UNIVERSITY OF KENTUCKY
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Kentucky Transportation Center

Research Report
KTC -14-05/SPR456-13-1F

Coordinating the Use and Location of Weigh-In-Motion Technology for Kentucky

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We provide services to the transportation community through research, technology transfer and education. We create and participate in partnerships to promote safe and effective transportation systems.

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Coordinating the Use and Location of Weigh-In-Motion Technology for Kentucky

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16. Abstract

Several agencies in the Kentucky Transportation Cabinet make use of data collected by weigh-in-motion (WIM) scales throughout the state. These scales are used to collect traffic counts, weigh vehicles, weigh individual axles, determine vehicle length, classify vehicles, and determine speed. The data is primarily used for planning, law enforcement related to commercial vehicles, and pavement design. This study details the applications of WIM data, and reviews existing literature on how WIM data is used and shared. The study provides survey feedback from other states, specifically about how they use WIM data. It details competing WIM technologies currently on the market, and provides measures of performance along with cost estimates. Details on current WIM locations throughout the state are provided, and plans for future WIM locations are also explained. Recommendations about how Kentucky can better utilize WIM technology and data are provided in the final chapter.

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Executive Summary

The Kentucky Transportation Cabinet (KYTC) commissioned this study to determine if it should develop a comprehensive plan to procure, manage, and share weigh-in-motion (WIM) stations throughout the state. WIM systems have a variety of applications, and the potential benefits can be distributed more effectively through a coordinated effort between state agencies. Currently the Division of Planning, Division of Motor Carriers, and the Commercial Vehicle Enforcement Division of Kentucky State Police all have needs for such technology at roadsides around the state. Limited resources need to be pooled to get the most out of this expensive equipment.

WIM data is a valuable tool for transportation planning, commercial vehicle enforcement and pavement design. In terms of planning, WIM data is used to calculate traffic volumes on public roads and classify the types of vehicles traveling along particular routes. Law enforcement officials screen commercial vehicles using WIM data to identify violations of Kentucky truck weight laws and regulations. Pavement design engineers use WIM traffic volume and vehicle class data to select the optimal materials for surfacing roads. Engineers base these choices on the representative traffic patterns experienced on highways and routes the state is responsible for maintaining.

To understand how other states share and use WIM data, KTC researchers developed a survey that was sent to state transportation agencies. Survey respondents supplied an ample amount of information about the use and sharing of WIM data. A few critical generalizations emerged from the surveys. First, most of the WIM sites are located on routes with significant heavy truck travel. Most data collected from WIMs is used to meet federal requirements and preserve infrastructure. Engineers use this data to determine the state's infrastructure maintenance and construction needs. Second, states gather a wealth of information from WIM systems. Survey respondents reported that WIM provides data on traffic volume, vehicle classification, average daily traffic (ADT), average annual daily traffic (AADT), weight, and speed. There is no clear pattern on information sharing – some states are more willing than others to share data. Among the states responding to the survey, none have any formalized sharing agreements. Third, the majority of states surveyed have adopted piezoelectric WIM sensors, systems that are expensive to install and maintain. Installation and maintenance is sometimes conducted by state employees or is contracted out to private firms. The vast majority of funding for WIM installation and maintenance comes from the federal government. Finally, in terms of gathering and analyzing the data from these systems, some states' contracting budgets have led to less robust data collection; there are also problems with presenting data accurately and in an acceptable format. Budgetary squeezes are not an issue in all states; likewise some respondents reported few challenges in data accuracy and sharing.

To meet the planning, commercial vehicle enforcement and pavement design requirements for Kentucky, the Cabinet has purchased and currently maintains a substantial number of WIM and automatic traffic recorder (ATR) equipment around the state. Some of the sites were purchased by the KYTC's Division of Planning and are maintained by the Division of Maintenance. Currently, Kentucky's Division of Planning has 35 WIM sites throughout the state. These sites do not include the 86 ATRs the Division of Planning has throughout the state. The Division of Motor Carriers has 14 weigh stations, 13 of which are equipped with WIM scales. Nine of those scales have medium- to high-speed WIMs, and three others have slow rollover WIMs. The Shelby County weigh station will soon have a fully operational mainline WIM. The Fulton County weigh station only has a static scale.

Right now, the Division of Motor Carriers plans to install WIM at two sites, and the division is placing equipment at a third site that could be potentially interfaced with WIM technology. The WIM locations include:

- Virtual Weigh Station site with a WIM on U.S. 25 northbound in Laurel County
- Virtual Inspection Station site on Kentucky Route 9 in Carter County
- Mainline WIM on I-64 EB just prior to the weigh station in Shelby County

Based on the data gathered, KTC researchers put together several recommendations related to the collection and usage of WIM data. The focus of these suggestions is on improving the means by which state agencies share this information.

1. The Division of Motor Carriers and Division of Planning should conduct periodic discussions about potential partnerships and ways in which WIM equipment, data, and costs can be shared. Initial discussions did much to identify some of the obstacles. The Division of Planning does not want to invest in more expensive WIM products because less expensive equipment is sufficient for their needs. The Division of Motor Carriers and KSP-CVE require an extremely low margin of error – which is achieved by using expensive WIM equipment and calibrating it frequently. Traffic data and geographic information systems (GIS) data can be used to decide where to install future virtual weigh stations. Planning can also make use of the truck weight and classification data from WIM scales at weigh stations around the state. The Office of Information Technology has agreed to let the Division of Planning access that data from the Cabinet's centralized commercial vehicle observation database.

2. Securing external funding sources will continue to be important for the Transportation Cabinet. The Division of Motor Carriers has relied heavily on the Federal Motor Carrier Safety Administration as a partner for its Commercial Vehicle Information Systems and Networks (CVISN) and PRISM programs. The Division of Planning has depended on the Federal Highway Administration when working on the Traffic Monitoring Guide (TMG) and Highway Performance Monitoring System. When funding opportunities arise, these

state agencies must coordinate to ensure they gain every possible advantage to shore up needs for WIM equipment and data.

3. Kentucky agencies needing WIM data should reach out to vendors of new WIM products that can potentially improve the performance of commercial vehicle screening systems and the accuracy of WIMs used to collect vehicle weight and classification data. If the pilot project with Intercomp meets its objectives, Kentucky may have a new WIM option that is cheaper and just as accurate as traditional WIM technology going forward.

4. Although the Division of Planning responds to formal requests to WIM data, obtaining it would be much simpler if all data were available to download from a KYTC-hosted website. KYTC recently launched a web portal, DataMart, for this purpose. This service provides access to more transportation-related data in one place than what has been previously available to the public. Some of the information housed on DataMart includes: vehicle registration statistics, crash rates, state-maintained bridge locations, travel statistics, GIS data, and MAP-21 performance measures. Much of the data discussed in Chapter 1 is available online. However, KYTC should consider making WIM data files available on DataMart so the Division of Planning would no longer have to fulfill WIM-related data requests. Users requesting information could be referred to DataMart.

5. To further refine WIM data collection and sharing, the Division of Planning and Division of Motor Carriers should identify other stakeholders who may benefit from WIM data and make it available accordingly, preferably through DataMart. Chapter 2 discusses how Connecticut shares data with several state agencies. Connecticut also shares data with the Department of Energy and Environmental Protection (DEEP), Department of Motor Vehicles (DMV), the State Police, local law enforcement agencies, Office of Policy and Management (OPM), and the Council of Government (RPO-MPO), among others. KYTC should seek out other users of this data and adapt reporting needs to help agencies that use this data. This may require the periodic updating or modification of data stored in DataMart to better meet the needs of these new consumers.

6. Users of the Division of Planning's GIS data may find it easier to identify the correct variables if the associated data dictionary was updated more frequently and was more user-friendly. The current data dictionary dates from 2006, and some of the data fields in the traffic data, for example, are not clearly specified. It would also be helpful if the traffic flow data were included in subsets of the state highway network, such as the National Highway System (NHS) shapefile. Additional iterations of this data, or easier methods of matching traffic flow data to various subsets of the state highway network would be useful.

7. The Division of Planning and/or Division of Maintenance should develop cost estimates for repairing WIM sites where the equipment is functioning but not communicating the data to the state's data networks. Repairing these sites could significantly increase the amount of WIM data available for state use, increasing the number of functioning WIM sites operated by the Division of Planning from 12 to 17.

8. KYTC should highlight the value of WIM data to the Kentucky General Assembly in an effort to secure appropriations for the purchase and maintenance of WIM scales around the state. With state governments becoming increasingly data-centric, traffic data, weight data, and vehicle classification will play a central role in state planning, meeting federal data reporting requirements, informing decision making about which highway projects' funding should be prioritized

9. KYTC should commission a study that identifies the best locations for future WIM sites based on current data and projected traffic patterns around Kentucky. Assessing current WIM site performance and value would help to better allocate resources to achieve this end. Connecticut routinely performs these evaluations. Those studies can potentially offer a template for Kentucky moving forward.

10. If there are locations that interest both the Division of Motor Carriers and the Division of Planning, resources could be shared to purchase and maintain WIM equipment. The WIM scale would need to be located on a mainline, so this would lend itself more to a VWS concept than a new fixed weigh station. If the route has strategic importance to both divisions, and both agencies can agree on a suitable vendor whose products meets the technical specifications of both divisions, pooling resources makes fiscal sense.

Chapter 1. Applications of WIM Data

KYTC commissioned this study to determine if it needs a statewide plan to procure, manage, and share WIM scales. These scales have many applications, and if state agencies worked in a coordinated manner it would be possible to realize their full benefits. Currently the Division of Planning, Division of Motor Carriers, and Commercial Vehicle Enforcement all have needs for this technology at roadsides around the state. Limited resources need to be pooled and coordinated in order to get the most out of this expensive equipment.

For this study, KYTC is primarily interested in orchestrating the use of new WIM scales as well as data collection with the currently existing WIM scales among the Division of Planning, the Division of Motor Carriers, and Commercial Vehicle Enforcement. The effort attempts to maximize the benefits of WIM technology in a cost-efficient manner. One recommendation of a previous KTC study, "WIM Data Collection and Analysis" was for KYTC to operationalize a data collection plan "to capture sufficient data to develop length-based classification factors."[1] These classification factors are important for the Division of Planning, which has collected classification information since 1986. Data collection proceeds are based on the recommendations found in the Federal Highway Administration's (FHWA) "Traffic Monitoring Guide." The 2013 version of the FHWA TMG outlines policies, standards, procedures and equipment used to monitor traffic volume, vehicle classification, weight and other crucial characteristics necessary to meet federal and state planning requirements.[2]

WIM equipment has important uses for law enforcement as well. WIM scales, along with License Plate Readers (LPR) and United States Department of Transportation (USDOT) readers, can be installed in weigh stations or on known bypass routes that commercial vehicles use to avoid weigh stations. These Virtual Weigh Stations (VWS) help stakeholders enforce weight laws, credentials, and safety regulations on bypass routes.

The Division of Design also uses WIM data to calibrate the material composition of pavements applied to resurfacing projects and new roads around the Commonwealth. Based on the vehicle classification, traffic volume, and life expectancy of the pavement, pavement engineers can modify pavement composition to complete projects that yield ideal performance and efficiency outcomes.

An initial task for this project is to examine existing research to identify placement strategies, methods, and approaches of other efforts at coordinating WIM scale technologies. The general findings within this set of literature emphasize the importance of interagency cooperation,

[1] Pigman, J.G., R.C. Graves, D.Q. Hunsucker and D.H. Cain. 2012. "WIM Data Collection and Analysis." Kentucky Transportation Center. KTC-12-5/SPR404-10-1F.

[2] "Traffic Monitoring Guide." 2013. Federal Highway Administration.

strategies to effectively share WIM data, and real-world examples of how WIM coordination works among various stakeholders.

This study reviews existing approaches to WIM data collection, summarizes survey information about how WIM data is collected and shared in other states, describes currently available WIM technology and associated costs, maps current WIM locations, identifies potential future WIM locations, overviews a pilot WIM project, and develops recommendations for sharing WIM data.

WIM Data and State Planning

In transportation planning, pavement design, and maintenance, WIM data is collected to provide state DOTs and FHWA with traffic volume and weight data. These data are then used to allocate resources in areas where there is need. The FHWA's Highway Performance Monitoring System (HPMS), developed in 1978, requires states to submit data on all public roads. The data provides federal, state and local officials with information about highway conditions, investment requirements, performance, and air quality trends.[3] The data are published annually by FHWA, and include information on bridges, highway infrastructure, highway travel, travelers, vehicles, motor fuel consumption and taxes, highway revenues, debt obligations, apportionments, and expenditures. To meet requirements specified by the Highway Performance Monitoring System Field Manual (authorized under 23 U.S.C. 315), states must use WIM data to provide the FHWA with knowledge of annual average daily traffic (AADT) and vehicle classification information. Classification is based on vehicle type, number of axles, axle spacing, and overall vehicle length and width.[4] In many instances, where specific weight and axle configuration data is not required, states only use automatic traffic recorders (ATRs), which provide raw traffic counts. On less-traveled routes, most states use estimation techniques to derive traffic counts.

Table 1 shows data from the HPMS that is compiled using samples from WIM equipment, ATRs, and other estimation procedures.[5] Specifically, this chart contains information about the traffic volumes on all highways that are part of the NHS, whether they are an Interstate, a U.S. route or state route. These data are available for each U.S. state, the District of Columbia and Puerto Rico. "Area" refers to whether the roads are in a rural or urban area. The "Volume" is the average daily traffic count for a particular segment of road. "Miles" are total highway miles that fit into a particular category. The rightmost column indicates where Kentucky ranks nationally – excluding DC and Puerto Rico. This information assists the USDOT and Congress when they decide where to direct federal highway aid. Obviously other factors are assessed (e.g. funding,

[3] Highway Performance Monitoring System. 2003. FHWA. Accessed online 21 April 2014 at: http://www.fhwa.dot.gov/policyinformation/hpms/hpmsprimer.cfm

[4] Ibid.

[5] Official Highway Statistics. 2012. FHWA: Office of Highway Policy Information. Accessed online 24 April 2014 at: http://www.fhwa.dot.gov/policyinformation/statistics/2012/

pavement condition, safety issues, etc.), but the WIM and ATRs used by planning divisions of state DOTs provide essential data points to perform inter-state comparisons and rank needs.

Table 1. Kentucky Average Daily Traffic Volume for Federal Aid Highways, 2012

Highway	Area	Volume	Mileage	State Rank
Interstate	Rural	<10,000	38.3	25
Interstate	Rural	10,000-19.999	94.8	34
Interstate	Rural	20,000-34,999	182.1	21
Interstate	Rural	35,000+	281.5	9
Interstate	Rural	Total	596.8	27
Other	Rural	<1,000	0.2	39
Other	Rural	1,000-1,999	45.4	40
Other	Rural	2,000-2,999	79.1	39
Other	Rural	3,000-3,999	94.5	36
Other	Rural	4,000-4,999	143.5	30
Other	Rural	5,000-9,999	938.9	5
Other	Rural	10,000-14,999	420.5	6
Other	Rural	15,000+	163.6	18
Other	Rural	Total	1,885.8	28
Interstate	Urban	<30,000	1.4	48
Interstate	Urban	30,000-69,999	103.8	22
Interstate	Urban	70,000-124,999	62.4	28
Interstate	Urban	125,000-174,999	33.7	19
Interstate	Urban	175,000+	2.7	25
Interstate	Urban	Total	203.9	30
Other	Urban	<7,500	51.1	40
Other	Urban	7,500-14,999	126.4	38
Other	Urban	15000-34.999	347.8	29
Other	Urban	35,000-59,999	70.3	28
Other	Urban	60,000+	11.4	32
Other	Urban	Total	607.0	34

As the data show, Kentucky ranks 27th in total rural Interstate mileage and 30th in total urban Interstate mileage. Kentucky has a substantial network of rural Interstates moving relatively high volumes of traffic. This is not surprising for a mostly rural state where there is a lot of through traffic. Kentucky has seven bordering states and is a crossroads between the Midwest and Southern United States. Kentucky's contingent of federal, non-Interstate highways with an AADT of 5,000 to 9,999 and 10,000 to 14,999 ranks 5th and 6th, respectively. Kentucky has substantially less urban Interstate and urban federal highway mileage relative to the rest of the country. In the entire state, there are 2.7 miles of Interstate highways, with an AADT greater than

175,000. These data provide a good overview of the traffic flow on NHS in Kentucky, and can aid planning officials who allocate resources based on the traffic volumes, total mileage and road types in each state.

Table 2. Kentucky Vehicle Miles Traveled (Millions)

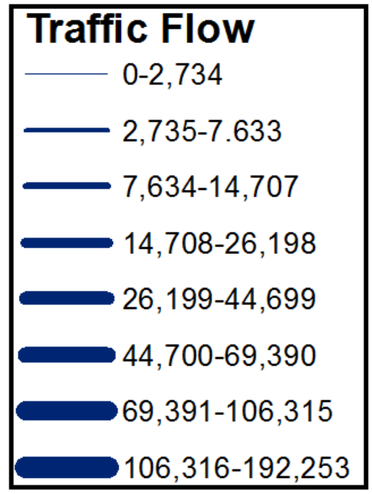
FHS Type	Area	VMT	State Rank
Interstate	Rural	7,088	12
Interstate	Urban	5,987	26
Interstate	Total	13,076	21
Other	Rural	5,993	14
Other	Urban	5,005	31
Other	Total	10,999	28
Total	Rural	13,082	12
Total	Urban	10,993	28
Total	Total	24,075	26

Table 2 displays total vehicle miles traveled (in millions) on each type of NHS highway, broken down by area. This data is estimated based on WIM/ATR data provided to FHWA by states for the Highway Performance Monitoring System, although vehicle miles traveled (VMT) for smaller rural minor collector and rural/urban local functional systems is sometimes estimated by state DOTs using a model or other methods. The data for Kentucky reveal a significant amount of VMT on rural Interstate and non-Interstate highways in the NHS, placing the state 12th in overall rural NHS rankings. Its vehicle mileage totals for urban highways on the NHS, as well as overall vehicle miles traveled for all NHS roads are lower. But in no category does the state fall below 31st, which shows that Kentucky's federal highways are of substantial importance for the Commonwealth as well as interstate commerce and travel. It should also be noted that this data does not include information on Kentucky highways or roads not in the NHS, even if those routes receive federal aid.

The KYTC Division of Planning maintains several databases on state highways, including: GIS data and maps; roadway queries and reports; Highway Performance Monitoring System Daily Vehicle Miles Traveled (DVMT) reports; state primary road system data, maps, and listings;

functional classification data, maps, and listings; truck data, maps, and listing; and miscellaneous highway and Kentucky geospatial data.[6]

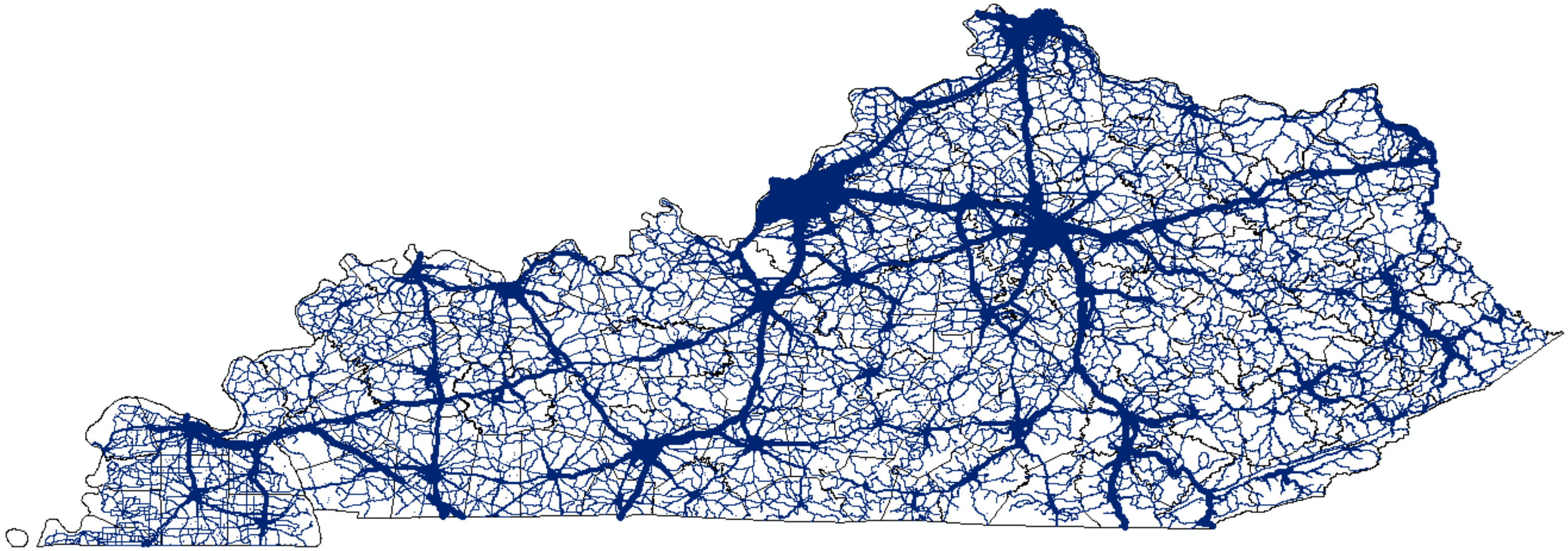
Figure 1 displays two representations of traffic flow on major Kentucky roads using GIS data maintained by the Division of Planning. The first map contains data for all routes for which traffic flow is tracked in Kentucky. Traffic flow measurements (AADT) are taken for select routes periodically, and estimates are made for other routes. The maps rely mostly on measurements that were taken in 2012, although some of the data used are slightly older. The measures include actual counts and computer-generated estimates. Shaded in blue are all highway routs; the line thickness indicates traffic levels on each route segment. The key to the right shows how line thickness corresponds to traffic flows. The heaviest traffic in the state is concentrated around Louisville, Lexington, and northern Kentucky, just outside Cincinnati. Interstate routes are the busiest, but a number of U.S. routes throughout the state are heavily trafficked as well.

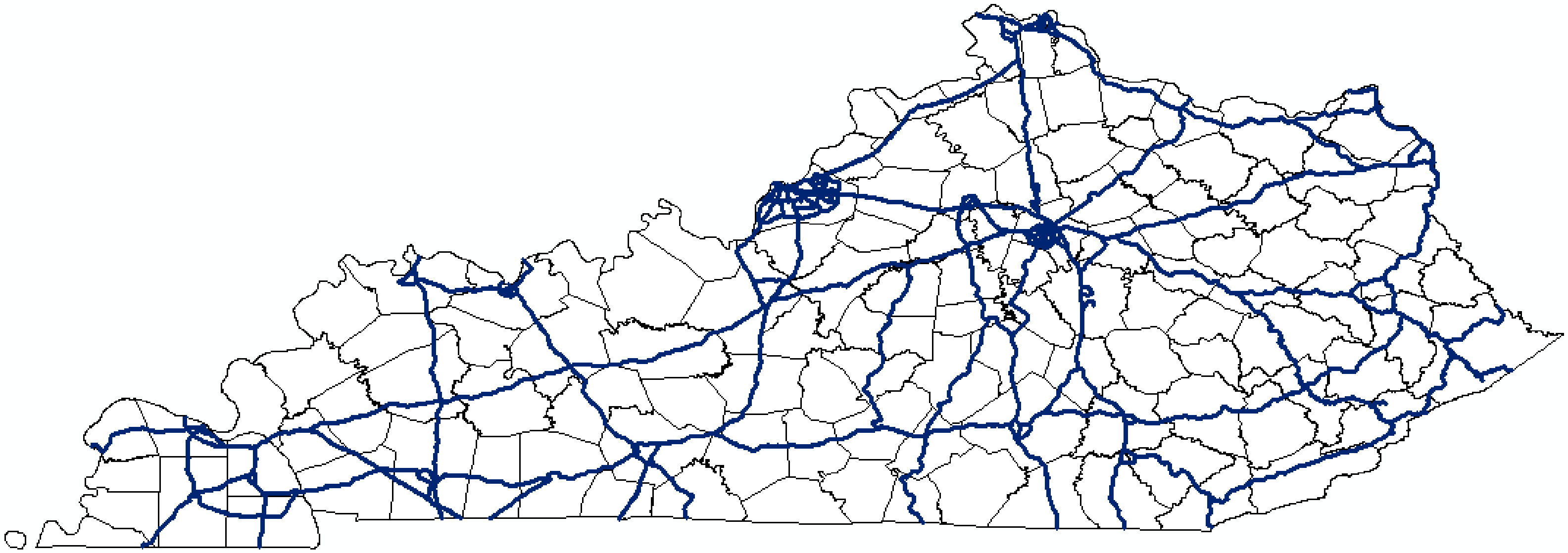


The second state map (bottom map in Figure 1) shows the NHS routes for the state with other routes excluded. There is no correlation here between traffic congestion and line thickness. Comparing the second map to the first demonstrates that most of the high-traffic routes in the state are part of the NHS. Significant federal funding goes toward these routes to ensure the system remains in good condition and meets taxpayer needs. These routes are a funding priority, also, because they protect the strategic national security interests of the federal government and facilitate quick responses to natural disasters. This data is made possible by the confluence of GIS software, measurements taken by WIM systems and ATRs around the state, and computer estimates based on actual counts of traffic on selected routes.

[6] Kentucky Transportation Cabinet: Division of Planning. 2014. "Planning Highway Information (HIS Database)." Accessed 28 April 2014.

Figure 1. GIS Traffic Flow Data for All Kentucky Roads, National Highway System Routes





Commercial Vehicle Enforcement

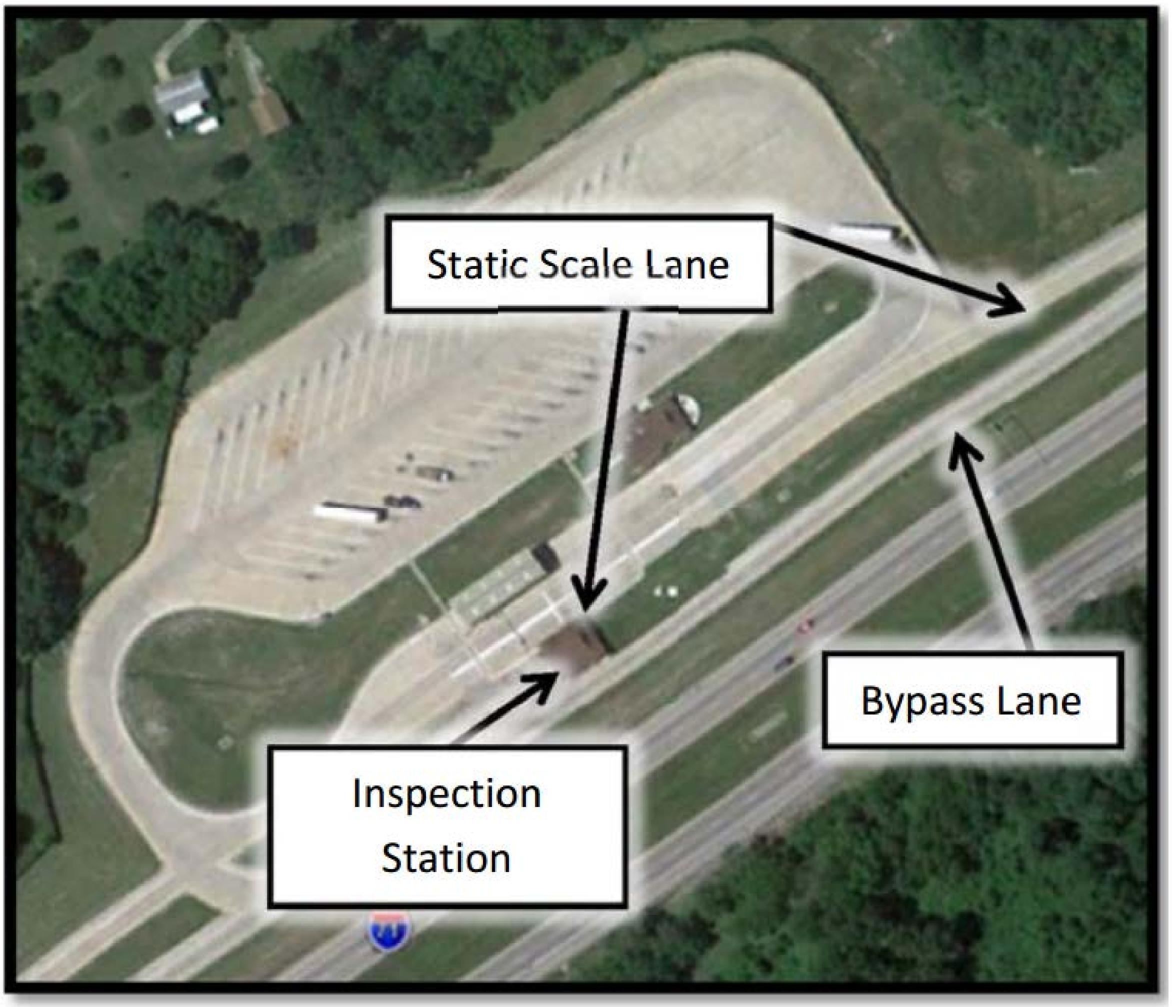
Law enforcement officials use WIM data to enforce statutory and regulatory requirements that are related to vehicle weight at the state and federal level. On any Kentucky highway that is part of the NHS, or which receives federal aid (also called Class AAA highways), trucks cannot have a gross vehicle weight exceeding 80,000 pounds without an Overweight-Overdimensional (OW/OD) permit. Gross vehicle weight cannot exceed 62,000 pounds on class AA Highways, and it cannot exceed 44,000 pounds on a Class A highway. Trucks surpassing weight requirements can legally obtain OW/OD permits from the Division of Motor Carriers for overweight loads and superloads. Trucks may be authorized for limited travel with an OW/OD permit on Class AA and Class A highways, but Division of Motor Carriers would have to approve the route. Carriers transporting coal on approved coal hauling routes may also obtain Extended Weight Decals for carrying overweight loads on those roads.

Table 3. OW/OD Enforcement Protocol for KSP-CVE

KRS	KAR	Description
189.223		Refusing to be weighed/Failure to unload OW truck 431.015(2) gives the authority to arrest.
189.222	603KAR5:066	Overweight on Class AAA Highway (80,000lbs) No tolerance on Interstate unless they have a permit.
189.222	603KAR5:066	Overweight on Class AA Highway (62,000lbs)
189.222 189.222	603KAR5:066 603KAR5:066	Overweight on Class A Highway (44,000lbs) Overweight on a bridge (posted on a sign)
189.221		Overweight on County Road (36,000lbs) OW permit can be given by county official
189.222	603KAR5:066	Violation of Bridge formula - (only applies if two sets of tandems are less than 36') Look at the KAR for details, 603KAR5:066(3)
189.222	603KAR5:066	Overweight on Single axle (20,000lbs)
189.222	603KAR5:066	Overweight on Tandem axle (34,000lbs)
189.222	603KAR5:066	Overweight on Tri-axle (48,000lbs)
189.270	603KAR5:075	Violation of Special Permit (weight)

Table 3 lists existing oversize=overweight (OW/OD) laws and regulations enforced by KSP-CVE officers in Kentucky. Officers enforcing these laws use WIM technology at weigh stations or VWS sites to screen trucks, but information from these scales cannot be used to distribute any citations. To do that, officers must weigh the truck on a static scale at a weigh station or use portable static scales if they have any available. Refusal to unload an overweight truck can result in an arrest, per KRS 189.223. Violations of KRS 189.221, 189.222 and 189.270 are punished by levying a fee on the carrier – two cents per pound for each pound over the allowable limit. If the load is more than 5,000 pounds overweight, a minimum fine of $100 is imposed, with a maximum fine of no more than $500, per KRS 189.990(2)(a).

Figure 2. Aerial Shot of Boone County Weigh Station, WIM Sorting System



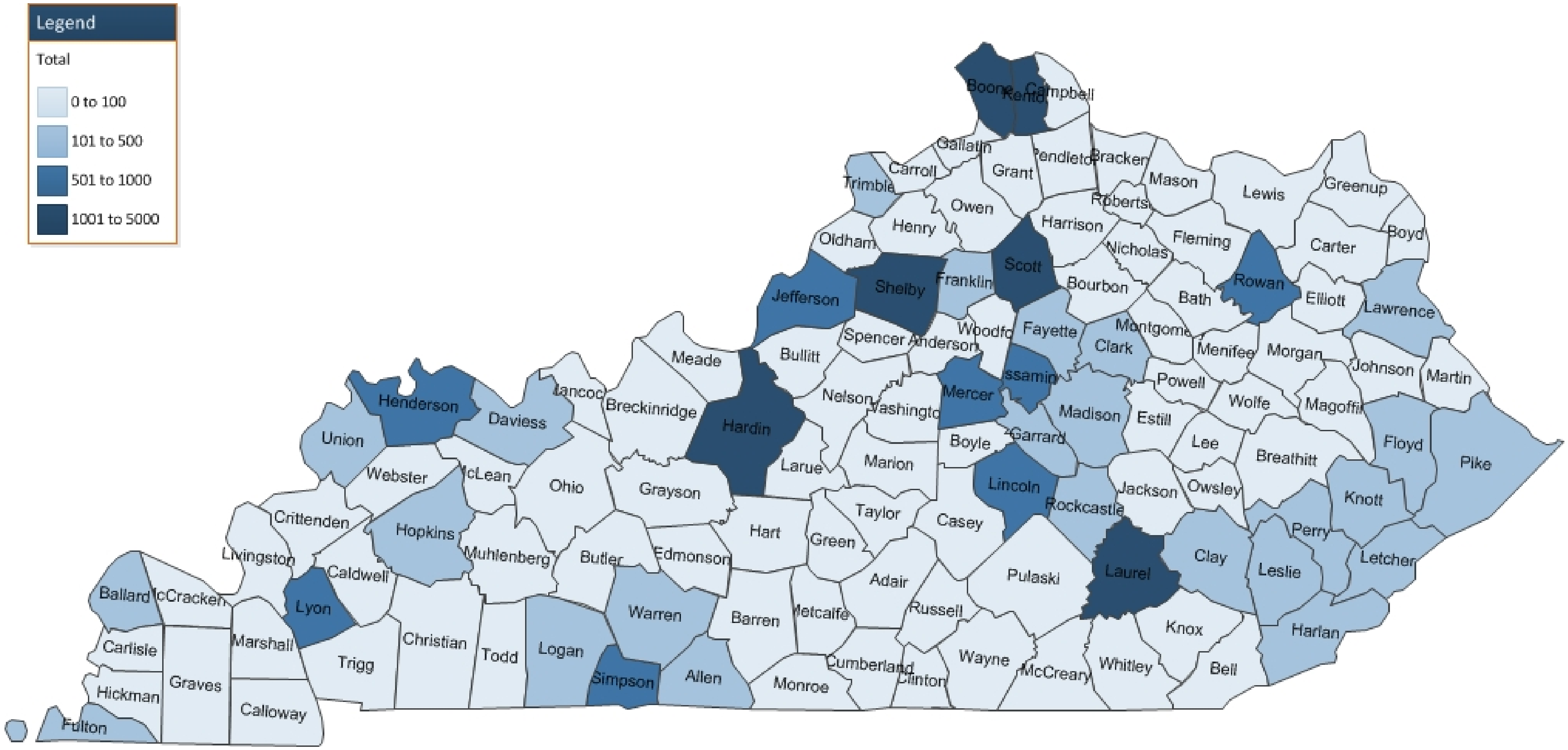
(Image Source: Google Earth October-2011)

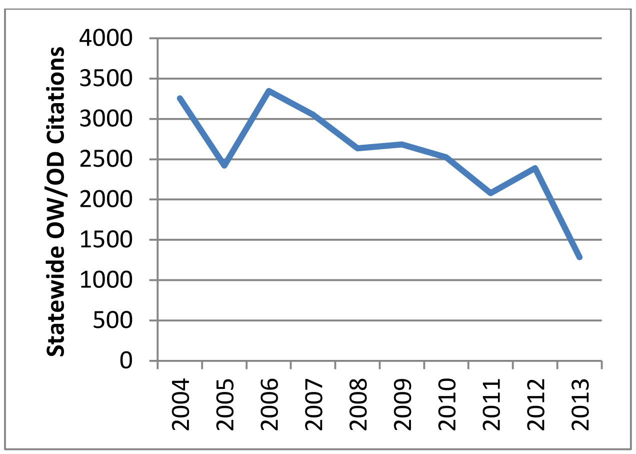
When a truck approaches a weigh station with a WIM sorting system, it crosses a series of loops that creates a truck observation record in the Mettler Toledo WIM and truck sorting system. If the weigh station is equipped with a Kentucky Automated Truck Screening (KATS) system, cameras will grab an image of the trucks' U.S. Department of Transportation (USDOT) decal and license. The system then decodes them using Optical Character Recognition (OCR) technology. These cameras are typically referred to as USDOTRs and LPRS in Intelligent Transportation Systems (ITS) literature. The Boone County station featured in Figure 2 has this system. Once the USDOT and LPR decode USDOT number and license plate number, checks are run against the safety and credentials data from FMCSA and the KYTC. The WIM gross vehicle weight and axle weights are collated with this information. The officer monitoring the system then receives the outcome of this evaluation. If the vehicle passes all checks, it is sent to the bypass lane, where it is allowed to pass the scale and re-enter the Interstate mainline. If the safety, credentials, or weight data trigger a screening flag, the truck is weighed on a static scale to obtain a more precise and accurate weight measurement; if necessary, enforcement personnel will interview the driver and inspect the truck. If the truck is overweight, the driver receives a citation. If the truck has a non-divisible load, the carrier is typically allowed to purchase an OW/OD permit from the Division of Motor Carriers. However, if the load is divisible, the truck may be detained and the driver required to unload enough cargo to comply with vehicle OW/OD laws and regulations.

Figure 3 shows a geographic breakdown of OW/OD citations in Kentucky from FY 2004-2013. Note that not all of these citations relate strictly to truck weight, as overdimensional numbers are included as well. There were 25,680 OW/OD citations issued during this period of time. Those numbers have decreased in recent years, in large part due to cutbacks on officer staffing levels in KSP-CVE. Nonetheless, the data reveal the importance of WIM scales as a screening tool for KSP-CVE officers. Approximately 61.3 percent of OW/OD citations came from counties with a weigh station, and 59 percent from counties with weigh stations and a high-speed or slow-rollover WIM. But not all of those citations are weight-related, and some of the citations may not have been written at the weigh station. Yet it is a safe surmise that a large percentage is directly related to the screening of the WIM systems throughout the state. In the 11 counties with WIM scales at the weigh station, enforcement of existing OW/OD laws for commercial vehicles is less cumbersome because of the weight screening benefits of WIM scales as well as the ample space and facilities to safely perform inspections. Counties with high citation counts are often adjacent to Interstates, particularly the I-65, I-75 and I-64 corridors. Citation rates in Eastern Kentucky are high due in part to enforcement of weight limits on coal haul routes throughout the region.

VWS sites have the potential to be used in this capacity as well. Currently, there are no VWS sites being used by KSP-CVE for weight enforcement throughout the state. These stations are costly to install. Site prep, electrical connections, communications capability, WIM equipment, cameras, and integration with existing screening systems are all complex processes that require significant labor inputs, new equipment, or both. One motivating factor for this project was to collaborate with the Division of Planning to determine if any WIMs operated by the agency could be retrofitted to use with other screening equipment (e.g. LPRs, USDOTRs, etc.) for enforcement purposes. This would shave approximately $100,000 off the initial cost of a VWS, and it would continue to yield savings on maintenance costs if shared by multiple agencies. However, there are several obstacles to making such arrangements in Kentucky (see Chapter 6).

Figure 3. Total OW/OD Citations Issued by County, FY 2004-2013; Statewide Totals





- OW/OD citations totaled 25,680 from FY 2004-2013.
- The number of citations issued in 2009-2013 decreased 25.4 percent from 2004-2008.
- Of the total citations, 15,737 (61.3 percent) OW/OD citations came from counties with a weigh station.
- Of the total citations, 15,164 (59 percent) of OW/OD citations came from weigh stations with a high-speed or slow-rollover WIM.

One key difference between the measurements needed for citing an overweight truck and the data needed for the FHWA's Highway Performance Monitoring System reporting is the level of accuracy. Citations for violations must be based on highly accurate scales with a known margin of error plus or minus 2 to 3 percent. In Kentucky, citations are only written based on static scale readings at weigh stations and portable scales used by officers for roadside enforcement. WIM data are used for screening purposes. The data needs of KSP-CVE officers are much more specific and require more accuracy than the Highway Performance Monitoring System reports submitted by the Division of Planning. In many instances, the Highway Performance Monitoring System only requires traffic counts for specific routes; the system lacks data on weight, length, axle weight, or axle configuration. The allowable margin of error for traffic counts based on data sampling is much higher according to the precision labels detailed in the Highway Performance Monitoring System Field Manual.[7] The confidence levels are generally 80-90 percent, and the allowable margin of error ranges from plus or minus 5 to ±15 percent depending on the type of road and the population density of the surrounding area. As such, the equipment functionality requirements for the enforcement of OW/OD laws and planning purposes are substantially different.

WIM Data and Pavement Design

WIM data is also useful for improving pavement design – namely its structural properties. There are dozens of variables pavement design engineers account for when developing road project specifications. The federal specification standards for the NHS are provided by 23 U.S.C. 109(C), 23 CFR 625.4, and 49 CFR 37.9. Additionally, the MAP-21 legislation enacted by Congress in 2012 also adds more routes to the NHS, and these requirements extend to those routes as well.[8] The Federal Highway Administration (FHWA), American Association of State Highway Transportation Officials (AASHTO) and Transportation Research Board (TRB) have developed publications and guides to assist state DOTs with this process as well. The KYTC's Division of Highway Design has published a pavement design guide for non-NHS projects that have limited traffic and a low percentage of trucks.[9] Key variables that influence designs include average daily traffic, equivalent single axle loads (ESALs) and percentage of truck traffic. These are used to calculate pavement thickness, asphalt mix, and other design-related specifications. A corresponding Excel worksheet has been produced that highway engineers working for KYTC or

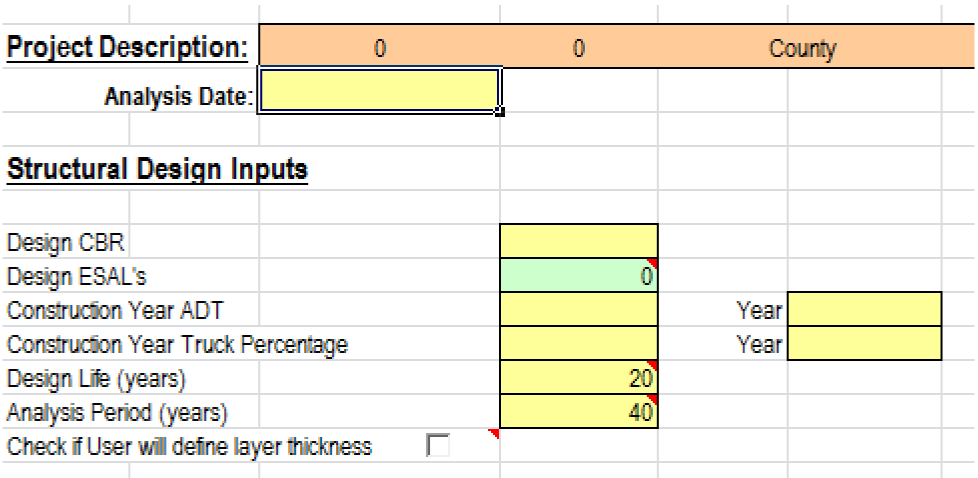
[7] Highway Performance Monitoring System Field Manual. 2013. FHWA: Accessed 21 April 2014 at: http://www.fhwa.dot.gov/policyinformation/hpms/fieldmanual/hpms2013.pdf

[8] Guidance on NHS Design Standards and Design Exceptions. 2013. FHWA: Accessed 28 April 2014 at: https://www.fhwa.dot.gov/design/standards/qa.cfm

[9] Pavement Design Guide. 2007. Kentucky Transportation Cabinet. Accessed 28 April 2014 at: http://transportation.ky.gov/Highway-Design/Pavement%20Design/Pavement%20Design%20Guide%20Updated2-2007.pdf

contractors bidding on contracts can use when submitting pavement design specifications for a particular project.

Figure 4. Data Entry Fields from Kentucky Pavement Design Form



Project Description:	0	0	County	
Analysis Date:				
Structural Design Inputs				
Design CBR				
Design ESAL's		0		
Construction Year ADT			Year	
Construction Year Truck Percentage			Year	
Design Life (years)		20		
Analysis Period (years)		40		
Check if User will define layer thickness	☐			

Figure 4 is a screen capture from this spreadsheet. It shows data entry fields that are populated using data from the Cabinet's WIMs, if they are operational and located on a route where work is scheduled. The California Bearing Ratio (CBR) was developed by the California Department of Transportation before World War II. This measure evaluates road subgrade strength, and it is not related to WIM data. Design ESALs refer to the projected life of the pavement in terms of the number of ESALs the surface can withstand before it is necessary to repave it. The Kentucky Pavement Design Guide requires ESALs be calculated as:

ESALs = *ADT* x *T* x (*ESAL*s per truck) x *DL* x 365 x *L*

- *ADT* is the average daily traffic at the mid-year of the design life,
- *T* is the percentage of trucks in the traffic stream,
- *ESAL*s per Truck is the amount of pavement damage associated with one application of a typical truck in the traffic stream,
- *DL* is the design life or design period in years, and
- *L* is the proportion of the traffic in the design lane (Typically 0.5)[10]

The construction year ADT, length of the design life, and truck percentage determine a baseline, from which an assumed rate of growth is built into the projections. The objective is to establish the expected wear and design a surface capable of meeting the needs over its projected life. In addition to traffic and vehicle classification data, the designs incorporate pavement design forms, notes and provisions, type selection summary, geotechnical information, technical details, comparisons of alternatives, and other documentation. However, the WIM instruments (or in the

[10] Ibid.

absence of their availability, ATRs) play a critically important role in developing pavement design specifications in Kentucky and nationally.

Chapter 2. WIM Literature Review

WIM Technology and Coordination

WIM scales weigh commercial vehicles and determine the amount of weight each axle carries. Also, WIM scales automatically collect data on traffic volume, vehicle classification, speed, and the amount of travel time.[11] Some WIM systems operate 24 hours per day, seven days a week so states can gather data on traffic factors such as daily traffic variation, seasonal traffic variation, and peak travel. Often, WIMs are more efficient than separate ATRs and automatic vehicle classification (AVC) equipment.[12][13] WIM scales are often used in tandem with other technologies such as LPRs and USDOT readers in a VWS.

According to the FHWA, heavy trucks do the most damage to pavement and technologies such as WIM scales can help lessen the damage.[14] FHWA further acknowledges that agencies should cooperate with each other and share data because it decreases cost, is more efficient, and takes advantage of expertise available in other agencies.[15][16][17] There are various stakeholders who would benefit from coordinated WIM technologies, including law enforcement, planning, design, environmental groups, and researchers.

Stakeholders need to provide input about what data to collect and analyze from the WIM scales and educate each other on the best uses of this information.[18] A best practice recommendation is creating reports that can help other highway agencies obtain information from WIM systems in

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[11] Weigh In Motion Benchmarking. (2002): Pennsylvania Department of Transportation Bureau of Planning and Research.

[12] Faghri, Ardeshir, Glaubitz, Martin, & Parameswaran, Janaki. (1996). Development of Integrated Traffic Monitoring System for Delaware. Transportation Research Record(1536), 40-51.

[13] Hallenbeck, Mark E., & O'Brien, Amy J. (1994). Truck Flows and Loads for Pavement Management (pp. 40): Washington State Department of Transportation.

[14] Weigh in Motion Benchmarking, 2002.

[15] Hallenbeck, Mark E., & O'Brien, Amy J, 1994.

[16] Skszek, Sherry L. (2003). Coordination of Commercial Vehicle Data Collected By Automatic Traffic Counter (ATC) and Weigh-In-Motion (WIM): Arizona Department of Transportation.

[17] Weigh in Motion Benchmarking, 2002.

[18] Traffic Monitoring Guide. (2011): USDOT Federal Highway Administration.

an understandable format.[19] The FHWA's *Traffic Monitoring Guide* cautions that agencies must be committed to sharing data and finding ways to improve that process so that it is easier to obtain and use data. The use of incentives, such as shared funding or equipment, can also foster continued cooperation.

Applications of Coordinated WIM Technology

Much of the literature on the use and coordination of WIM technology focuses on lessening or preventing pavement and infrastructure damage on highways. Pavement damage is calculated by equivalent single axle loads (ESALs) that measure pavement damage from different axles with varying load sizes.[20] WIM data is used to calculate ESALs for each axle weight and this calculation allows for various axle configurations.

The State Truck Activities Reporting System (STARS) program in Montana used WIM data to reduce pavement damage[21] by installing WIMs on the highways that suffered the most pavement damage from overweight trucks. The planning department wanted to determine whether or not it could decrease pavement damage through targeted law enforcement.[22] WIM data was sent to law enforcement officers at roadsides, who then pulled over possible violators. The study found that enforcement based on WIM data was more productive than relying on just officer experience to determine where to patrol for overweight trucks.[23] The Montana study revealed that 22 percent fewer overweight vehicles traveled in the WIM enforcement areas; the state saved $700,000 in pavement damage because of the enforcement efforts.[24]

Another example of coordinated WIM efforts is the Gary, Chicago, and Milwaukee (GCM) Corridor pilot project that runs through Indiana, Illinois, and Wisconsin.[25] The GCM corridor has a high commercial vehicle volume but few weigh stations. The GCM corridor project aims to enhance cooperation among the three states, as well as county and local stakeholders located in

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[19] Li, Shuo, Nantung, Tommy, & Jiang, Yi. (2005). Assessing Issues, Technologies, and Data Needs to Meet Traffic Input Requirements by Mechanistic-Empirical Pavement Design Guide. Transportation Research Record: Journal of the Transportation Research Board (1917), 141-148.

[20] Besinovic, Nikola, Markovic, Nikola, & Schonfeld, Paul. (2013). Optimal Allocation of Truck Inspection Stations Based on K-Shortest Paths. Paper presented at the 2013 TRB 92th Annual Meeting.

[21] Stephens, Jerry, Carson, Jodi, Hult, Dennis A., & Bisom, Dan. (2002). Infrastructure Preservation Using WIM Coordinated Weight Enforcement. Paper presented at the 82nd Annual TRB Meeting, Washington DC.

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] Regan, Amelia, Park, Minyoung, Nandiraju, Srinivas, & Yang, Choon-Heon. (2006). Strategies for Successful Implementation of Virtual Weigh and Compliance Systems in California. University of California, Irvine.

the corridor, and the FHWA.[26] As part of this project, one VWS, based on WIM technology, was installed in each state to improve enforcement and protect infrastructure along the corridor. A centralized computer system will track the VWS activities in each state and provide real-time information to law enforcement at the roadside.[27] Once officers acquire this information, along with a picture of the overweight truck, they will pull the truck over and weigh it on static, portable scales. No definitive empirical analysis was provided in the study, but the states view the initiative as an effective solution that can be quickly implemented.

These success stories attest to the utility of WIM technologies and VWS activities, however, Besinovic, Markovic, and Schonfeld caution that while WIM is effective in preventing pavement and infrastructure damage if located properly, ineffective WIM placement can do more harm than good. [28]The reason for this is that WIM placement is often based on an assumption that truck drivers opt for the shortest path between two locations.[29] This assumption does not account for overweight trucks sometimes traveling longer distances to avoid known enforcement areas such as weigh stations or VWS.[30] As such, trucks can inflict more damage to the pavement than originally estimated because of these drawn-out routes. So the ESAL calculations and the decisions about where to place WIM scales must factor in trucks driving around them. Besinovic, Markovic, and Schonfeld provide a mathematical formula that agencies can use to calculate the best placement of WIM scales that maximizes enforcement coverage and savings in pavement damage.

Alternatively, WIM coordination can also help ameliorate highway congestion. The Bi-National Virtual Weigh Station for Cross-border Mobility is a project intended to decrease congestion and delays of commercial vehicles at the border between British Columbia and Washington State.[31] This involves coordination among stakeholders in government agencies and businesses from the United States and Canada. The current proposal is for the WIM scales to be placed along the corridor near fixed weigh stations. The methods use a transponder-based WIM technology system. Trucks are weighed once and then allowed to bypass the remaining weigh stations. The outcome will be significant savings in time and productivity for commercial vehicle traffic in the corridor area.[32]

TMG Case Studies on Data Sharing

[26] Regan, Amelia, Park, Minyoung, Nandiraju, Srinivas, & Yang, Choon-Heon. (2006). Strategies for Successful Implementation of Virtual Weigh and Compliance Systems in California. University of California, Irvine.
[27] Ibid.
[28] Besinovic, Nikola, Markovic, Nikola, & Schonfeld, Paul. (2013). Optimal Allocation of Truck Inspection Stations Based on K-Shortest Paths. Paper presented at the 2013 TRB 92th Annual Meeting.
[29] Ibid.
[30] Ibid.
[31] Regan et al, 2006.
[32] Ibid.

The FHWA's September 2013 TMG includes three case studies on data sharing by the Colorado Department of Transportation (CDOT), the Delaware Valley Regional Planning Commission (DVRPC), and the Pennsylvania Department of Transportation (PennDOT). While these case studies primarily involve ATR units rather than WIM scales, they still demonstrate the benefits of data sharing among governmental agencies.

In Colorado, local agencies in cities and counties report traffic data to CDOT, which then uploads the raw information to a database and publishes it on a website dedicated to traffic data.[33] CDOT allows agency representatives to submit their data in any format such as MS Excel and Adobe PDFs. Then CDOT converts the data to TRADAS. The benefits of data sharing include $400,000 in savings and better data accuracy.[34] Quality control is important to data sharing. In Colorado, local participants are responsible for ensuring data is accurate before submitting it to CDOT.[35] Because of the program's success, CDOT is actively encouraging other local stakeholders to participate in data sharing by emphasizing its benefits

The DVRPC shares AADT and classification counts with PennDOT, New Jersey DOT, and county and local governments. DVRPC distributes the data, which is used to study regional environmental issues, limit congestion, and protect infrastructure.[36] Data is shared through Traffic Count Viewers that are available on the DVRPC website. The major benefit is the centralization of data and the Traffic Count Viewers, which ensure easy access for participating agencies.[37] It also limits duplication of efforts. This system is more efficient than previous efforts, so DVRPC and other agencies are able to save time and money. Also, the breadth of available data facilitates planning efforts. [38]

Finally, the TMG recounted the data sharing efforts among PennDOT, planning organizations, engineering districts, and the Metropolitan Planning Organization (MPO).[39] Agencies that share data report it to the Bureau of Planning and Research, a department in PennDOT. Like the other TMG case studies, the primary data being shared was for AADT and vehicle classification counts. PennDOT created three web-based software applications to facilitate data sharing. The major benefit this case study found was the time savings that resulted from increased efficiency.[40] The web-based applications dramatically decreased the time that it took to upload and download data. Data processing that previously took a week to finish could be done in a few hours. Ease of use and efficiency are also demonstrated by the fact that requests for traffic data

[33] Traffic Monitoring Guide. (2013): USDOT Federal Highway Administration

[34] Ibid.
[35] Ibid.
[36] Ibid.
[37] Ibid.
[38] Ibid.
[39] Ibid.
[40] Ibid.

dropped 50 percent, indicating broader access.[41] These data systems also made it easier to submit data to the FHWA.

Conclusion

Coordinating the uses of WIM technologies is beneficial because it reduces duplicate efforts among agencies, allows agencies to share resources like money and equipment, fosters interagency cooperation, and protects infrastructure. However, these efforts hinge on open communication and willingness among agencies to either continue or bolster cooperation. The example of Montana's STARS program demonstrates that coordination among agencies works well and produces favorable results. Although the GCM Corridor or the Bi-National projects are ongoing, they provide examples of different approaches to data coordination among interagency, intrastate, or even international officials. The TMG case studies also provide evidence that cooperation is beneficial and accessibility is an important component of sharing data. At the same time, these case studies examine the ways in which budgets and staffing can challenge data collection and sharing.

[41] Ibid.

Chapter 3. WIM Usage in Other States

Task 2 of this project involved creating a survey that asked states about their experiences with WIM and data sharing. The survey contained 19 questions that explored the criteria used for locating WIM scales, the amount of resources expended, the number of WIM sites, data sharing with other agencies, and the coordination of the technology. KTC researchers contacted 12 states requesting information on their experience with WIM sites and data sharing. Those states were: Kentucky, Washington, Indiana, New Jersey, New York, Connecticut, California, Ohio, Montana, Mississippi, and Illinois. Washington, New Jersey, Illinois, Kentucky, Mississippi, and Connecticut responded to the survey. The survey answers were compiled and then analyzed. The following summarizes the responses received.

WIM Locations

Where to install WIM sites is a critical factor for data collection. In Connecticut and Illinois, WIM sites are used at weight station facilities. Typically, Connecticut stations are at the port of entry from bordering states. In Mississippi and Ohio, WIM sites are placed in areas with high commercial vehicle traffic, which is often based on vehicle miles traveled (VMT). Washington installs their WIMs based on traffic volumes, freight volumes, and seasonal shipping routes. Kentucky installs sites based on vehicle class and also works to monitor coal truck travel.

Each state provided information on the number of WIM sites collecting data. Table 4 shows that New Jersey has the largest number of WIM sites followed by Washington, Illinois, and Connecticut. Kentucky has the fewest sites.

Table 4. WIM Installations in Surveyed States

State	Number of WIM Sites
Connecticut	20
Illinois	37
Kentucky	11
Mississippi	24
New Jersey	87
Ohio	23
Washington	37

Reasons for Collecting WIM Data

The main reason for collecting WIM data is to meet requirements for a variety of federal programs and research. The TMG is a publication from FHWA that helps states build effective traffic monitoring programs. Each state must report traffic data such as volume, classification, weight data and speed through the HPMS. FHWA shares this data with Congress and the public. FHWA oversees the Long-Term Pavement Performance (FHWA-LTPP) program, which collects data about pavement performance. States also report data to the Strategic Highway Research Program (SHRP). SHRP attempts to decrease highway crashes while improving and protecting aging infrastructure. Not all of the survey respondents mentioned these programs, but these are basic requirements for state-level traffic management programs.

Kentucky started using WIM equipment in 1986 in response to the FHWA's TMG recommendations. As such, Kentucky collects data to fulfill FHWA-related obligations as well as meet the needs of KYTC. Mississippi also collects WIM data to meet the guidelines in the TMG. In Connecticut, the state collects data for the Highway Performance Monitoring System. Connecticut also has continuous sites for FHWA-LTPP data. Data collection in New Jersey goes toward SHRP. The state's efforts were expanded by the enactment of the Intermodal Surface Transportation Efficiency Act (ISTEA). ISTEA was signed in 1991 with the goal of reducing traffic congestion and rebuilding infrastructure. Like other states, Washington uses WIM data to meet requirements set by the federal government and to procure federal funding.

WIM data is also used to formulate strategies to preserve infrastructure. In New Jersey and Connecticut, WIM data is integral to pavement and bridge management. Connecticut also uses WIM data for construction, planning, research, and safety projects. However, not all states collect WIM data for planning. In Illinois, the Department of Transportation only uses WIM scales and sensors for weighing and sorting commercial vehicles at interstate weigh stations as part of its size and weight enforcement program.

Data Collection and Sharing

Survey respondents were asked to provide information about the types of WIM they were using as well as the brands. The table below shows that most of the states use piezoelectric WIMs, with the Lineas Quartz piezoelectric from Kistler and/or the IRD Roadtrax Brass Linguini piezoelectric. Illinois and Ohio also use load-cell-type WIMs. The surveyed states collect data on traffic volume, traffic counts, vehicle classification, Average Daily Traffic (ADT), weight data, annual travel, speed, and seasonal traffic. Connecticut gathers data on ADT every three years and weight data is collected three to four times a year. The state also receives requests for speed data and turning movement data, the latter of which helps to design turn lanes. A Traffic Log is distributed annually based on that year's collected and adjusted data.

Table 5. WIM Types and Brands

State	Type	Brand
Connecticut	Piezoelectric Counting products Counters	IRD Type 1 Diamond (Unicorn and Pegasus) Peek (2000-2000 plus)
Illinois	Load Cell Sensors	IRD Kistler
Kentucky	Piezoelectric Load Cells Miniature Load Cells	Measurement Specialties IRD Roadtrax Mettler Toledo Intercomp
New Jersey	Piezoelectric Lineas Quartz	IRD Kistler
Ohio	Load Cell Brass Linguini Piezoelectric Lineas Quartz Piezoelectric	Mettler-Toledo IRD Roadtrax Kistler
Washington	Brass Linguini Piezoelectric Sensors	IRD Roadtrax Kistler

Connecticut has the most extensive sharing program of the surveyed states. Data is shared with Engineering, Construction, and the Environmental – Traffic Commission. Connecticut also shares data with the Department of Energy and Environmental Protection (DEEP), Department of Motor Vehicles (DMV), the State Police, local law enforcement agencies, the Office of Policy and Management (OPM), and the Council of Government (RPO-MPO). This state also provides information to private stakeholders such as engineering firms, environmental consultants, real estate firms, individuals, lawyers and elected officials.

The New Jersey freight planning department collects WIM data to study long-term trends in trucking and overweight enforcement. New Jersey supplies the information to other units of the New Jersey Department of Transportation (NJDOT), including Pavement Management, Bridge, Freight, Safety, and Traffic Operations. New Jersey makes WIM data available to the public via the internet. Internally, data is accessed through the internet as well as a shared drive within the department. This state also distributes reports in requested formats to interested parties.

Like most states, Ohio and Washington compile data internally for pavement maintenance purposes. However, these states occasionally share their WIM data with law enforcement. In Ohio, WIM data is shared with law enforcement so that they can target routes on which it is most likely that overweight trucks are operating.

Kentucky, Washington, and Mississippi, lack any extensive data sharing capabilities. Mississippi only shares weight and volume data with its Weight Enforcement Office, while Kentucky shares data only when it is requested. Interestingly, officials from Washington noted that state agencies and the public have expressed little interest in WIM technology and the data it generates.

None of the states surveyed have formal sharing agreements. However, Mississippi has an informal sharing agreement with the Office of Weight Enforcement. On the issue of sharing and formatting, the survey asked respondents about how data are formatted before sharing, the types of file extensions adopted, software used, and the location of data storage. Table 6 summarizes the states' responses. States use a variety of analytical software. Data is often formatted so it is compatible with Microsoft Office products, Adobe PDFs, ASCII, and the TMG w-card format. All states store their data locally.

Table 6. WIM Data Format and Analysis Software

State	Available Format	Analysis Software	Data Storage
Connecticut	Adobe, Excel, Word, Access, Outlook, PowerPoint, Digital Highway, Google Earth, DOS and .txt to document	Diamond - IRD-PEEK software TraffMan- TELMIKROS-Prosoft	Local
Kentucky	FHWA's TMG w-card format File extensions are .wgt (weight) and .sta (station)	PEEK's Viper program for data retrieval via ip addressable modems. Chaparral's TRADAS program for data entry, manipulation, QC, storage, etc.	Local
Mississippi	TMG File extension: RSA	Mikros' TEL	Local
New Jersey	ASCII, excel, word, pdf	WIM Manufacturer VTRIS, TMAS, TRADAS	Local
Ohio	weight data .pvr classification data .bin	Peek ADR 2000+ units and is downloaded using Peek TOPS	Local
Washington	text, pdf, Excel, etc.	iAnalyze-vendor supplied SAS	Local

Maintenance

States use their own personnel to install and maintain WIM sites or contract those tasks out to private firms. In Illinois and Mississippi, state DOTs are responsible for installation of WIM sites. Illinois maintenance and calibration is contracted out to a private firm. In Mississippi the Planning Division installs, monitors and maintains their WIM systems, although WIM scales are sometimes installed by private contractors.

Connecticut also uses in-house staff for installation while private contractors perform calibration at WIM sites. Connecticut relies on the District Electrical offices for installation and maintenance. District offices are operating on tight budgets and confronting staffing issues, which reduce their ability to monitor WIM sites. Because of these problems, there is likely to be less data collection and distribution moving forward.

In other states, namely Kentucky, New Jersey, and Ohio, maintenance contracts are in place to cover the installation of WIM systems. These states also use contracts for system maintenance.

Troubleshooting at WIM sites is another important factor. New Jersey uses employees within its data development section for this kind of maintenance. Kentucky's Division of Planning staff performs minor troubleshooting duties; however, when more complex problems occur the state contracts the work to an external firm. New Jersey's data development office has a technician and engineers who do troubleshooting and monitoring data. Ohio also uses state employees to monitor WIM data and data quality.

Cost and Funding

WIM systems are expensive to install and maintain. This is particularly true of the piezoelectric types that are used by the majority of the survey respondents. According to the survey results, the installation of piezoelectric WIMs can cost anywhere from $100,000 to $150,000 for a four lane highway and $250,000 for an eight lane highway. In some cases installation is contracted out, but some states, like Mississippi, install WIMs using labor from the Department of Transportation because it is more cost-effective. Repairs at WIM sites can range from a few thousand dollars to $250,000 depending on what needs to be replaced. Replacement costs also varied by state. Loop or sensor replacement is as little as $2,000 in Kentucky, but in Mississippi a sensor replacement would cost $7,500. Finally, according to all of the respondents, these costs are not shared among agencies. The WIM scale's primary function will typically dictate which agency shoulders the cost. WIMS used for planning purposes are generally purchased and maintained by state planning divisions, whereas WIMs used for law enforcement purposes are generally funded through state police agencies.

The survey also asked how states funded WIM sites. Much of this funding comes from federal programs. Mississippi, New Jersey, and Ohio rely on State Planning and Research (SPR) grants to fund WIM sites. Typically, SPR funds require an 80/20 match where 80 percent is funded by the federal government and 20 percent is funded by the individual state. However, some of the states also acquired WIMs solely using state funds. Connecticut uses a state-funded "Vendor in Place," which is a paving program. In New Jersey, the funds for electronic maintenance and calibration are paid for by its Transportation Trust Fund. Illinois WIM projects are also funded through the state.

Evaluating previously installed WIM Projects

Connecticut's WIM projects are evaluated by visiting the sites. The focus of evaluations is on contract compliance, the site map, scale and equipment measurements, and the completion of all electrical items. Connecticut has extensive information available online about WIM evaluations. New Jersey also supplies standards and testing procedures online. Mississippi evaluates the WIM data accuracy by comparing data over time. Ohio does not perform a full evaluation on installed sites, but they do check calibration annually and monitor data quality throughout the year.

Challenges

Numerous challenges confront WIM programs and the prospect of data sharing, including issues related to budgeting, staffing, and the accuracy and accessibility of data.

Connecticut was the most upfront about fiscal problems, as its WIM program has faced budget cuts. This makes it difficult to upgrade their software and technologies. In addition, because of these budget constraints, there has been a reduction in personnel. Previously, their staffing included four employees that collected and analyzed WIM data; now, there are two employees. As a result, there is not enough money or staff to run the maintenance system and inspection programs. At the same time, there are an increasing number of requests from their DOT for traffic data, which places a strain on personnel. Another challenge for Connecticut pertains to the software used to analyze data – it is not always compatible with private consultants' software. Data available on the website is sometimes difficult to interpret. Like Connecticut, Mississippi also faces staffing shortages, which makes maintaining the accuracy of the WIM data a formidable task.

Other states surveyed are not dealing with as many fiscal challenges as Connecticut and Mississippi. The respondent from Washington said the state has sufficient financial resources, although future budgetary issues might limit the collecting and processing of WIM data. Ohio does not have as many financial challenges as Connecticut and Mississippi, but data collection and analysis can be complicated for mainframe reporting. New Jersey did not indicate that it had budgetary shortfalls. The respondent also stated that they have no problems with generating and sharing reports. Much of their data is available on the web.

Conclusions

The survey respondents supplied a great deal of information about the use of WIM data sharing. Analyzing the surveys has yielded several conclusions. Most of the WIM sites are on routes with heavy truck travel. Much of the data collected from WIMs is used to meet federal requirements and preserve infrastructure. The vast majority of funding for WIM installation and maintenance is through the federal government. States glean a wealth of information from WIM systems. Survey respondents reported that WIM provides data on traffic volume, vehicle classification, ADT, AADT, weight, and speed. Some states share more data than others. It is also important to point out that there are no formal sharing agreements in any of the states surveyed. The majority of states surveyed use piezoelectric WIM sensors, which are expensive to install and maintain. Installation and maintenance is sometimes conducted by state employees or is contracted out to private firms. Finally, in terms of gathering and analyzing the data from these systems, a number of states have suffered funding cuts; they have also encountered problems with the accuracy and formatting of data. On the other hand, some states are not facing funding issues and report fewer challenges in terms of data collection, accuracy and sharing.

Chapter 4. Survey of WIM Technology

WIM technology developed in the 1950s by engineers in the United States Bureau of Public Roads (now FHWA), although the original technologies were very basic. [42,43] The sensor had a reinforced concrete platform and was fitted into the pavement surface. The data output of this precursor to modern-day WIM technology was measured using an oscilloscope trace that generated a reading for each vehicle in approximately ten seconds.[44] Experimentation with WIM technology in the 1950s included work at Mississippi State University, the University of Kentucky, and the Transportation and Road Research Laboratory (later FHWA). Work in Denmark and Germany brought some successes and failures. Early prototypes were especially susceptible to inaccuracy caused by temperature fluctuations, sensor wear, and calibration issues.[45]

As material issues were sorted out and load-cell technology was developed, advances in digital computers and sensors improved the data gathering capabilities of WIM scales. In the late 1970s, bending plate technology was developed in West Germany, and remains a popular choice for state and federal agencies in the United States, and in other parts of the world.[46] Piezoelectric sensors and load cells are also popular choices for WIM systems. Since the late 1970s, advances in design and technology have led to further improvements. WIMs can now calculate vehicle-specific weight, axle weight, and vehicle configuration at high speeds, the margin of error hinges on the kind of system used.

Piezoelectric sensors are the most common sensors used for WIM data collection.[47]These sensors consist of copper wire that is surrounded in piezoelectric material. An electrical charge is produced when pressure is applied to the material. Piezoelectric sensors are installed in highway or road pavement. Pavement materials must be carefully chosen because they affect the sensor's output. Bending plates are comprised of two steel platforms that measure tire or axle weight by using strain gages. Plate analysis determines the axle weight. Single load cells also consist of two platforms. These systems employ hydraulic load cells inset at the center of each platform to

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[42] NORMAN, O.K. and HOPKINS, R.C. (1952). Weighing vehicles in motion. Bulletin 50. Highway Research Board, National Research Council.

[43] Koniditsiotis, Chris. (2000). *Weigh-In-Motion Technology*. Austroads, Inc.

[44] Ibid.

[45] Ibid.

[46] Ibid.

[47] Bushman, Rob and Andrew J. Pratt. 1998. Weigh In Motion Technology – Economics and Performance. North American Travel Monitoring Exposition and Conference: Charlotte, NC.

measure the amount of force applied to it.[48] Most of these systems use inductive loops to activate the measuring instruments.

According to the FHWA, the typical WIM system contains a scale or sensor set, a roadside cabinet with a data processor, and a communications system that transmits WIM data to agencies that collect it. Those agencies range from law enforcement agencies at roadside to state DOTs collecting information for their enterprise systems.[49] WIM systems play a key role in screening and sorting commercial trucks at weigh stations on the Interstate system and other highways. The scales automatically weigh a commercial vehicle as it pulls onto the weigh station ramp; based on the results, the truck is directed to either bypass the station or stop for further inspection. The total weight, as well as the weight of each axle, is used to determine whether a truck is operating over the legal weight limit for a particular jurisdiction. WIM systems can also screen commercial vehicles at a VWS or on the mainline, although this approach is less common. These WIM systems interface with other Intelligent Transportation Systems (ITS) technologies, including transponders (RFID technology), commercial mobile radio service (for cell phones and other mobile devices), and automated license plate/USDOT readers (ALPR/USDOTR) that photograph each truck going through the weigh station. WIM systems provide data for weight enforcement and the complimentary ITS technology sends safety and credentials information to enforcement officials at weigh stations or roadside traffic enforcement points.

One of the primary tasks associated with this project is to contact vendors to determine the costs of WIM technology with different features and from different vendors. KTC researchers contacted several WIM technology vendors for quotes on equipment, the conditions under which it could be utilized, installation time and requirements, longevity, accuracy, and maintenance costs.

Several WIM vendors were interviewed to get pricing information, including Mettler Toledo, International Road Dynamics, Cardinal, and Intercomp. These companies manufacture a variety of WIM products, and some are developing new technologies that have the potential to reduce costs while maintaining the accuracy standards of currently available technology. Kentucky plans work with Intercomp to install a mainline WIM prototype and integrate it into the Shelby County weigh station's Kentucky Automated Truck Screening (KATS) System.

Table 7 summarizes information about various WIM technologies. Comparisons include systems using bending plates, load cells, or piezoelectric strips. Prices for Two types of load cells are in the table – including a lower cost load cell strip that is a newer technology and has just arrived

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[48] Ibid.

[49] Krupa, Cathy and Tom Kearney. "Truck Size and Weight Enforcement Technologies." 2009. Prepared by Cambridge Systematics and FHWA. Accessed 18 April 2014 at: http://ops.fhwa.dot.gov/publications/fhwahop09050/sec03.htm

on the market. The piezoelectric and load cell strip model quoted are used for high-speed applications, whereas the bending plate and more traditional load cell system can be adopted for low-speed and high-speed settings. As the table shows, the load cell strips and piezoelectric models take far less time to install than the bending plates or traditional load cell systems. This is a consideration officials have to take into account because there are significant costs associated with shutting down lanes for an extended period of time, particularly Interstate corridors and other high-volume federal and state highways.

Table 7. WIM Technology Comparison

Type	Application	Time to Install	Installation Area	Accuracy	Longevity	Maintenance Cost per Year	Cost (Equip. + installation)
Bending Plate *Concrete	Low or High Speed	3 days	166" x 58" x 30" L x D x W	± 4 - 5% ± 3 - 4% (dual)	7 years	$2,500 - $4,300	$100-$125,000 $125-$150,000 (dual)
Load Cell *Concrete	Low or High Speed	3 days	165" x 58" x 38" L x D x W (Concrete Vault)	± 2 - 3%	12 years	$2,500	$175,000 + $75,000 for concrete
Load Cell Strip	High Speed	Unknown	Similar to Strip	Unknown	Unknown	Unknown	~ $25,000
Piezoelectric Strip *Asphalt or Concrete	High Speed	< 1 day	68.9"x .25" x 3" L x D x W	± 5% ± 4 - 5% (dual)	4-5 years	$4,000 - $7,000	$28 - $50,000 $100-$125,000 $125-$150,000 (dual)

Installation area requirements for the bending plate and the load cell WIM systems are nearly identical in terms of length and depth. The load cell requires an additional eight inches in width and must be placed in a concrete vault. Piezoelectric strips require substantially less installation area than the bending plates or load cells.

Accuracy rates for WIM systems are similar based on the quoted specifications obtained from manufacturers, irrespective of the technology employed. But error margins are based on optimal WIM performance, assuming proper installation and routine maintenance and scale calibration.

If scales are not maintained and regularly calibrated, errors can be substantially higher. When this happens, law enforcement officials may pull over a truck measured as overweight, but only because of poor data quality (and not because there is actually a violation).

KTC estimates that for some of the less accurate piezoelectric WIM systems, a truck would need to be at least two standard deviations above the gross vehicle weight or axle weight limits to justify traffic enforcement. Otherwise, there is a significant likelihood the truck will be at a legal weight – measurement error would be blamed for the WIM system flagging it as overweight. If officers pull a vehicle over at roadside based on a WIM reading, and discover the vehicle is operating within legal weight after confirming the weight with their portable WIMs, they will not make use of those WIM systems. Therefore, a scale's margin of error is very important to KSP-CVE officers, and is a major consideration for the agency as it decides what WIM technology it will use.

There are other consideration besides accuracy and performance that KYTC has to take into account, including the system's warranty, expected longevity, and installation and maintenance expenses. Maintenance costs include replacing or repairing equipment, replacing concrete or asphalt, fixing the communications link, addressing electrical issues, and calibrating the scale. WIM life cycle costs vary substantially depending on the initial installation costs, warranty policy and the year-to-year markup on maintenance costs if maintenance is handled by a vendor and not the KYTC Division of Maintenance.

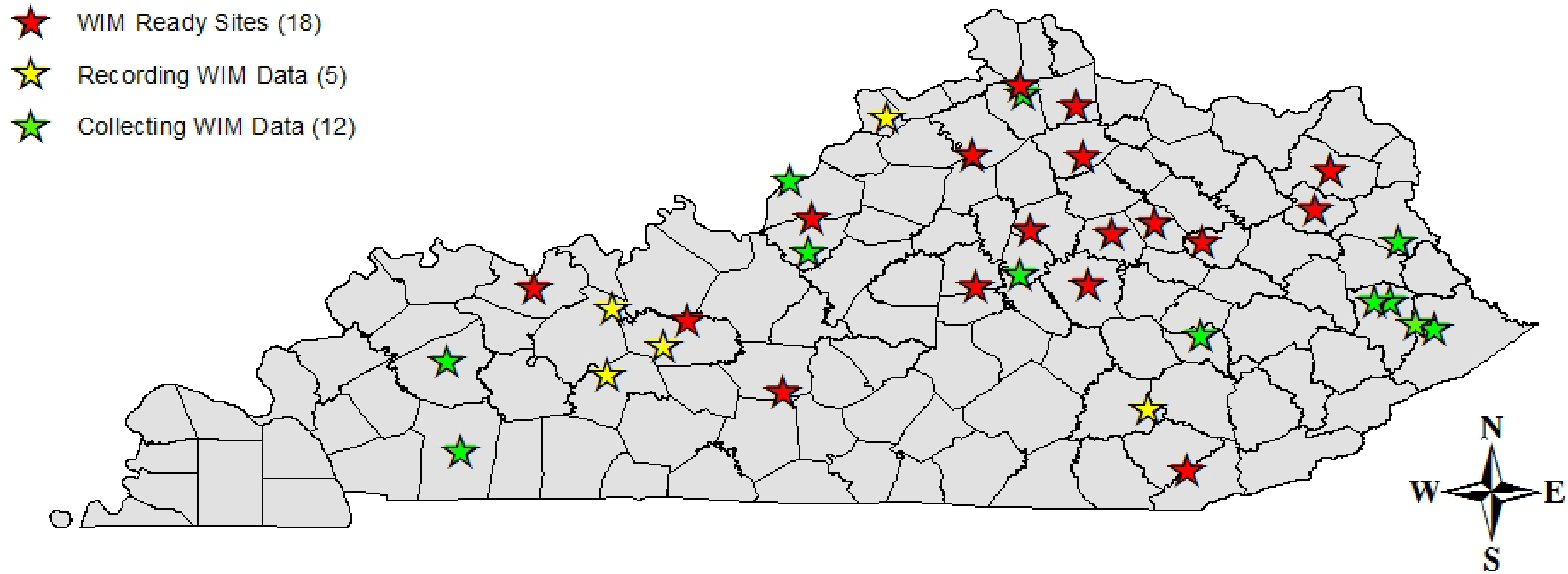
Chapter 5. Current WIM Locations

To meet the planning, commercial vehicle enforcement and pavement design requirements for Kentucky, the Transportation Cabinet has purchased, and currently maintains, WIM and ATR equipment around the state. Some of the sites were purchased by the KYTC's Division of Planning and are maintained by the Division of Maintenance. According to the latest numbers, Kentucky's Division of Planning currently has 35 WIM sites throughout the state. This excludes the Division of Planning 86 ATRs. The Division of Motor Carriers has 14 weigh stations, and there are WIM scales at 13 of those locations. Nine scales have high-speed WIMs, three have slow rollover WIMs, and one station will soon have a mainline WIM.

Figure 5 is a map of locations maintained by the Division of Planning. The accompanying table specifies the county, route, and mile post marker where each WIM site is situated. Each WIM location is represented by a color-coded star that denotes the operating status of each site. The 18 red stars, or WIM-ready sites, indicate WIM sites where equipment has been installed but is no longer functioning. To make these sites operational again some repairs would be necessary. The significance and cost of those repairs will vary depending on specific site characteristics such as the age of the equipment, the type of system in place, whether the equipment was paved over during a later resurfacing project, and other local conditions. The five yellow stars represent sites where WIM data is currently recorded, but where problems with the communications equipment or Internet connectivity prevent the WIM system from relaying observation data to the Cabinet's network. The 12 green stars signify sites where WIM data is being recorded and communicated to KYTC.

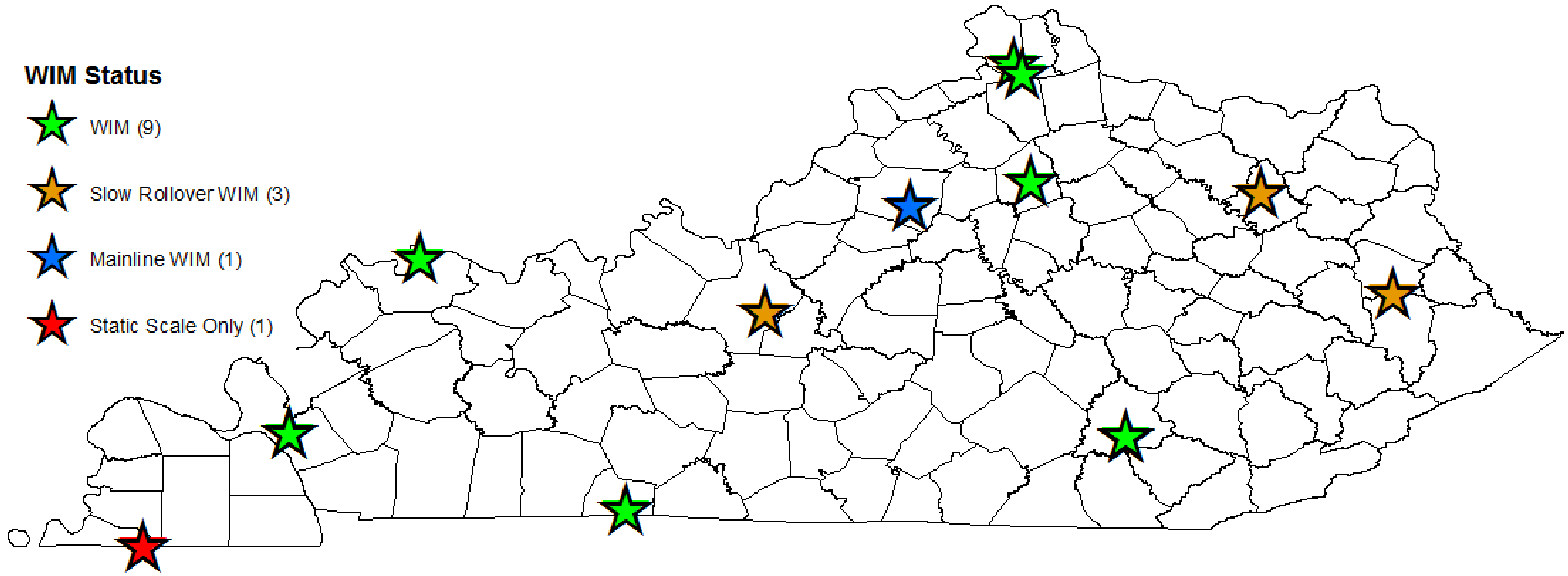
As the map illustrates, a significant number of WIM sites are not currently in use. As of August 2013 just 12 available WIM locations are reporting data to the Division of Planning, not including ATRs around the state. A status check showed that 32 of the 86 ATRs also needed various repairs. Maintaining all of this equipment requires substantial labor, frequent inspections, and money for installation and maintenance. Given Road Fund revenue shortfalls, and the high cost of keeping equipment running, the state is currently unable to restore functionality at all of these sites. Decisions about which WIM sites to keep operational are made by the agency responsible for the WIM system. The Division of Motor Carriers, in conjunction with KSP-CVE, operates weigh stations in 12 counties. Laurel County and Lyon County each have two weigh stations, bringing the number of fixed weigh stations in Kentucky to 14. Most weigh stations are located on high-volume Interstates and ports of entry. Figure 6 displays the GPS coordinates of each. On this map, stars symbolize the weigh stations and the color of the stars represents the type of scale equipment used at each location.

Figure 5. Division of Planning WIM Locations in Kentucky



County	Route		MP	Latitude	Longitude	County	Route		MP	Latitude	Longitude	County	Route		MP	Latitude	Longitude
Bell	US	25	18.2	36.79704	83.75435	Grant	US	25	17.5	38.71583	84.59051	McCracken	US	41	2	3734682	87.53214
Bullitt	I	65	110.6	37.90671	85.69145	Grant	I	75	164.2	38.7643	84.60846	Menifee	US	460	5	37.95982	83.67176
Butler	US	231	15.9	37.28191	86.71223	Grayson	US	62	12.1	37.42911	86.4293	Mercer	US	127	2.3	37.73112	84.83064
Carter	US	60	20	38.32691	83.02022	Grayson	KY	259	18.8	37.56298	86.30499	Montgomery	KY	713	7..62	38.05669	83.91899
Carter	I	64	167.1	38.3267	83.01762	Harrison	US	62	10.04	38.3946	84.28459	Ohio	KY	54	9.6	37.6188	86.69437
Christian	TR	9004	11.425	36.89076	87.46884	Hart	US	31	3.95	37.19768	85.82208	Owen	US	127	4.2	38.408592	84.853918
Clark	TR	9000	1.33	38.00567	84.13721	Jefferson	KY	61	0.1	38.08604	85.66808	Owsley	KY	11	13.3	37.47767	83.68468
Daviess	US	60	16	37.72773	87.09529	Jefferson	I	64	2	38.27408	85.7872	Pendleton	US	27	5.3	38.65684	84.32346
Elliott	KY	7	10	38.1259	83.09969	Jessamine	US	27	1.6	37.79193	84.60439	Pike	US	23	30.3	37.54008	82.58184
Fayette	KY	4	3.5	38.02563	84.55823	Laurel	TR	9006	9.2	37.10695	83.95165	Pike	US	119	2.3	37.51415	82.49018
Floyd	KY	1428	10.6	37.65541	82.71251	Lawrence	US	23	3.5	37.96214	82.66888	Trimble	US	42	10.05	38.5957	85.2866
Floyd	KY	114	11	37.65691	82.79065	Madison	KY	52	13.25	37.74335	84.26161						

Figure 6. Current WIM Locations at Kentucky Weigh Stations



Scale	Dir.	Latitude	Longitude	Route		Scale	Dir.	Latitude	Longitude	Route	
Henderson Co.	SB	37.9193	-87.549	US	41	Kenton Co.	SB	38.819	-84.601	I	75
Lyon Co.	EB	37.0605	-88.184	I	24	Shelby Co.	EB	38.171	-85.155	I	64
Lyon Co.	WB	37.0615	-88.183	I	24	Scott Co.	NB	38.2933	-84.559	I	75
Fulton Co.	NB	36.5060	-88.899	US	51	Laurel Co.	NB	37.0428	-84.097	I	75
Simpson Co.	NB	36.6868	-86.538	I	65	Laurel Co.	SB	37.0475	-84.099	I	75
Hardin Co.	NB	37.6539	-85.857	I	65	Rowan Co.	EB	38.2364	-83.439	I	64
Boone Co.	SB	38.8649	-84.648	I	71	Floyd Co.	NB	37.7408	-82.789	US	23

All weigh stations have static scales, but at nine sites there is also a WIM scale built into the station ramp that screens the truck weight before the station bypass, which facilitates a sorting decision (bypass or stop). The green stars denote stations with WIM capability. These stations, sometimes referred to as "Super Stations," are located in Lyon County (2), Henderson County, Simpson County, Kenton County, Boone County, Scott County and Laurel County (2). Some of the other stations do not have WIMs due to site limitations or budgetary constraints. In Hardin County, Floyd County, and Rowan County there are slow rollover WIMs, which also double as static scales. At those stations, trucks must drive much slower over the scale (10 MPH) compared to the high-speed WIM scales located at other stations (35 MPH). Shelby County is a unique station because it will soon feature the state's first mainline WIM scale for screening trucks. Instead of measuring truck weight, axle weight, and axle spacing on the weigh station ramp, the mainline WIM will be installed on the Interstate. Trucks will be screened and directed to the old slow rollover WIM if the station's KATS system identifies any potential violations. For more information about the Shelby County weigh station WIM, see Chapter 6. The Fulton County weigh station only has a static scale.

Chapter 6. Future WIM Locations

Background

Future installations of WIM scales in Kentucky will primarily depend on the priorities that are set and the resources available to the Divisions of Planning and Motor Carriers – the two main stakeholders and users of WIM data. The Divisions of Highway Design and Maintenance are less active in these decisions. The Division of Planning fulfills most of their data requirements. The Division of Planning and Division of Motor Carriers (in conjunction with KSP-CVE) sought to determine if it made sense for the two agencies to share existing WIM equipment, data and costs. Because each uses WIM scales and data in a slightly different way, it is challenging for the two agencies to share equipment.

As noted, the main purpose of the WIM data for the Division of Planning is for uses related to FHWA's TMG and Highway Performance Monitoring System recommendations and requirements, along with other federal reporting requirements. The data are also used internally by the KYTC to plan state road maintenance and pavement design for the Division of Highway Design. Traffic volume is in many cases just as important a metric as vehicle classification and axle weight for purposes of these activities. Additionally, the levels of acceptable error are much higher for state planning activities than for enforcement of commercial vehicle weight laws. From a planning and design standpoint, the accuracy of the individual vehicle weight data is less of an issue because the agencies using WIM data for these purposes aggregate large data samples and can easily account for the margin of error.

Commercial vehicle enforcement officers are generally concerned with the gross vehicle weight and axle weights of commercial trucks; they need assurances the WIM scales are accurate and consistent. Standard protocol requires officers to cite overweight trucks only after weighing them on a static scale. However, officers rely heavily on WIM scales for screening, and if those scales are unreliable, they will direct less effort toward weight enforcement. The equipment that the Division of Motor Carriers and KSP-CVE want to purchase is typically more expensive what is favored by Planning. Maintenance costs are also important because WIM scales used by KSP-CVE must be calibrated frequently to minimize the margins of error.

Another issue concerns the placement of the WIM scales. Enforcement has traditionally valued installation of WIM equipment at fixed weigh stations rather than virtual weigh stations because doing inspections at them is safer and more efficient. However, while WIM scales at VWSs would typically be installed on the mainline, WIM scales at fixed weigh stations are typically installed on the ramps going into the station. As a result, only a percentage of commercial trucks would be weighed, measured, and classified. When a weigh station is open, trucks with PrePass or other weigh station bypass clearance do not exit the mainline to go up the weigh station ramp. If a station is closed, trucks are informed by the Open/Close sign that they do not have to go down the ramp. The result is fewer trucks measured by weigh station WIM scales. Conversely, the Division of Planning would like WIM scales to always be placed on the mainline across both lanes of the highway or Interstate to ensure a comprehensive sample is taken.

Prioritization of WIM installation sites is another area where the Division of Planning and Division of Motor Carriers/KSP-CVE have different incentives. For purposes of planning, new WIMs would ideally be placed on routes where updated measurements of traffic flows, vehicle counts, and axle classification are needed. From an enforcement perspective, the priority should be weigh station bypass routes, coal hauling routes, and areas where there are higher rates of commercial safety issues.

Other issues will also impact future WIM scale installations. Construction schedules for route resurfacing must be taken into consideration. Resurfacing paves over WIM equipment, which in turn prevents it from operating properly – so it makes little sense to install such equipment on highways due for maintenance. While federal funding is often used to procure WIM scales, the FHWA and FMCSA typically stipulate parameters under which states can receive funds to buy WIM scales, including where they can be installed, what kind of equipment is purchased, and the manner in which the scales are expected to be used.

Differences in how WIM scales are used in agencies that have divergent mandates and roles make it challenging for state agencies to coordinate the use of WIM technology. There are scenarios under which sharing WIM data may be profitable. For example, the Division of Planning wants to obtain commercial vehicle weight, axle weight and vehicle classification from the Division of Motor Carriers to supplement other data inputs needed for estimating traffic flows on Kentucky highways. Given the limitations of using WIM data collected at weigh station ramps, these data would have to be supplemented by examining PrePass bypass records and requesting that enforcement keep a scale open for a 24-hour period to get a representative sample of daily truck traffic. The Office of Information Technology (OIT) has agreed to create an annual file containing all commercial vehicle weight, axle and classification observations from the KATS systems located around the state. This will come from an observation system that OIT is currently building to store all of these records as well as manual observations made by KSP-CVE officers. The mainline WIM at Shelby County may offer the best opportunity for the Cabinet's agencies to share data. It will be operational 24 hours a day and its planned location is on the mainline, not a weigh station ramp. In other instances, planning and design data from WIM scales will likely continue to come from less expensive equipment placed on the mainline of crucial routes. Law enforcement will continue to use WIM scales with the highest available accuracy on weigh station ramps to enforce commercial vehicle weight limits.

Future WIM Locations

Currently, the Division of Motor Carriers is planning WIM installations at two sites, and the division is installing equipment at a third site that could be interfaced with WIM technology. The WIM locations include:

- Virtual Weigh Station site with a WIM on U.S. 25 northbound in Laurel County
- Virtual Inspection Station site on Kentucky Route 9 in Carter County
- Mainline WIM at the weigh station in Shelby County

Virtual Weigh Station in Laurel County

When its 2009 implementation plan was developed, FHWA decided to provide funding support to states for Smart Roadside activities and technology deployments. The agency created an "Electronic Permitting/Virtual Weigh Station" architecture project to determine the best use of Intelligent Transportation Systems (ITS) to heighten the technological sophistication and refine the standards set in the CVISN program. The idea was to create test sites where Smart Roadside, vehicle identification, and driver identification tools for commercial vehicle enforcement and inspections that embody a working architecture concept and provide insight into the data relationships between various elements in the architecture could be evaluated.[50]

Stations operating under this system architecture are supposed to combine data from the SAFER and PRISM databases with state databases to identify and screen vehicles. The system will include a license plate reader, USDOT reader, scene camera, and WIM. FHWA is funding the project, and has also selected the vendors for the project. Cambridge Systematics is leading the project, and will be working with Intelligent Imaging Systems to implement the new technology. The WIM will be supplied by International Road Dynamics. Kentucky has asked that the equipment be interfaced with its proprietary KATS software, which was developed by KYTC, KTC, and Iteris.

This virtual weigh station will be located on the Laurel County bypass route, and the activity will be monitored remotely at the Laurel County weigh station and at roadside by KSP-CVE officers. This will enhance commercial vehicle enforcement on this key station bypass route by alerting law enforcement of problems with a vehicle's credentialing, screening, and weight.

Estimated Completion Date: Summer 2014

[50] Implementation Plan: Truck Size and Weight Enforcement Technologies. 2009. FHWA and Cambridge Systematics. Accessed 5 May 2014 at: http://ops.fhwa.dot.gov/publications/fhwahop09049/implementation_plan.pdf

Virtual Inspection Station in Carter County

Kentucky applied for CVISN funds to install a virtual inspection station (VIS) site in the 2011 CVISN grant. There has been considerable discussion about how to proceed and where to place the next weigh station because of KSP-CVE staffing shortages, construction schedules for resurfacing potential sites, wireless communications availability, the cost of running electrical components to ideal locations, and finding a location with adequate shoulder room to safely stop vehicles and perform inspections. Kentucky Route 9 (the AA Highway) was eventually selected. This route, which runs from I-275 outside of Cincinnati to I-64 is a rural two-lane highway for most of its length and has significant truck traffic. Trucks traveling along this route can enter and exit the state without ever having to pass through a weigh station, which potentially makes it an attractive route for non-compliant carriers. The VIS site will include a license plate reader, USDOT reader, and scene camera. However, the KSP-CVE and the KYTC have elected not to install a WIM at this time because of the expense and the general feeling among KSP-CVE officers that weight violations are not pervasive. If weight issues become a problem, the Cabinet and law enforcement officials may decide to install a WIM along with the screening system at a later date.

Estimated Completion Date: Fall 2014

Mainline Screening System at the Shelby County Weigh Station

As acknowledged previously, the Shelby County weigh station is going to have a mainline WIM installed and interfaced with a KATS system. This is part of the Shelby County weigh station renovation. The aim is to screen commercial vehicles moving at Interstate speeds in the rightmost lane. The screening process will begin when vehicles are instructed to get in the right lane – which trips the loop or sensors that initiate the WIM. The WIM will send information to the scale house, and it will be collated with the screening results from the KATS license plate reader, USDOT reader and overview image.

This pilot project will use a prototype WIM model manufactured by Intercomp. This high-speed WIM scale employs a strain gauge-based load cell in a strip sensor. The purpose of the prototype is to develop a WIM that is less expensive and intrusive to install, yet maintains a high level of accuracy and will wear well over time. Beta testing has taken place in Minneapolis, MN on a segment of I-94 with promising results.[51]

The WIM module can accept up to four in-road strip sensors and triggers, which can be in loop sensors or laser detectors. The module has standard TCP/IP for communications and will be integrated with the user interface of KATS. The system will include the WIM module, sensors, and loops, along with a license plate reader, USDOT reader, scene camera, and variable message

[51] Kroll, Kai, Matthew Young, and Karl Kroll. 2014. "Strain Gauge Strip Sensor for Precision Weigh-In-Motion." Intercomp: Medina, MN.

signs for sorting trucks as they enter the weigh station ramp from the mainline. The static scale at the weigh station will be the final arbiter of whether a truck is overweight; the WIM will be used only for screening purposes. Officials at the Cabinet and KTC plan to work with Intercomp to coordinate the installation sometime during summer 2014.

Completion Date: Summer 2014 (estimated)

Chapter 7. Study Recommendations

Based on the data gathered, KTC researchers put together several recommendations related to the collection and usage of WIM data. The focus of these suggestions is on improving the means by which state agencies share this information.

1. The Division of Motor Carriers and Division of Planning should conduct periodic discussions about potential partnerships and ways in which WIM equipment, data, and costs can be shared. Initial discussions did much to identify some of the obstacles. The Division of Planning does not want to invest in more expensive WIM products because less expensive equipment is sufficient for their needs. The Division of Motor Carriers and KSP-CVE require an extremely low margin of error – which is achieved by using expensive WIM equipment and calibrating it frequently. Traffic data and geographic information systems (GIS) data can be used to decide where to install future virtual weigh stations. Planning can also make use of the truck weight and classification data from WIM scales at weigh stations around the state. The Office of Information Technology has agreed to let the Division of Planning access that data from the Cabinet's centralized commercial vehicle observation database.

2. Securing external funding sources will continue to be important for the Transportation Cabinet. The Division of Motor Carriers has relied heavily on the Federal Motor Carrier Safety Administration as a partner for its Commercial Vehicle Information Systems and Networks (CVISN) and PRISM programs. The Division of Planning has depended on the Federal Highway Administration when working on the Traffic Monitoring Guide (TMG) and Highway Performance Monitoring System. When funding opportunities arise, these state agencies must coordinate to ensure they gain every possible advantage to shore up needs for WIM equipment and data.

3. Kentucky agencies needing WIM data should reach out to vendors of new WIM products that can potentially improve the performance of commercial vehicle screening systems and the accuracy of WIMs used to collect vehicle weight and classification data. If the pilot project with Intercomp meets its objectives, Kentucky may have a new WIM option that is cheaper and just as accurate as traditional WIM technology going forward.

4. Although the Division of Planning responds to formal requests to WIM data, obtaining it would be much simpler if all data were available to download from a KYTC-hosted website. KYTC recently launched a web portal, DataMart, for this purpose. This service provides access to more transportation-related data in one place than what has been previously available to the public. Some of the information housed on DataMart includes: vehicle registration statistics, crash rates, state-maintained bridge locations, travel

statistics, GIS data, and MAP-21 performance measures. Much of the data discussed in Chapter 1 is available online. However, KYTC should consider making WIM data files available on DataMart so the Division of Planning would no longer have to fulfill WIM-related data requests. Users requesting information could be referred to DataMart.

5. To further refine WIM data collection and sharing, the Division of Planning and Division of Motor Carriers should identify other stakeholders who may benefit from WIM data and make it available accordingly, preferably through DataMart. Chapter 2 discusses how Connecticut shares data with several state agencies. Connecticut also shares data with the Department of Energy and Environmental Protection (DEEP), Department of Motor Vehicles (DMV), the State Police, local law enforcement agencies, Office of Policy and Management (OPM), and the Council of Government (RPO-MPO), among others. KYTC should seek out other users of this data and adapt reporting needs to help agencies that use this data. This may require the periodic updating or modification of data stored in DataMart to better meet the needs of these new consumers.

6. Users of the Division of Planning's GIS data may find it easier to identify the correct variables if the associated data dictionary was updated more frequently and was more user-friendly. The current data dictionary dates from 2006, and some of the data fields in the traffic data, for example, are not clearly specified. It would also be helpful if the traffic flow data were included in subsets of the state highway network, such as the National Highway System (NHS) shapefile. Additional iterations of this data, or easier methods of matching traffic flow data to various subsets of the state highway network would be useful.

7. The Division of Planning and/or Division of Maintenance should develop cost estimates for repairing WIM sites where the equipment is functioning but not communicating the data to the state's data networks. Repairing these sites could significantly increase the amount of WIM data available for state use, increasing the number of functioning WIM sites operated by the Division of Planning from 12 to 17.

8. KYTC should highlight the value of WIM data to the Kentucky General Assembly in an effort to secure appropriations for the purchase and maintenance of WIM scales around the state. With state governments becoming increasingly data-centric, traffic data, weight data, and vehicle classification will play a central role in state planning, meeting federal data reporting requirements, informing decision making about which highway projects' funding should be prioritized

9. KYTC should commission a study that identifies the best locations for future WIM sites based on current data and projected traffic patterns around Kentucky. Assessing current WIM site performance and value would help to better allocate resources to achieve this end. Connecticut routinely performs these evaluations. Those studies can potentially offer a template for Kentucky moving forward.

10. If there are locations that interest both the Division of Motor Carriers and the Division of Planning, resources could be shared to purchase and maintain WIM equipment. The WIM scale would need to be located on a mainline, so this would lend itself more to a VWS concept than a new fixed weigh station. If the route has strategic importance to both divisions, and both agencies can agree on a suitable vendor whose products meets the technical specifications of both divisions, pooling resources makes fiscal sense.

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