ARDOT TRC TRANSPORTATION RESEARCH COMMITTEE

TRC0503

Development of a Virtual Weigh Station for Monitoring Overweight Vehicles on Secondary Routes

Davin Webb

ARKANSAS DEPARTMENT OF TRANSPORTATION

Final Report

December 2019

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Disclaimer:
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16. Abstract
The problem of weigh station avoidance by heavy trucks exists throughout the United States. In Arkansas, alternate highways exist near every weigh station and are being used by some trucks to bypass without inspections. Although these trucks can be intercepted by roving Arkansas Highway Police (AHP) units, the ability to detect where this problem may exist is not currently available. Therefore, the interception of heavy truck by-passers is, at best, a random occurrence accomplished by trial and error surveillance of AHP units.

Research in both Kentucky and Virginia has confirmed the existence of heavy truck avoidance of weigh stations. The exact reasons for this have not been conclusively determined. It has been determined that a larger proportion of these trucks are more overweight than those encountered with the normal truck traffic at the weigh stations. Consequently, it follows that these trucks, which are avoiding the weigh stations, generate a proportionately larger amount of pavement and bridge wear while carrying illegal loads and avoiding the payment of appropriate highway tax.

In order for the AHP to address this problem adequately, cost-effective, non-intrusive methods and techniques are needed to effectively monitor heavy truck traffic on close bypass routes to weigh stations.

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
^oC	Celsius	1.8C+32	Fahrenheit	^oF
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	$candela/m^2$	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

CONTENTS

EXECUTIVE SUMMARY

The objective of research project TRC0503, “Development of a Virtual Weigh Station for Monitoring Overweight Vehicles on Secondary Routes”, was to assist the Arkansas Highway Police (AHP) with detection of Oversize/Overweight commercial vehicles that attempt to bypass the staffed scales on Interstate 40 eastbound at Alma.

In the spring of 2017, the Arkansas Department of Transportation (ARDOT) installed a new state-of-the-art Virtual Weigh Station (VWS) in the eastbound lanes of US 64 in Crawford county. The system that ARDOT installed will be used to evaluate the viability of future uses for similar systems and multiple types of weigh-in-motion.

The completion of the project has resulted in an improved traffic data collection system and provided AHP with an enforcement tool to detect overweight vehicles that may otherwise try to avoid detection by using secondary highways, the potential benefits to Department and AHP personnel that can be gained are numerous. The Improved traffic data collection system is a more useable format and will help with data reporting and traffic predictions, as well as presenting a clear view of the performance of the existing piezo system. The time and resources saved by the use of a VWS will be substantial. This system reduces inspections of suspected overweight vehicles that are within legal weight limits by eliminating the guesswork of determining potentially overweight vehicles, thus making AHP personnel more efficient.

OVERVIEW

The Arkansas Highway Police (AHP) didn't have the technological capabilities to continuously target bypass routes and secondary roads used by trucks to avoid fixed weigh stations. The Weigh In Motion (WIM) system that the System Information and Research Division uses does not provide enough accuracy in weight data to be used as an enforcement tool to curb overweight vehicles.

CHAPTER 1. SYSTEM INTRODUCTION

A Virtual Weigh Station measures vehicles' weights and dimensions automatically and provides vehicle record information to an authorized user either locally or remotely for enforcement, commercial vehicle, and traffic data analysis. The vehicle record information may be provided via a network communication service.

The WIM system is to be modular in design for ease of service and upgradeability. Changing or upgrading the functionality at a site shall only require the addition of the electronics modules and peripheral devices needed for that functionality; existing equipment shall be usable in the upgraded system.

The scope of work is to supply and install the following:

- WIM Scales, axle sensors, inductive loops, controller electronics, and cabinet
- Side image camera installation
- Communications wiring and conduit for all equipment
- Power wiring and conduit
- Network communications
- Any other desired peripheral sub-systems (e.g., License Plate Readers and Automatic Vehicle Identification)

The purpose of this project is not for the research and development of a Virtual Weigh Station system. The Contractor shall be required to provide documentation which demonstrates to the satisfaction of the Department that all equipment proposed for use in the Virtual Weigh Station is of standard manufacture; that the manufacturer has had WIM equipment available for purchase for not less than ten (10) years and has at least three (3) successful Virtual Weigh Station installations (which are not for research and development purposes); and that the manufacturer's WIM equipment has a proven acceptable performance history while in use under conditions similar to those for the intended use. The manufacturer shall be registered to an ISO 9001 Quality Control Program.

As a minimum, the equipment documentation provided by the Contractor shall include the following:

- A detailed description of how the system requirements will be met
- Drawings with descriptions
- Manufacturer's name and model number, supported by descriptive material for (but not limited to) the standard package components with all accessories identified under "Description"; submittals shall be supported by descriptive material, such as catalog cuts, diagrams, and other data published by the manufacturer, to show conformance to specifications and plan requirements; model numbers alone will not be acceptable.
- At least three (3) Virtual Weigh Station references; these shall all be different references.

VIRTUAL WEIGH STATION OPERATIONAL OVERVIEW

The Virtual Weigh Station system shall include a system controller and signal processing electronics, sensors, cameras, and network communication equipment. The system shall produce a vehicle record for all vehicles within a user-defined set of classes that pass over the Virtual Weigh Station sensors. The cameras capture an image of each vehicle as it passes the WIM Scales and associates each image with the appropriate vehicle record.

VIRTUAL WEIGH STATION FUNCTIONAL REQUIREMENTS

Lanes at the Virtual Weigh Station site equipped with WIM sensors are called WIM lanes. Vehicle data from WIM lanes shall include axle and vehicle weights. Lanes at the Virtual Weigh Station site not equipped with WIM sensors are called Automatic Vehicle Classification (AVC) compliance lanes. Vehicle data from AVC lanes shall include vehicle classifications but no weight data.

WIM SCALES/SENSORS

The WIM Scales/Sensors must be one of the following:

- Bending Plate (BP) WIM Scales (Separate specifications are available)
- Single Load Cell (SLC) WIM Scales (Separate specifications are available)
- Lineas™ Quartz Sensors (Separate specifications are available)

AXLE SENSORS

The Virtual Weigh Station shall use axle sensors in each lane for classification and speed operations for Bending Plate and Single Load Cell Scales. The axle sensors shall be Class I piezoelectric and approximately 12 feet (3.5 meters) in length.

The axle sensors shall be installed below the road surface. The axle sensors and their electrical wiring connector shall be completely water tight and sealed.

DETECTOR LOOPS

The Virtual Weigh Station shall use inductive detector loops to detect the presence, entry or exit of a vehicle in support of WIM and AVC operations.

For the Virtual Weigh Station operation, the sensor configuration shall be:

"loop – WIM Scale – axle sensor – loop" (if BP or SLC are used)
or
“loop – Quartz – Quartz – loop” (if Lineas Quartz Sensors are used)

Each detector loop shall have a minimum loop area of 6 feet x 6 feet (1.83 m x 1.83 m) with 45° angle cut at the corners.

Loop wire shall be 1-conductor, 14 AWG, IMSA 51-5 cable. Loop leads must be 2-conductor, 18 AWG, IMSA 50-2 cable.

All saw-cut loops shall be sealed with 3M loop sealant.

AVC COMPLIANCE LANES

Depending upon configuration, an Automatic Vehicle Classification (AVC) system be located adjacent to the WIM lane. The purpose of the AVC system is to check that commercial vehicles have properly complied with the sign directing trucks into the right-hand lane.

Each AVC lane shall consist of two sets of piezoelectric vehicle classification sensors to track the commercial vehicles that bypass the WIM lane. The sensors in the AVC lane shall consist of inductive loops and axle sensors in the following configuration:

"loop – axle sensor – axle sensor – loop".

SYSTEM ELECTRONICS

The System Electronics shall be located next to the WIM scales in a roadside cabinet. The System Electronics shall be responsible for creating vehicle records and formatting the truck data to enable a user to view the vehicle records remotely. The WIM interface electronics will be a standalone system with the capability to collect and interpret the signals from the WIM Scale.

All materials necessary for setup and operation of the system must be provided, including all wiring and cabling.

The system must be provided with the required software pre-loaded. The software must automatically execute when the system is powered up.

The electronics must be modular to facilitate easy maintenance, troubleshooting, and in-field servicing. For ease of maintenance, each type of input and output device shall interface to a system electronics printed circuit board interface module. All interface modules shall feature self-testing and built-in fault diagnosis. All sensor modules shall be field replaceable and slot mounted in a system electronics sub-chassis.

The system electronics shall be available in optional CE compliant configurations. These configurations shall satisfy the following European Union directives:

- Low Voltage 2006/95/EC
- Electromagnetic Capability Directive 2004/108/EC
- Restriction of Hazardous Substances Directive 2002/95/EC
- Waste Electronic and Electrical Equipment Directive 2002/96/EC

The system shall be of durable industrial design and construction, and enable continuous operation, with an automated start-up in the event of a power outage. For reliability, modularity, and ease of communication with any additional system components that may be added at a future date, system electronics modules shall communicate over a rugged CAN Bus system (Controller Area Network protocol).

The electronics shall include interfaces to the following components:

- WIM Sensors including Piezo, Bending Plate, Single Load Cell, Kistler Lineas Quartz
- Axle Sensors including Piezo and DYNAX
- Loops
- Off-scale Detectors
- Communications System

The roadside electronics shall provide a facility for viewing vehicle records and sensor diagnostics over either a direct computer connection or a telecommunications link.

All components of the electronic system, including inductive loop detectors, will contain electrical over-voltage protection to prevent damage from electrical surges.

The System Electronics shall provide the following functions:

- Insert sequence numbers for vehicle records for tracking purposes.
- Perform WIM operation.
- Weigh all vehicles traveling over WIM scales.
- Classify all vehicles traveling on all instrumented lanes of the highway.
- Perform weight compliance analysis on vehicles per department or agency regulations.
- Perform sorter operation per weight compliance analysis and other violations (speeding, improper maneuver, sudden speed change, etc.).
- Capture images for all vehicles.
- Filter out all non-interesting images and format for a web server.
- Perform data collection, data storage, file management, and report generation functions for collected vehicle information.

The system shall include a data-downloading system to allow collected vehicle data to be retrieved either remotely or on-site.
The Virtual Weigh Station shall be provided with a secure, weather-resistive roadside enclosure to house the System Electronics, the WIM computer and its peripherals and the side image camera equipment.

All wires from scales, off-scale sensors, axle sensors, loops, etc. shall be terminated on terminal strips. The terminal strips shall be identified by the terminal strip number and screw connection number and shall be readily accessible. All cables shall be long enough to reach these terminal strips. Terminal strips, splices, or other types of connections before these standard terminal strips shall not be allowed except for splicing of a loop to a shielded twisted loop lead.

All AC power connections shall be shielded to prevent electrical shock.

System Electronics shall meet the following requirements:

System	Low Temperature: -40 degrees C Cold start
	High Temperature: +75 degrees C
	Humidity: 95% relative humidity, non-condensing
	Processor: 32-bit RISC architecture
	Memory: 32 MB RAM, up to 4 GB Storage
	CAN Bus environment for sensor and control configuration
	Non-volatile storage for vehicle information to prevent data loss during power outages and to retain sensor module configuration
Communications	Industry-standard CAN Bus environment
	USB interface
	Ethernet interface
	One RS-232 serial interface dedicated to an external interface
	One RS-232 serial interface dedicated to remote administration (modem dial-in)
	Remote administration via Telnet Secure Shell (SSH) or Windows Remote Desktop
	Remote file download via Secure FTP
Software	Sensor inputs include Single Load Cell, Bending Plate, Slow Speed WIM, Kistler Lineas Quartz, DYNAX, Piezo, Loops and Serial, and Digital Devices
	Sensor inputs from WIM Scale, loop and piezo sensors
	Vehicle Classification performed utilizing user-defined classification scheme
	Weight Compliance performed utilizing user-defined weight compliance scheme
	Records data logs on operational status, power supply condition and system activity
Maintenance	Local connection through laptop PC in terminal mode
	Remote connection through a dial-up modem to a PC in terminal mode
	Telnet over an Ethernet Interface

	Interface cards shall be hot-swappable (i.e., cards can be safely removed or replaced while the system is operating and powered)
	System configuration and fault diagnosis operations
Axle Sensor Interface (WIM and Piezo)	Adjustable threshold for detecting axles
	Capable of automatic temperature compensation
	Capable of autocalibration
Digital I/O Interface	Report on the rising edge, falling edge or both
	Adjustable input debounce
	Control output state, single pulse, or square wave
	Adjustable timeout on inputs

VEHICLE IMAGING

The System shall include a video imaging system to record images of vehicles for identification purposes. The imaging system shall consist of a camera capable of taking pictures in all lighting conditions and image processing electronics to record the image of each vehicle that passes through the system. The side image camera shall be mounted alongside the roadway on the mainline positioned to obtain the best possible images, detailing their cab and side. The images shall be linked with the vehicle records of commercial vehicles; non-commercial images shall be discarded. The camera shall be capable of full-color images during daytime operation, and monochrome (black & white) near-infrared images during nighttime and low light operation. The imaging system electronics shall be located in the roadside System Electronics enclosure.

The Imaging System shall consist of the following system components:

- Color and low light monochrome (black & white) video camera
- Illuminator system
- Video capture system

LICENSE PLATE READER (LPR)

The system shall be able to interface with an optional License Plate Reader (LPR) system. At the Department's option, this system may be either supplied and supported by the vendor or supplied and supported by another contractor. In either case, the Virtual Weigh Station electronics shall be capable of interfacing with industry-standard LPR systems.

Images produced by an LPR system shall be linked to the record of the appropriate vehicle.

AUTOMATIC VEHICLE IDENTIFICATION (AVI)

The system shall be able to support the option of Automatic Vehicle Identification (AVI) using Dedicated Short Range Communication (DSRC) transponders. At the Department's option, this system may be either supplied and supported by the vendor or supplied and supported by another contractor. In either case, the Virtual Weigh Station electronics shall be capable of interfacing with industry-standard AVI systems.

COMMUNICATIONS

Vehicle record data from the Virtual Weigh Station shall be accessible from the Virtual Weigh Station electronics controller to a single user via a network connection. The client will select one of the two following options:

- The installation of a computer in the Virtual Weigh Station electronics cabinet to act as an Internet server to allow the vehicle record data from the Virtual Weigh Station to be accessible to multiple users over the Internet using a Web browser.
- The option of sending vehicle record data to a remote central host server, allowing vehicle data from multiple Virtual Weigh Stations to be accessible to multiple users over the Internet using a Web browser. At the Department's option, the central host server is to be supplied either by the Department or by the Vendor.

CHAPTER 2. VIRTUAL WEIGH STATION DISPLAY REQUIREMENTS

The display for a single user connected to the Virtual Weigh Station via a network connection shall show a list of vehicle records. Each vehicle record shall contain the following information:

- A thumbnail image of the vehicle
- The vehicle record number
- Date and time
- The vehicle class
- Speed
- Length of the vehicle
- Gross Vehicle Weight
- Individual axle weights
- Axle spacings
- A color indicator for whether the vehicle is compliant (green) or in violation (red)
- A message indicating any violations or errors

The user shall be able to select any vehicle record in the listing and open a detailed display which shows all data recorded for that vehicle, including all the data above plus individual wheel weights, maximum allowed weights for each axle, all violations, and the full-size image in the vehicle record.

When viewing a detailed vehicle record, the user shall be able to step forward or back to the next record in the system memory.

The system shall support the option of displaying the vehicle record data over the Internet to authorized viewers using a Web browser. The web browser display shall include all the information above and have the following capabilities:

- The user shall be able to select to display all trucks or only violation vehicles.
- The user shall be able to search the vehicle record database using vehicle record numbers or date and time to select vehicle records.

The system shall support the option of displaying vehicle record data from multiple Virtual Weigh Stations over the Internet to authorized viewers using a Web browser. Each Virtual Weigh Station site shall be user selectable from the Web browser.

TRAFFIC DATA CAPABILITIES

The vendor shall supply software that can be used to retrieve traffic data from one or more WIM sites automatically. The user shall be able to configure the frequency of the downloads (typically weekly or monthly) and the information to be obtained.

The system shall store up to 6 million vehicle records without images or up to 40,000 vehicle records with one image per vehicle.

INFORMATION AVAILABLE

The vendor shall supply data analysis software compatible with the format of the data downloaded from the WIM systems and capable of computing various classification schemes to provide various reports based on the data collected.

The following information shall be made available from the data collection feature of the WIM systems:

- Reports over any selected amount of time in hourly increments, daily, weekly, or monthly
- Summary of vehicle speeds
- Summary of vehicle classification counts
- Equivalent Single Axle Load (ESAL) count
- Reports on the number of violating and non-violating axles, axle groups, and gross vehicle weights
- User-selected reports based on adjustable parameters such as periods and vehicle types
- Customization for generating reports for specific needs that are not available using basic parameters

In addition to the requirements listed above, the following data analysis options shall be available:

- The Vendor shall have available and may supply a raw vehicle record data output for the Department to perform additional analysis using the Departments' software.
- The Vendor shall have available and may supply additional optional data analysis software.
- The Vendor shall have available and may perform data collection, analysis, and report generation as an optional service to the Department.

CHAPTER 3. CONDUITS AND PULL BOXES REQUIREMENTS

All cables shall be in conduits unless specifically approved by the engineer. All pull boxes are to meet Department specifications.

All materials shall comply with the "National Electrical Code", the current Department Standard Specifications for Highway Construction, "Highway Division Standard Drawings for Design and Construction", and special requirements by Department weigh in motion and automatic vehicle identification system specifications. Duct seal shall be used to seal all conduits in the cabinets and all junction boxes. All conduits shall have a polyethylene pull string with at least a 210-pound break strength left in place at the completion of construction.

Separate conduits shall be used for AC/DC power and low voltage signal cables. Low voltage signal cables shall include video, digital communication, sensor signal cable, and sensor excitation cables where voltage is under +/- 20 volts DC. Conduits for video and RF cables shall be of a large enough size to accommodate the maximum bend radius using factory 90-degree bends.

All cables shall be in conduits unless specifically approved by the Department.

CHAPTER 4. SYSTEM ACCEPTANCE REQUIREMENTS

The system shall be accepted subject to fulfilling the following conditions:

- System review
- Acceptance tests
- Training

SYSTEM REVIEW

The WIM vendor shall submit three (3) copies of documentation as follows:

- A detailed description of how the system requirements will be met
- Drawing layout with descriptions
- Manufacturer's name and model number, supported by descriptive material for (but not limited to) the standard package components with all accessories identified under "Description"
    - Submittals shall be supported by descriptive material, such as catalog cuts, diagrams, and other data published by the manufacturer, to show conformance to specifications and plan requirements; model numbers alone will not be acceptable.
- At least three (3) Virtual Weigh Station System references that have had systems in regular use for no less than one year
    - The Department reserves the right to request the owner's evaluation of in-service equipment. These shall all be different references.

ACCEPTANCE TESTS

The system, all-inclusive as contracted, shall be designed, built and tested by the Vendor, and as proof of operation. The system(s) shall be tested following ASTM E-1318-09 standard specifications for Highway WIM Systems for a Type 1 System. Field tests shall be performed by the WIM Vendor and observed by the Department with reports submitted to the Department.

FACTORY ACCEPTANCE TESTS

Before shipment of any equipment, Factory Acceptance Tests shall be performed for each system to verify the equipment is operating as described in the contract documents and the test specifications approved by the Department.

FIELD ACCEPTANCE TEST

The Department shall issue a Certificate of Final Acceptance upon successful completion of the acceptance test.

This calibration/acceptance procedure follows ASTM E1318 Standards. Calibration is to be performed by the running of one calibration truck. The test vehicle shall be a five-axle tractor/trailer combination

(3S2), with air ride suspension in excellent mechanical condition. It shall be loaded with solid, non-shifting material to within 90 to 100% of allowable Gross Vehicle Weight for the road under test.

The calibration procedure is as follows:

- The vehicle shall be weighed at a government certified static weigh scale. The weight information on the front (single axle), drive (tandem axle group), and trailer (tandem axle group) shall be recorded. The Gross Vehicle Weight (GVW) of the vehicle shall be calculated by adding the three weights together.
- The distance between the five individual axles on the truck shall be measured and recorded.
- The test vehicle will make three test passes over the road under test at a selected speed that is indicative of the truck traffic at the site. Adjustments will be made by vendor personnel on-site during this time to fine-tune the axle spacing and weight output of the WIM system.
- Once all initial adjustments have been made, the test vehicle will make an additional two test passes to confirm the accuracy of the adjustments. If all the readings fall within the ASTM ranges for the WIM Type under test, and vendor personnel does not warrant additional adjustments, the tests will continue. If this is not the case, additional adjustments will be performed, and two more confirming passes shall be made by the test truck.
- The test truck shall then make an additional ten passes at a selected speed that is indicative of the truck traffic at the test site.
- All of the data shall be recorded and placed into a spreadsheet. The mean error and standard deviation for all recorded measurements shall be calculated at the end of the ten test passes. The calculations will be as follows:
    - For weight measurements, the percent error for each test pass shall be calculated using the following formula:
        - [(WIM Weight - Static Weight)/Static Weight] x 100 = % error
    - The mean error for each weight type (single, group, GVW) shall be calculated as follows:
        - % errors for single, group or GVW/# of samples = Mean error
          (Each weight type calculated individually)
    - The error for individual axle spacings shall be calculated using the following formula:
        - 10 of [(WIM Axle Spacings - Actual Axle Spacing)]/10 = Mean Axle Spacing Error
          (Each of the four axle spacings calculated individually)

  All of the calculated errors shall also be entered into the spreadsheet.
- A check will be made of the calculated result against the acceptable range for the ASTM WIM Type under test. There will be one of two results:
    - If 95% of all recorded test results (single axles, axle groups, GVW, axle spacing) fall within the specified tolerance for the ASTM WIM Type under test, then the system will have passed the requirements.
    - If less than 95% of the calculated differences fall within the specified tolerance for the ASTM WIM Type under test, then the system will be readjusted, and an additional ten test passes will be required to retest the system.
- The testing will continue until the system passes all criteria according to ASTM E1318 Standards.

CHAPTER 5. TRAINING REQUIREMENTS

The Vendor shall set up and conduct formal training programs for Department personnel on the operation of the WIM Systems. The training shall include at a minimum the following:

- One half-day operator training session providing an introduction to the operation of the WIM Systems and the functions performed by the major system components with a class size of up to eight individuals
- One day "hands-on" guidance session for operators in the operation of the systems with a class size of up to four individuals

The contract price includes the first training sessions. The Department shall, from time to time, review any future training requirements. The WIM Vendor shall agree to provide future and additional training sessions upon receipt of requests from the Department. The Department shall reimburse the WIM Vendor the cost of providing additional training sessions on a per diem basis and at a rate agreed upon by the Department at the time of the request. The Department shall provide classroom space for the training session.

CHAPTER 6. WARRANTY REQUIREMENTS

The WIM Vendor shall warrant all manufactured materials and equipment for a period of one year from the date of acceptance of the system.

The warranty shall cover the manufacture of the equipment, and includes the manufacturer's workmanship, material defects, assembly and installation of system components, hardware and software. The warranty shall not cover damage to any in-road equipment as a result of pavement deterioration. The warranty shall not cover physical damage caused by accident, vandalism, lightning, flood, fire, acts of God, acts of war or terrorism, or improper installation or servicing by personnel not authorized by the vendor.

The vendor shall not under any circumstances be liable for any special, incidental, indirect or consequential damage, including damages from the use or malfunction of the product, loss of profits or revenue or cost of replacement goods, whether the Vendor has been informed or not in advance of the possibility of such damages.

Following the expiration of the warranty, the vendor shall provide the option of a system maintenance service contract for a period to be negotiated between the Department and the vendor.

CHAPTER 7. MATERIAL REQUIREMENTS

The material used in the construction of this equipment shall be of good commercial quality entirely suitable for the intended purpose. Material shall be free from all defects and imperfections that might affect the serviceability of the finished product.

CHAPTER 8. STANDARD PRODUCTS REQUIREMENTS

The equipment shall be constructed of standard material, so that the prompt and continuing service and delivery of spare parts may be assured. The components need not be products of the same manufacturer.

CHAPTER 9. LIGHTNING PROTECTION REQUIREMENTS

Ground rod(s) shall be provided and installed at all outdoor equipment cabinet locations, scale vault(s), and equipment mounting pole(s) and structure(s). All system components and equipment shall be properly grounded.

Lightning protection devices shall be provided for signal input/output and power connections at any separately packaged electronic signal processing device/equipment.

Lightning protection devices shall be either in the form of terminal boxes equipped with terminal blocks and lightning/transient suppressors or modular lightning protectors. Lightning protection shall be provided.

CONCLUSION

In December 2018, Sgt. Jeffrey Smith of the Arkansas Highway Police (AHP) Alma weigh station stated that the Virtual Weigh Station (VWS) system had been inundated with problems since coming online. Sgt. Smith also stated that the inaccuracy of the scales is "mind-blowing". For example, an alert from the VWS indicated a commercial vehicle had a Gross Vehicle Weight (GVW) in excess of 100,000 pounds. When an officer made an enforcement stop and weighed the truck in question using calibrated portable scales, the weight was within legal limits.

Mr. John Ballard of the Arkansas Department of Transportation (ARDOT) was the Field Engineer on the VWS project and provided a very different perspective on the performance of the system. Mr. Ballard agreed with Sgt. Smith that early on, the scales were inaccurate. Mr. Ballard stated that the system had weighed a car at around 30,000 pounds. However, Mr. Ballard stated that he had spoken with the manufacturer who suggested the cause was a bad sensor(s) in the pavement. The manufacturer replaced the malfunctioning sensors and recalibrated the system. The manufacturer determined that the sensors had malfunctioned because of a lightning strike.

Mr. Ballard confirmed that in May of 2017, Mr. John Sharum (ARDOT) had said everything seemed to be in proper working order and agreed to start the one year warranty period to end May 2018. The manufacturer offered to extend the warranty until February 2019 because of the many issues with the system.

Mr. Ballard also explained that VWS's are susceptible to weight manipulation by commercial truck drivers, for instance, fuel truck drivers have learned that before approaching the scale, the driver can tap the brakes causing the fuel in the tank to slosh causing the scales to produce a false reading and allowing overweight loads to go undetected. Drivers can also manipulate the sensors in the pavement by changing lanes when passing over the scale. The lane change causes a false reading to be recorded at the AHP weigh station or in a mobile unit. Mr. Ballard stated that VWS manipulation is common knowledge in the trucking industry.

The Automatic License Plate Reader (ALPR), one of the key components of the VWS, had to be disabled at one point because Arkansas legislation did not allow for the Arkansas Highway Police to capture that data; however, in the 2017 regular session of the Arkansas Legislature, HB1423 made technical corrections to Ark. Code Ann. § 12-12-1803 Law Enforcement, Emergency Management, and Military Affairs as follows:

(4)(A) By the Arkansas Highway Police Division of the Arkansas State Highway and Transportation Department for the electronic verification of registration, logs, and other compliance data to provide more efficient movement of commercial vehicles on a state highway.

(B) An automatic license plate reader system used under subdivision (b)(4)(A) of this section shall be installed at an entrance ramp at a weigh station facility for the review of a commercial motor vehicle entering the weigh station facility.

SYSTEM PICTURES

Print

Lane: 2 12/20/2018 13:44:13 ID: 43666 License: AR [redacted] 100 % DOT: [redacted] KYU: [redacted]

50540 lb 45.7 mph 57.2 ft Class 9

Owner: [redacted] Juris: USAR Veh: 2014 INTL Type: TT Fuel: N
VIN: [redacted] Title#: [redacted] Axles: 3 Unladen Wt: 19481 GVW: 80000
Base state: AR Sending state: AR Interstate flag: 1 IRP status code: 100 Reg. start: 2018-07-01 Expires: 2019-06-30


K79


[redacted]
Fort Smith / Little Rock, AR
Oklahoma City, OK
USDOT 2
KYU 05
FIRE EXTINGUISHER INSIDE
OPERATED BY
USDOT
VIN EN0

Connected

Time: 09:57:07
Speed: 46.9 mph

69580 lb

Class: 9
AR K80[redacted] 100 %
BUSINESS SOLUTIONS INC

Print

Lane: 2 12/28/2018 09:57:07 ID: 89118 License: AR [redacted] 100 % DOT: [redacted]

69580 lb 46.9 mph 56.4 ft Class 9

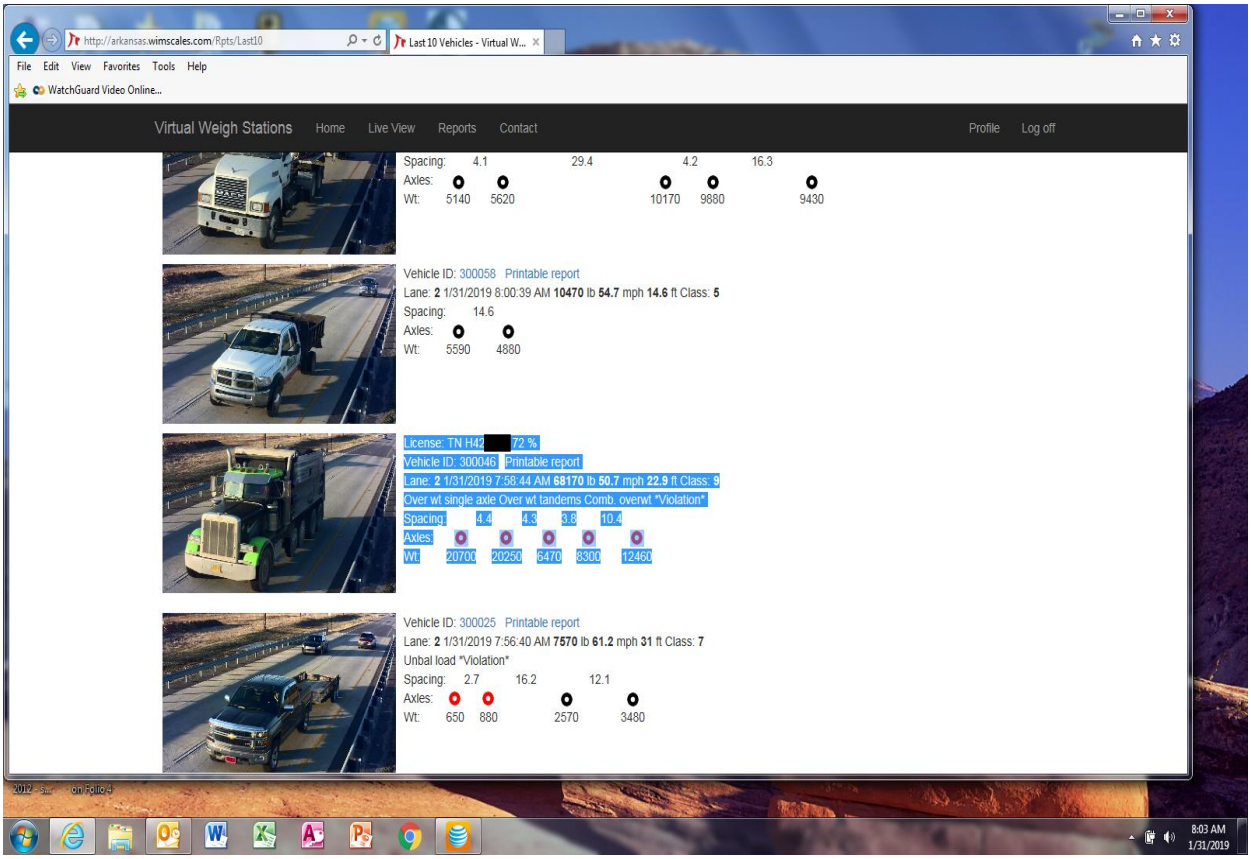
Owner: [redacted] Juris: USAR Veh: 2009 FRHT Type: TT Fuel: D
VIN: [redacted] Title#: [redacted] Axles: 3 Unladen Wt: 16000 GVW: 80000
Base state: AR Sending state: AR Interstate flag: 1 IRP status code: 100 Reg. start: 2018-11-01 Expires: 2019-10-31

Print

Lane: 2 12/28/2018 10:06:45 ID: 89172

24720 lb 45.9 mph 25.9 ft Class 4

Unbalanced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Last 10 Vehicles - Virtual W...
File Edit View Favorites Tools Help
WatchGuard Video Online...
Virtual Weigh Stations
Home
Live View
Reports
Contact
Profile
Log off
Spacing: 4.1 29.4 4.2 16.3
Axles:
Wt: 5140 5620 10170 9880 9430
Vehicle ID: 300058 Printable report
Lane: 2 1/31/2019 8:00:39 AM 10470 lb 54.7 mph 14.6 ft Class: 5
Spacing: 14.6
Axles:
Wt: 5590 4880
License: TN H42 72 %
Vehicle ID: 300046 Printable report
Lane: 2 1/31/2019 7:58:44 AM 68170 lb 50.7 mph 22.9 ft Class: 9
Over wt single axle Over wt tandems Comb. overwt *Violation*
Spacing: 4.4 4.3 3.8 10.4
Axles:
Wt: 20700 20250 6470 8300 12460
Vehicle ID: 300025 Printable report
Lane: 2 1/31/2019 7:56:40 AM 7570 lb 61.2 mph 31 ft Class: 7
Unbal load *Violation*
Spacing: 2.7 16.2 12.1
Axles:
Wt: 650 880 2570 3480
8:03 AM
1/31/2019