Using Highway Technology

Introduction

The Upper Midwest faces a variety of problems within its transportation network. There is a growing pressure for roadway systems to operate more efficiently in the face of increased congestion, more vehicle-miles-traveled, and a deteriorating infrastructure. The historical response to such problems has been expansion of the roadway's capacity. This solution is no longer as feasible, and now pressure has fallen on technology to maximize the efficiency of the current infrastructure.

Various highway technologies are available to facilitate safety and security, operational efficiency, administrative efficiency, and regulatory compliance of freight transportation. Many of these technologies are already implemented in several of the Midwest states.

CVISN

The Commercial Vehicle Information Systems and Networks (CVISN) integrates existing information systems with communication technology and standards. The objective is to improve safety, efficiency, administration, and regulatory compliance of commercial vehicle operations. CVISN has three major components: safety information exchange, electronic credentialing, and electronic screening.

Safety Information Exchange (SIE)

SIE is a centralized database that gathers information about commercial vehicles, such as driver and vehicle data and safety history. This information is then used by state agencies and law enforcement to determine which vehicles should be inspected and which ones should receive their credentials. SIE data gets entered, updated, and made available nationwide in less than one hour. SIE helps enforcement and regulatory compliance programs become more resourceful in maintaining commercial vehicles. For example, the technology can aid law enforcement in identifying high-risk vehicles for more in-depth inspection.

Electronic Credentialing

The process of electronic credentialing includes registering operators, registering and titling vehicles, checking insurance, collecting and distributing fuel taxes, issuing oversize/overweight permits, issuing licenses and permits to haul hazardous materials, and collecting federal heavy vehicle use taxes. The states process the applications using a combination of manual and automated systems.

Motor carriers generally use some type of credentialing system software on their computer to prepare and submit applications electronically. The state agency's system then processes the data. The processing includes error checking, cross-checks with other databases, fee calculations, invoicing, payment, and issuance of the appropriate decal, sticker, plate, or paper document.

Electronic credentialing makes organizing and retrieving of credentials very efficient. In conjunction, the system promotes safer roadways for all travelers by ensuring shippers are complying with regulations. This reduces cost and time to freight carriers, taxpayers, and end users.

Electronic Screening

Electronic screening is a system that monitors the weight of commercial vehicles. It works in conjunction with Radio Frequency Identification (RFID) transponders which are mounted onto commercial vehicles. These transponders communicate driver and vehicle information to receivers at weigh stations and border crossings. Compliant carriers are signaled to bypass the weigh stations, gain entrance to a port, or to expedite border crossing.

Figure 1: Electronic screening of a Commercial Vehicle

Electronic screening technology saves processing time at weigh stations and border crossings, which means it promotes fuel efficiency. Actual weigh station traffic is reduced, giving law enforcement agents more freedom to focus on extreme offenders. It improves traffic flow along the highways while requiring no expansion of the existing highway infrastructure. Electronic screening technology has low costs to the user with each transponder costing an average of about $40. The cost of the electronic screening equipment, however, is about 1.5 million dollars per weigh station, which is a huge burden on state DOTs.

Weigh-in-Motion (WIM)

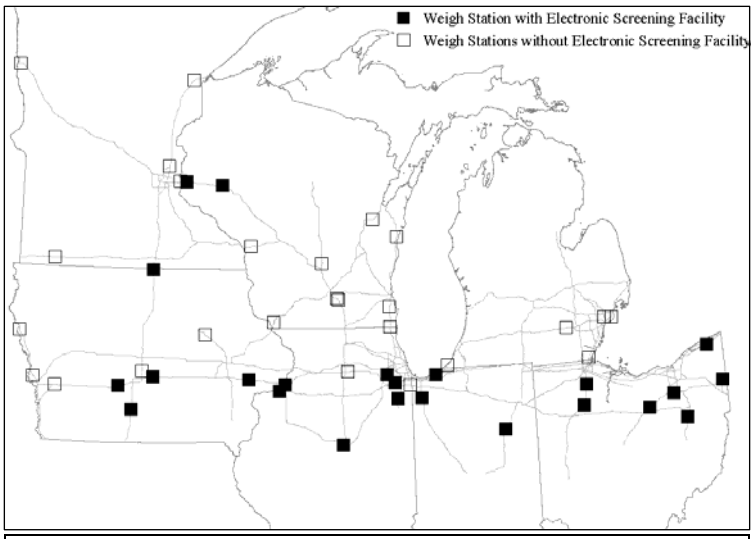

Figure 2: Weight Enforcement Facilities in Upper Midwest Region Study Corridor

WIM systems record truck axles and gross vehicle weights as vehicles drive over a plate sensor. These sensors measure a truck's gross weight, axle weights, axle spacing, speed, and vehicle classification. This sensor is located within the road and allows vehicles to pass through without stopping. The system can handle a commercial vehicle driving at speeds of up to 55 mph over the sensor. WIM is used for collection of statistical data, support of commercial vehicle enforcement, roadway and bridge cost allocation, and traffic management. These systems can be portable, semi-permanent, or permanent depending on their use. Electronic screening facilities include WIM. Figure 2 shows weigh stations within the corridor, some of which have WIM capabilities.

Virtual Weigh Stations

Figure 3: Virtual Weigh Station Camera

Virtual weigh stations have WIM scales installed along the highway mainline that are monitored remotely. An overview camera collects the vehicles license plate number. After the data and plate number are collected, the information can be sent to either a portable laptop or office computer to be monitored and/or regulated. Trucks are identified by automated images that record the USDOT number on the sides of their cabs. These images and sensor data are electronically communicated to a control center. Trucks that violate the scale requirements are stopped and inspected at portable scale inspection sites. Virtual weigh stations are being widely embraced and deployed for their cost benefits. The cost of a virtual weigh station is between $100,000-150,000, substantially less than a fixed weigh station. A major benefit of a virtual weigh station is that habitual offenders can be identified remotely, which can make the roadways safer and limit violators. Indiana is the only state in the Upper Midwest that is currently deploying these stations, though virtual weigh station deployment is a high priority of the Gary-Chicago-Milwaukee Corridor.

Freeway Management Systems

Freeway Management Systems (FMS) are used to inform transportation agencies of traffic volumes, traffic speeds, road conditions, and other related data. The systems utilize a variety of ITS tools such as closed circuit television cameras (CCTVs) and in-pavement traffic sensors. Administrators can use the data to inform the public of road and traffic conditions through dynamic signage, web sites with real-time data, and highway advisory radio stations. A functional FMS can aid in the deployment of maintenance and police vehicles, identify areas of obstruction, direct future capacity expansion or technology deployment strategies and location, and mitigate congestion without expanding capacity. The system can also assist in informing the public of important events like Ozone Action Days.

Funding for FMS can come from a variety of sources. Urban areas designated as non-attainment regions for National Ambient Air Quality Standards (NAAQS) under the Clean Air Act often have access to Congestion Mitigation and Air Quality (CMAQ) funds. Other funding can be drawn from the Surface Transportation Program and Interstate Maintenance Federal funding sources.

FMS is one of the few areas in which states have successfully shared technology benefits and responsibilities across the border. For example, the Ohio-Kentucky collaboration on Cincinnati's FMS funding, deployment, and management demonstrates that cooperation between states in using highway technology is attainable.

Asset Tracking Applications

An asset tracking system involves an assortment of technological devices. These devices can track trucks, trailers, containers, cases, or pallets. See Figure 4 for asset tracking technology implementations for freight shipments. Asset tracking coordinates telecommunications technologies, sensors, and simple bar codes and labels. These applications ensure shipments are moved from start to end safely and securely. Asset tracking is particularly helpful for shipments that are carried by multiple modes of transport. For

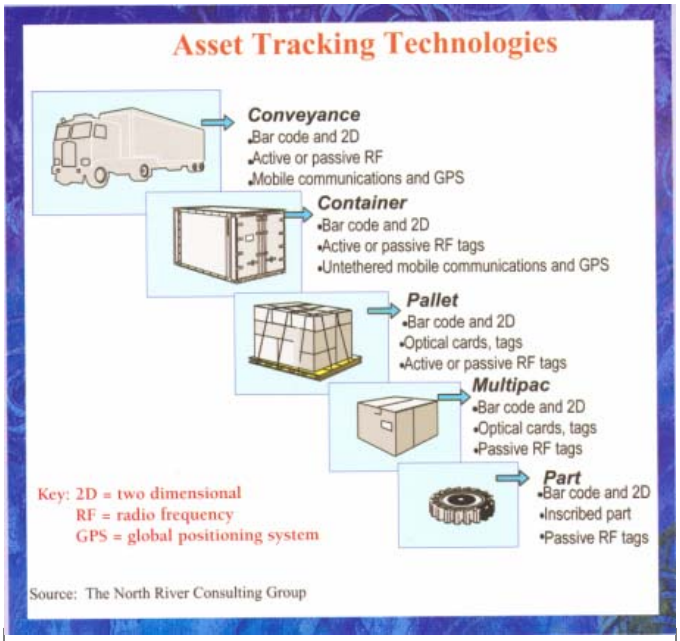

Figure 4: Asset Tracking Technologies for Hazardous Loads

example, a container may be shipped from a plant on a flatbed truck and then loaded onto a rail car, and then back onto a truck for the final leg of its journey. The tracking device on the container would ensure there was no tampering of the shipment. These devices are very important for material handling and anti-theft, which protects the public from threats such as shipments of contraband or potential terrorist weaponry.

HAZMAT Tracking

HAZMAT tracking is a serious concern within homeland security. Hazardous materials have the potential to be targeted by terrorists due to the rare and potentially volatile nature of the cargo. HAZMAT tracking uses GPS and communication applications. The GPS can track the cargo or vehicle to see if they stray from the pre-specified route. If this happens, an alert is dispatched. There are other technologies such as a panic button and intelligent on-board computers. Panic buttons send emergency alerts via satellite or terrestrial communications. Lastly, an intelligent on-board computer can disable the vehicle's motor in the case of a security breach. HAZMAT tracking is often coupled with biometrics to verify operator identification. A biometric login can verify the identity of the driver.

Biometrics

Biometrics technologies are used to improve security. Unique physical characteristics such as the iris, fingerprints, retina, voice, and face are used to authenticate identity. At the Charlotte-Douglass Airport, iris scanners are used to verify the identity of airport employees, TSA, vendors, etc. through an eye-pass system. To establish this system, a photo of the eye is taken and converted into a unique digital signature. Other benefits to biometrics besides safety include are time and cost savings. Biometrics applications streamline checkpoints before the cargo is shipped, saving time and money. The system processes background and clearance checks for the operator faster through computers versus the manual paper work that was filled out and processed.

Radio Frequency Identification (RFID)

RFID uses radio waves to identify different cargo. This technology is already used at existing weigh stations for e-screening. There is an RFID tag which utilizes a microchip and an antenna. The microchip stores a unique serial number that is transmitted to a reader by the antenna. This application is used at weigh stations for e-screening and at toll booths for toll collection. The RFID tags are very inexpensive, generally costing less than $15. On the other hand, there are some disadvantages to RFID systems. The standards of RFID are still under development. The range of the RFID tag is limited to about 10 feet and high range tags, which broadcast farther, cost more.

E-Seals

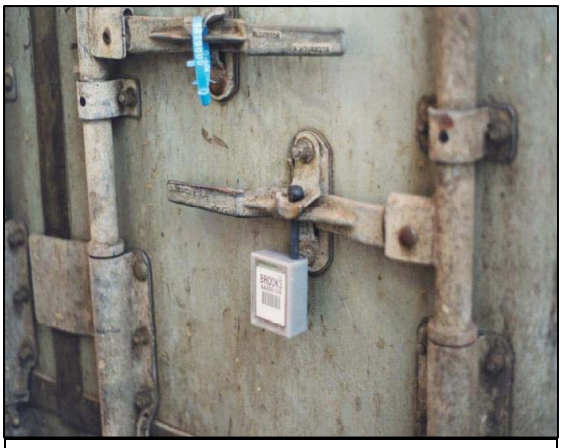

Figure 5: E-Seal attached to Shipping Container

E-Seals are disposable RFID transponders for container doors. Law enforcement and customs officials use expensive readers to track E-Seals' movements along highways, borders, and ports. The E-Seal transmits the container's ID number to a reader within an inspection station. The seals are readable at mainline speeds. If the container has been tampered with, a message will appear on the reader. The inspection station can then use the information to determine which containers should be inspected. When a container has left the country this information is posted on the internet for tracking purposes. This application can increase efficiency and security at border crossings. One application of E-Seals, used by the Department of Agriculture, is the tracking of in-transit containers of restricted foods. E-Seals, however, are not widely used within the country. A major problem with E-Seals is the lack of standardization in transponder frequencies. This not only causes problems within the US but makes it hard to coordinate with other countries.

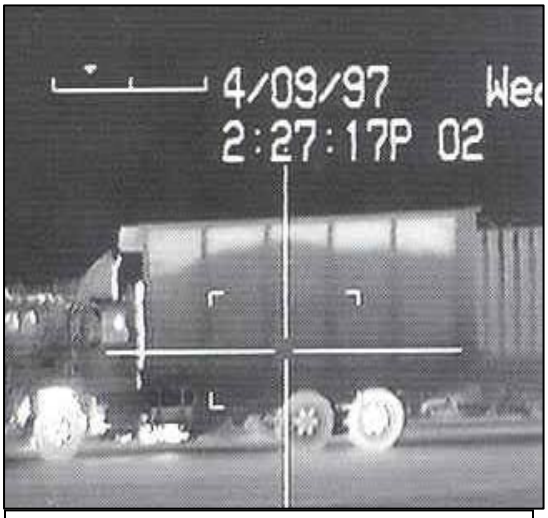

Figure 6: IRISystem Detecting Inoperable Brakes on the Vehicle

Infra-Red Inspection System (IRISystem)

IRISystem detects disconnected brakes on commercial vehicles. This system uses heat sensors to check if the brakes of the vehicle are operational. Figure 6 shows a commercial vehicle with one axle of non-operational brakes. The white wheels are warm which means the brakes are functional. The dark wheels' brakes are not in operation. Disconnected brakes make a commercial vehicle easier to drive and handle, which is why some drivers unhook them. The cost for one unit is about $300,000. IRISystem exhibits a significant increase in identifying problematic vehicles and out-of-service orders. This system is implemented at weigh stations and the vehicles can be screened at around 10 mph.

Vehicle and Cargo Inspection System (VACIS)

VACIS uses a non-intrusive gamma ray imaging system. The system is mounted within a truck. Short wavelengths with high energy concentrations penetrate thicker and denser materials than x-rays. Additionally, gamma rays are more cost effective and reliable. This system is implemented through homeland security grants and is frequently used to look for weapons, contraband, and other potentially dangerous objects entering the country. Illinois is the only state in the upper Midwest that has this system implemented. The major drawback to this system is its high cost. Each system costs about $1,500,000.

Identification and Monitoring of Radiation in Commerce Shipments (IMRicS)

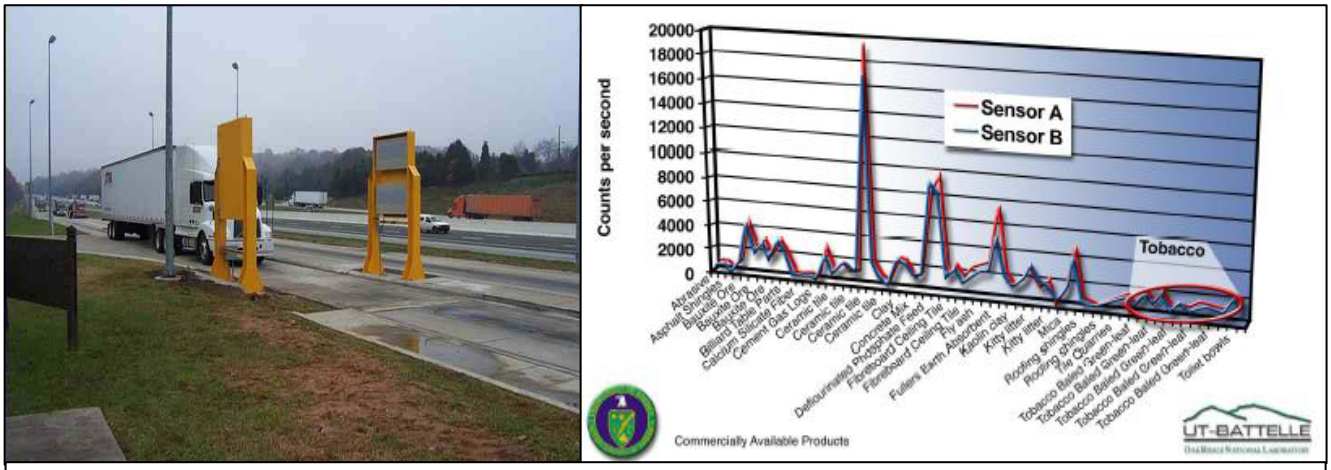

Figure 7: IMRicS System and Cargo Representation of Radiological Signatures

IMRicS systems send commercial vehicles through radiological sensors prior to stopping on a static scale. The cargo within the vehicle is detected by a radiological signature. Some of the signatures trigger alerts indicating potential illegal goods. Vehicles that are flagged are then subject to further inspection. This system is still within the development stage at Oak Ridge National Laboratory. Figure 7 shows a truck entering the IMRicS system. The graph to its right shows the radiological signatures for different types of cargo. State law enforcement officers can use IMRicS to crack down on shippers who are transporting illegal freight.

Fatigue Management Technologies (FMT)

Every year many drivers get injured or die due to fatigue-related accidents. It is difficult to validate this problem, because it is difficult to determine if the driver involved in a crash was fatigued or drowsy. FMT consists of many different types of technology applications to alert drivers and detect possible fatigue. One system detects eye closure by using infrared monitoring. The camera sits on the dashboard and is directed at the driver's eyes. It gives continuous feedback on

the alertness level of the driver and sounds an alarm when eye closure is detected. Another application tracks lane markings along the roadway. The system alerts the driver when the vehicle moves from the lane center. There are many other devices that measure sleep needs and control center steering.

Implementation of Technology

Figure 9 shows a distribution of the implemented technologies in each state. Within the Upper Midwest, Illinois is the leader in technology implementation. Overall, the Upper Midwest is a leader in transportation technology usage with some states deploying technology beyond electronic screening.

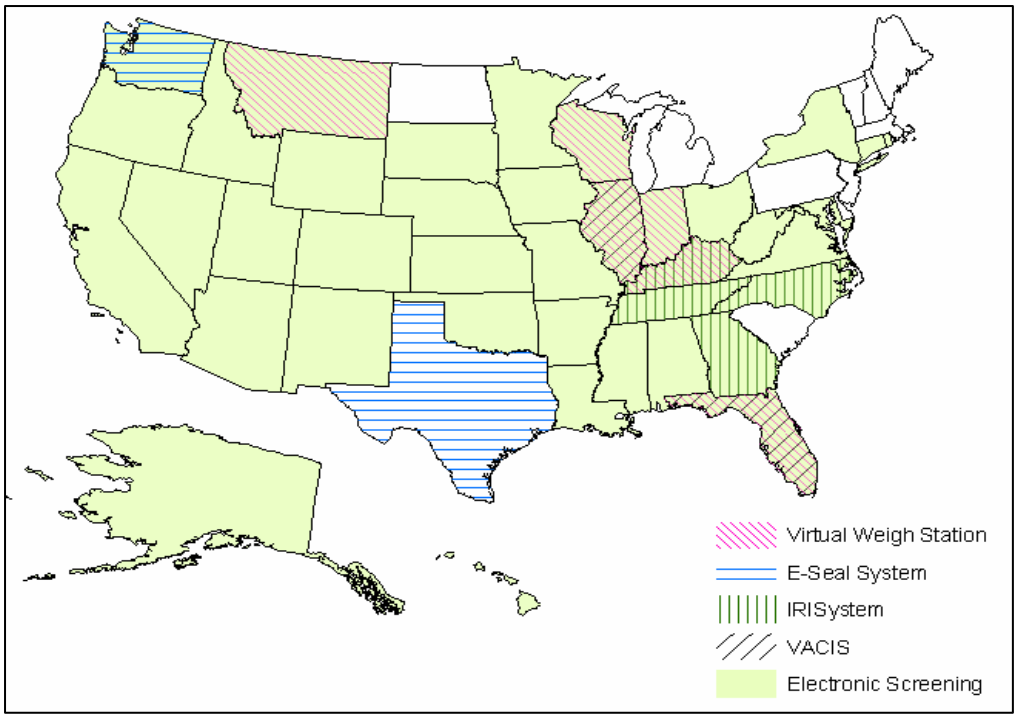

Figure 9: Technology Application Implementation

Table 2 shows a quick recap of the technologies status in development and the area of focus.

Table 2: Maturity and Focus Areas of Technology

Status	Technology	Driver	Vehicle	Cargo
Widely Tested and Deployed	GPS & Wireless Communication		X	X
	Hazmat Tracking	X	X	X
	WIM		X	
	RFID		X	
	Electronic Screening		X	
Tested by Limited Deployment	Virtual Weigh Station		X	
	Biometrics	X		
	VACIS			X
	IRISystem		X	
Under Development or in Testing	Fatigue Management Technology	X		
	E-Seal			X
	IMRicS			X

Each technology focuses within an area of safety, security, and/or enforcement. Table 3 displays the different technologies within these categories and lists an approximate cost with each.

Table 3: Highway Freight Technology Applications and Cost

Technology	Safety	Security	Enforcement	Fixed Cost
Fatigue Management Tech.	X			$
E-Seal		X	X	$
RFID		X		$
WIM			X	$
Virtual Weigh Station			X	$
Biometrics		X		$
GPS/Wireless Communication		X		$
Hazmat Tracking	X	X		$-$$
IRISystem	X		X	$$
Electronic Screening			X	$$$
VACIS		X	X	$$$
IMRicS	X	X	X	$$$
$=<$300K $$=$300-1M $$$=>$1M				

Barriers to Regional Coordination

There are many significant barriers to regional coordination in technology deployment and management. Interviews with Commercial Vehicle Operations (CVO) experts highlighted several obstacles that need to be effectively confronted in order to create an atmosphere in which regional cooperation can work.

There are limited clear benefits to regional cooperation. Most transportation agencies are concerned primarily with the freight traffic within their jurisdiction. Both congestion and infrastructure damage are viewed as localized problems with localized solutions. There is logic to this mindset. As transportation administrators are called upon to maintain high levels of service despite an aging infrastructure, increasing traffic volumes, and shrinking funding, they must look to their own area of responsibility before considering the larger good of the region. Allocation of funds to regional projects with regional benefits is constantly taking the back seat to projects with easily quantifiable local benefits.

Agencies differ in policy directions. Even within states, there are significant disputes that arise due to different perspectives and directions. For example, weight enforcement in Minnesota is a coordinated effort between the Department of Public Safety's Pro-Rate Division, the State Patrol, and the Department of Transportation's Freight and CVO Office. All approach the table with different agendas, different performance measures, and most importantly different priorities. Without incorporating a uniform policy direction, any plans for regional cooperation are unlikely to succeed. In addition, developing a uniform policy direction for a wide variety of stakeholders with significantly different structures is a serious challenge. There is a lack of quality plans that produce trustworthy, realistic assessments of the benefits that regional cooperation can foster.

Regulations are not standardized across borders. In order to utilize regional technologies, states must agree on what they desire from their transportation system. Regulations reflect differing ideologies that would be sources of conflict in regional cooperation. On an operational level, differing regulations create problems with enforcement, credentialing, and licensing. While it may be a huge efficiency boost to issue one permit to a freight hauler for the entire Upper Midwest, this is impossible if every state in the region has different regulations on when, where, and at what weight the driver can operate.

The current culture of transportation management does not foster cooperation. Several CVO experts mentioned that one of the biggest challenges to regional cooperation was simply finding people willing to try it. Locating agency champions for regional deployment of technology with support from their upper management will be essential for overcoming barriers. Unfortunately, there is a significant opposition to the notion of change within transportation agencies. Cooperation beyond one's borders has never been part

of the job for most transportation administrators. It has been viewed as unrealistic, ineffective, and extracurricular. In order to foster the long term vision and dedication that a regionally deployed technology infrastructure would demand, the culture of transportation management must adapt to incorporate a broader view of the transportation system.

Agencies lack the trust necessary to share information and technology management responsibility. For a public agency, sharing of responsibility has traditionally meant losing direct control. This is one reason why transportation agencies are hesitant to trust other agencies. One state DOT has no guarantee that another state DOT is applying the appropriate standards and scrutiny to data. States frequently disregard data that comes from sources they have little experience with. Unfortunately, other state DOTs typically fall into this category. This lack of trust is not limited to public relationships. Private firms are also resistant to cooperative efforts due to trust concerns. The desire of private firms to protect proprietary information mandates caution. Additionally, a tradition of overestimating the benefits of transportation improvements has created skepticisms amongst private firms that must be addressed to gain their trust.

Interestingly, there are few technological hurdles that arose during conversations with CVO experts. The challenges that must be overcome in order to effectively share information which can increase efficiency in regulatory enforcement, credentialing, and freight movement are minimal. Most barriers to regional cooperation are products of the culture, traditions, and structure of transportation administrations rather than technological limitations.

Funding is obviously of great importance when considering regional cooperation. All of the aforementioned barriers limit the amount of funding state DOTs are willing to dedicate to regional projects. Once the barriers of perspective, policy and regulation differences, culture, and trust have been effectively addressed (not that anyone is holding their breath), it is reasonable to expect to see an increase in the funds state DOTs are willing to contribute to regional scale technology deployment.

Opportunities for Regional Cooperation: *The Low-Hanging Fruit*

Cooperative technology management would aid the push to standardize regulations, leading to increased efficiency and lowered administrative costs. States could greatly benefit from the increased ability to share information across state lines. A regional database with real-time data would improve efficiency in weight enforcement, safety, security, and congestion mitigation. All of these advances are possible through coordinated efforts. Regional cooperation, a perceived option now, will become a necessity. The issue is whether the Upper Midwest begins to take action now, or waits until regional coordination is no longer an option, but a necessity.

There are several possibilities of how to proceed in developing a regional technology deployment and management strategy. Listed below are several ideas intended to foster discussion and thought.

Discussion between CVO experts throughout the Upper Midwest should be a regular component of technology planning. CVO experts within the Upper Midwest region frequently interact at conferences and other professional gatherings. Yet there is rarely a defined component of technology planning that promotes communication between states as an essential element for effective deployment and maximum results. By fostering interstate communication, the benefits to regional cooperation will become clearer and the barriers to coordination will lower. For example, weight enforcement facility sites are frequently located at state borders, rather than dispersed evenly along corridors. This pattern leads to concentrated weight enforcement and delays at borders and long stretches of highway without any enforcement. The placement of weigh stations at borders is often unneeded, particularly when the neighboring states have similar weight regulations. Communication between CVO experts prior to deployment could help prevent inefficient allocation of resources before they are fixed in place.

Involving freight companies can promote the benefits of a regional perspective. It is important for state DOTs to understand that political boundaries are of far less importance to freight carriers than they are to the government. By bringing freight companies into policy development forums, the interests of the users of the transportation system can begin to take precedence over the interests of the administrators. Freight companies are motivated, efficient, and often have access to the latest technologies. For example, Fatigue Management Technologies (FMT) will likely move from the Federal government into the hands of private freight carriers. If individual states in the Upper Midwest wish to encourage the use of such technologies because of their impacts on highway safety, the states will benefit from a regional approach. It is harder for a single state to enact and enforce a regulation on FMT usage than it would be for a region. By involving freight companies, state transportation administrations can learn about the latest technologies and methods and, through dialogue with the private sector, identify reasonable and effective regulation strategies. Engaging freight companies is not an easy task, given the reservations and skepticisms they frequently have with the public sector. But courting freight carriers' interests and input will ultimately help the Upper Midwest to remain a competitive region for freight movement.

The Upper Midwest should solicit the Federal government to play a stronger role within the regional plan. The Federal government has the potential to provide the states of the Upper Midwest with a regional vision. This vision can be backed by funding that ensures the effective implementation of a regional technology program. The Federal government provided states with a

strong vision of the potential for CVISN. They are frequently praised for their role in getting the program off the ground. Yet their failure to provide the necessary funding throughout the development of CVISN is one of the reasons behind the lackluster adoption of the second phase of the program. States in the Upper Midwest need to recognize that the Federal government's involvement can be crucial to large-scale programs. The states should actively pursue Federal involvement in areas of concern such as security and safety. If the Federal government can perform with endurance in both the visioning *and* funding of a regional technology program, the program will have a far better chance of seeing the light of day.

Freeway Management Systems should operate on a corridor scale. By extending metropolitan ideas about traffic management along interstates, the benefits that are realized on a local level for local trips can apply to the longer trips typical of freight carriers. The compatibility of technology should not be an obstacle to gathering information. Standardized databases can easily adapt data into a usable format. Most importantly, this regional coordination opportunity can use currently deployed technologies as a platform, limiting the need for capital start-up funding. Information that is collected from an FMS informs state DOT monitoring centers of traffic accidents, traffic flows, and congestion along the roadways. This information could be shared between state DOTs to notify them of other states' problems. Issues of congestion and traffic flow interruption impact a corridor. They do not stop at a state border. When state DOTs receive such data from other states, they can then warn their drivers of upcoming delays and possible detours through dynamic signage and other advisory tools.

The consistency of CVISN components within the Upper Midwest states should be enhanced. By improving communication between states through CVISN technology, states will be able to strengthen law enforcement, safety, and security. In addition, by incorporating electronic credentialing and screening within all the states, the Upper Midwest's roadway system could gain a significant advantage. Other transportation networks unable or unwilling to integrate their technological communications would operate less efficiently, giving a competitive edge to the Upper Midwest. CVISN technologies could be extremely helpful in maintaining security, obtaining better safety and operational efficiency of the roadways, and achieving better regulatory compliance across state lines. One benefit is that freight carriers would face fewer delays for unneeded inspections. A compliant vehicle that was inspected in Indiana could be waived through Illinois without inspection delays. This would create more time for enforcement officers to target genuine offenders. Additionally, consistent CVISN components would provide a platform to integrate regional electronic credentialing. Commercial vehicles would benefit from time and cost savings under such a program. Reduced paperwork, lower administration fees, and fewer processing delays would be the greater result of regional electronic credentialing. All in all, both private and public stakeholders would profit from an increase in CVISN consistency.

Improving regional shipping integrity could provide better homeland security while at the same time protecting shippers. Intelligent freight technologies can help protect freight carriers against theft, shipment of contraband, and terrorism. Increased security can generate significant economic advantages for freight carriers in the form of lowered insurance costs, higher consumer confidence, and increased reliability. In order for surveillance to be effective, it must operate on a regional scale. Non-compliant and potentially dangerous shipments do not remain within state lines. Interstate coordination can ensure that if a shipment attracts suspicion for any reason within a state, the shipment will not escape scrutiny the moment it crosses a state border. If the Upper Midwest has communication protocols and procedures to coordinate the tracking of suspicious or potentially dangerous shipments (similar to those tracked under HAZMAT), the entire region can monitor its roadway networks collectively. Intelligent freight technologies have received increased attention following the events of 9/11, particularly those which prevent shipments from being tampered with. For example, E-seals ensure that the container has not been tampered with. RFID can track packages to ensure shippers have not deviated from assigned routes.

A regional vehicle-based surveillance system could benefit the Upper Midwest by providing detailed road network traffic flows. Through coordination with state and local law enforcement, freight carriers, and cellular phone companies, state DOTs may be able to cooperatively establish a regional information-sharing, real-time database of the movements of commercial vehicles. Existing technology can connect law enforcement officials through use of their 911 database, freight carriers through GPS-linked cellular phones, and state DOTs who monitor commercial vehicle movement. This vehicle-based surveillance system could provide accurate, real-time travel data. This data could supplement existing strategies to identify and manage congestion problems. The GPS data would easily integrate with Geographic Information Systems (GIS) for a variety of administrative and analytical functions. This standardized surveillance system could use technologies already deployed under the CVISN program as a platform, making regional cooperation possible. By operating the system on a regional scale, states would lower the barriers to information-sharing across borders and gain access to accurate, real-time data for the entire network.

Conclusion

The possibility of regional cooperation in technology deployment and management is one that the region could benefit greatly from exploring. The progress of ITS and other transportation technologies has significantly lowered the barriers and costs to regional cooperation. By working to create a system-wide technology deployment strategy, every transportation agency in the region

could see improved efficiency. As usage and congestion of the current national highway system increases, any efficiency progress can be a competitive boost to the Upper Midwest's transportation system and economic well-being.

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