or the sensor enough to provide a clear line of sight to the vehicles being observed. If a unit fails to pass the stand-alone test, repair or replace the unit, and repeat the test until successful. Document testing results, using **Attachment 1** as a template, and provide that documentation to the Engineer.

Complete a stand-alone test for each CMS prior to installation, to verify that the unit operates as specified. Include in the stand-alone test procedure tests for the following functions:

- turning the sign on and off;
- displaying and removing a test message;
- counting pixels not illuminated;
- checking message logs for accuracy; and
- measuring sign legibility and visibility.

If a unit fails to pass the stand-alone test, repair or replace the unit, and repeat the test until successful. Document testing results, using **Attachment 1** as a template, and provide documentation to the Engineer.

Complete a stand-alone test for each camera to verify that the units operate as specified. Include in the stand-alone test procedure tests for the following functions:

- turning the camera on;
- turning the camera off;
- panning right and left; tilting up and down;
- zooming in and out; and
- viewing the camera image locally and remotely.

If a unit fails to pass the stand-alone test, repair or replace the unit, and repeat the test until successful. Document testing results, using **Attachment 1** as a template, and provide documentation to the Engineer.

Complete a camera throughput test demonstrating that the Website, including video and images from the camera, can be viewed and controlled at the KDOT construction office, KDOT headquarters, and KDOT partner workstations.

(2) System Operational Testing. Provide a System Operational Testing Plan to conduct a five day operational test of the System Operational Requirements. Include in the plan procedures operation of the software using real time information from sensors already tested and installed and tested signs located in an off-project location. Begin testing at least 30 days prior to modification to traffic operations to verify system operation in a fully functional manner and as described herein for a duration of at least five days. After the system is tested and approved for use on the project, collect baseline traffic data for a minimum of 15 days prior to any modification to traffic operations.

Provide for complete operations support from the Software supplier during the operational test, if applicable. Provide verification that the reported drive times, speeds and volumes through the work zone accurately reflect actual field conditions, and use a human observer to monitor and document the posted messages. Post test messages two times per day during the test period to verify functionality and communications and verification that proper messages are being posted to the message signs. Monitor cameras twice per day to verify functionality and communications. If any equipment malfunctions occur for a combined period of four hours or more during this operational test on any day, restart the five day test and no credit will be given for that day of the operational test period.

Maintain records of equipment stoppages and resumptions during the five day operational test for submission to the Engineer. In the event that 10% or more of the time similar malfunctions occur that affect the proper operation of the Smart Work Zone System, the Engineer may declare a system component defective and require replacement of the equipment at no additional cost. When a system component defect is declared, restart the five day operational test after all defective equipment is replaced and the system is fully operational.

Submit a report to the Engineer, using **Attachment 1** as a template, detailing the daily activity of the system during the operational test. Indicate the date and time of any activity necessary to maintain operation of the SWZ System during the operational test period. Include in each entry, at a minimum, the following information:

- A description of the malfunction;
- Identity of the equipment on which work was performed;
- Cause of equipment malfunction (if known);
- A description of the type of work performed; and
- Time and date of repair completion;

Once the operational test report is received and approved by the Engineer, the Smart Work Zone System will be considered operational, and the system will be accepted for use.

4.0 MEASUREMENT AND PAYMENT

a. Smart Work Zone System Deployment. The Engineer will measure Smart Work Zone System Deployment by the lump sum, beginning the day the Smart Work Zone System is delivered to the job, according to the following schedule:

- 50% upon delivery of all equipment to a location designated by the Engineer;
- 70% upon successful completion of the System Operational test and approval of the Smart Work Zone System for use on the project; and
- 100% after the 15 day baseline data collection period is complete, prior to impacting traffic.

b. Smart Work Zone System. The bid item Smart Work Zone System is a single item that includes the correct placement and operation of the Smart Work Zone System on a daily basis. The Engineer will measure the Smart Work Zone System each per day and will begin after the 15 day baseline day collection period is complete and construction has begun. The Smart Work Zone System is expected to operate continuously (24 hours per day, 7 days per week) with no major malfunctions until project completion. Monitor and maintain the system according to the Malfunctions, Maintenance, and Inspection, **subsection 2.0k.**, above.

Payment will be made for the first day of a malfunction. However, if the system is not completely operational at the end of the 24 hours, payment will not be made for day 2, and all successive days of the malfunction. Payment will resume on the first day that the system once again becomes fully operational. If data malfunctions are detected, the first identified day for which data was inaccurately reported to the Traffic Management Software will be considered the day that the malfunction occurred and payment will be made only for the first day of the malfunction, to begin again once the data malfunction is resolved and the system is once again fully functional.

Payment for "Smart Work Zone System Deployment" and "Smart Work Zone System" at the contract unit prices is full compensation for the specified work.

12-28-15(TST)(KRE)

ATTACHMENT 1

REPORTING TEMPLATE

Contractor Name:
Project:
Date:

Description of Activity: EXAMPLE: Stand-alone testing of sensors #1- #10.
ALTERNATIVE EXAMPLE: System operational testing Day 1.

Summary of Activity: EXAMPLE: Successful completion of stand-alone test for all sensors. Tests restarted once each for sensors #2, #5, and #6.
EXAMPLE: Sensor #2:

- A description of the malfunction;
- Cause of equipment malfunction (if known);
- A description of the type of work performed; and
- Time and date of repair completion;

EXAMPLE: Sensor #5:

- A description of the malfunction;
- Cause of equipment malfunction (if known);
- A description of the type of work performed; and
- Time and date of repair completion;

EXAMPLE: Sensor #6:

- A description of the malfunction;
- Cause of equipment malfunction (if known);
- A description of the type of work performed; and
- Time and date of repair completion;

ALTERNATIVE EXAMPLE: Successful completion of System operational testing for Day 1. All devices operated within required parameters. Message testing occurred at 10am and 2pm. All messages were observed using human observers and received by the signs and posted automatically. Travel times were verified by [describe the process] and were correlated to correct system outputs, documentation attached. Speeds verified using human observers and were correlated to correct system outputs, documentation attached. Volumes were verified using human observers and were correlated to correct system outputs, documentation attached. Cameras were tested at 12noon and 4pm. All camera images were visible at KDOT offices, KDOT HQ, and through the website. Website was recorded concurrently with message testing and showed the confirmed travel times, speeds, volumes, messages, and device statuses. Website was tested at 1pm to observe and control cameras. Camera #1 and Sensor #7 malfunctioned today. Each was functional within 20 minutes and the System operational testing continued. System Operational testing will continue into Day 2.

EXAMPLE Camera #1:

- A description of the malfunction (include time of day);
- Cause of equipment malfunction (if known);
- A description of the type of work performed; and
- Time and date of repair completion;

EXAMPLE Sensor # 7:

- A description of the malfunction (include time of day);
- Cause of equipment malfunction (if known);
- A description of the type of work performed; and
- Time and date of repair completion;

_____ _____ _____
(SWZ Manager) (TMP Manager) (Date Signed by SWZ Manager)