Commercial Motor Vehicle Size and Weight Enforcement in Europe

July 2007 ■ International Technology Scanning Program

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16. Abstract

Continued growth in commerce and traffic congestion makes it difficult for industry to move freight economically without using larger and heavier loads. This trend challenges the effective and efficient monitoring of vehicle size and weight compliance. The Federal Highway Administration, American Association of State Highway and Transportation Officials, and National Cooperative Highway Research Program sponsored a scanning study to evaluate procedures and technologies for enforcing commercial motor vehicle size and weight laws in Belgium, France, Germany, the Netherlands, Slovenia, and Switzerland.

The scan team learned that the European countries use various technologies, such as bridge weigh-in-motion systems, to improve the effectiveness and efficiency of motor vehicle size and weight enforcement. The team observed a greater use of mobile enforcement activities and fewer fixed roadside weight facilities in Europe than in the United States.

The team's recommendations for U.S. implementation include a pilot installation of a bridge weigh-in-motion system, a demonstration of the European mobile enforcement approach to prescreening suspected overweight vehicles, and a synthesis of existing research on linkages between overweight commercial motor vehicles and roadway safety.

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Commercial Motor Vehicle Size and Weight Enforcement in Europe

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International Technology Scanning Program

The International Technology Scanning Program, sponsored by the Federal Highway Administration (FHWA), the American Association of State Highway and Transportation Officials (AASHTO), and the National Cooperative Highway Research Program (NCHRP), accesses and evaluates innovative foreign technologies and practices that could significantly benefit U.S. highway transportation systems. This approach allows for advanced technology to be adapted and put into practice much more efficiently without spending scarce research funds to re-create advances already developed by other countries.

FHWA and AASHTO, with recommendations from NCHRP, jointly determine priority topics for teams of U.S. experts to study. Teams in the specific areas being investigated are formed and sent to countries where significant advances and innovations have been made in technology, management practices, organizational structure, program delivery, and financing. Scan teams usually include representatives from FHWA, State departments of transportation, local governments, transportation trade and research groups, the private sector, and academia.

After a scan is completed, team members evaluate findings and develop comprehensive reports, including recommendations for further research and pilot projects to verify the value of adapting innovations for U.S. use.

Scan reports, as well as the results of pilot programs and research, are circulated throughout the country to State and local transportation officials and the private sector. Since 1990, about 70 international scans have been organized on topics such as pavements, bridge construction and maintenance, contracting, intermodal transport, organizational management, winter road maintenance, safety, intelligent transportation systems, planning, and policy.

The International Technology Scanning Program has resulted in significant improvements and savings in road program technologies and practices throughout the United States. In some cases, scan studies have facilitated joint research and technology-sharing projects with international counterparts, further conserving resources and advancing the state of the art. Scan studies have also exposed transportation professionals to remarkable advancements and inspired implementation of hundreds of innovations. The result: large savings of research dollars and time, as well as significant improvements in the Nation's transportation system.

Scan reports can be obtained through FHWA free of charge by e-mailing *international@fhwa.dot.gov.* Scan reports are also available electronically and can be accessed on the FHWA Office of International Programs Web Site at *www.international.fhwa.dot.gov.*

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Acronyms and Abbreviations

AASHTO American Association of State Highway and Transportation Officials
AVV Transport Research Center (the Netherlands)
BAG German Federal Office for Transport of Goods
BASt Bundesanstalt fur Strassenwesen (Germany's Federal Highway Research Institute)
BRRC Belgian Road Research Center
B-WIM bridge weigh-in-motion
CEN European Committee for Standardization
CMV commercial motor vehicle
DOT department of transportation
DSRC dedicated short-range communications
DWW Road and Hydraulic Engineering Institute (the Netherlands)
ECM Electronic Control Measure
ECR European Control Route
EC European Commission
EP European Parliament
EU European Union
FEDRO Swiss Federal Roads Authority
FEHRL Forum of European National Highway Research Laboratories
FHWA Federal Highway Administration
FMCSA Federal Motor Carrier Safety Administration
GPS Global Positioning System
GVW gross vehicle weight
HGV heavy goods vehicle
HS-WIM high-speed weigh-in-motion
ICWIM International Conference on Weigh-in-Motion
IR infrared
ITRD International Transport Research Documentation
ITS intelligent transportation system
IVWC International Vehicle Weight Certificate
km kilometer
km/h kilometers per hour
LCPC Laboratoire Central des Ponts et Chaussees (France)
m meter
MISTRA Road Traffic Management Information System (Switzerland)
MS-WIM multiple-sensor weigh-in-motion
NOR/FAD Nothing-on-the-Road/Free-of-Axle Detector
OECD Organization for Economic Co-operation and Development
OBU onboard unit
OIML International Organization of Legal Metrology
OS/OW oversize/overweight
REMOVE Requirements for Enforcement of Overloaded Vehicles in Europe
SIREDO Systeme Informatise de REcueil de DOnnées (France)
PPP public-private partnership
STIT scan tour implementation team
TIPSOL European Traffic Police Network
TRIS Transportation Research Information Services
VSW vehicle size and weight
WAVE Weighing-in-Motion of Axles and Vehicles for Europe
WIM weigh-in-motion
WIM/VID weigh-in-motion with video
ZAG Zavod za gradbenistvo Slovenije (Slovenia's National Building and Civil Engineering Institute)

Executive Summary

Significant growth in domestic and international commerce, coupled with ever-increasing traffic congestion and delay on surface transportation networks, challenges the ability of industry to move freight economically without the use of larger and heavier loads. This trend challenges limited enforcement resources tasked with monitoring vehicle size and weight compliance in the interest of infrastructure preservation and in response to the structural constraints of the existing infrastructure. The American Association of State Highway and Transportation Officials' (AASHTO) Technology Implementation Group has identified the weigh-in-motion (WIM) concept and its capabilities as a focus technology for enhancing the effectiveness and efficiency of vehicle size and weight enforcement in the United States.

The potential benefits of WIM-based vehicle size and weight enforcement extend beyond infrastructure preservation to include the following:

- Improved delivery of enforcement services by enhancing effectiveness and efficiency
- Improved commercial motor vehicle productivity (i.e., supply chain velocity) by reducing the total number of vehicles required to stop for enforcement purposes
- Fewer emissions by reducing unnecessary deceleration, idling, and acceleration of compliant vehicles
- Higher commercial and general motor vehicle safety levels by controlling the operation of nonpermitted, noncompliant (i.e., overweight or oversize) vehicles
- Better data quantity and quality to support pavement design, bridge/structural design, traffic engineering, and transportation planning efforts, as well as ongoing performance monitoring and evaluation of vehicle size and weight enforcement programs

The scanning study on commercial motor vehicle size and weight (VSW) enforcement, conducted June 16 through July 2, 2006, included a review and evaluation of contemporary European procedures and technologies for enforcing commercial motor vehicle size and weight laws and regulations.

Based on information obtained from reports on prior related scanning studies, published literature, various Internet sites, and U.S. and European experts in the field, recommended sites for the scanning study included France, Germany, the Netherlands, Slovenia, and Switzerland. In addition to visiting these countries, the scan team met with members of the European Union (EU) in Brussels, Belgium, to gain perspective on efforts to harmonize VSW enforcement activities among different countries.

The scanning study was conducted by a team of experts in the area of commercial motor vehicle size and weight enforcement. Jeff Honefanger, AASHTO cochair, and Julie Strawhorn, Federal Highway Administration (FHWA) cochair, led the 10-member team, which included personnel from FHWA (three members), various State departments of transportation (DOTs) (five members), law enforcement (one member), and academia (one member). In addition to breadth across agency types, the team had expertise in motor vehicle size and weight technologies, procedures, data applications, public-private involvement, and harmonization.

Scan Purpose and Scope

The scope of the scanning study included a review and evaluation of contemporary European procedures and technologies for enforcing commercial motor vehicle size and weight laws and regulations. Specifically, the study considered the following, as applied in Europe:

- Emerging vehicle size and weight enforcement technologies, including but not limited to third-generation WIM devices that can produce reliable evidence of specific violations capable of withstanding legal challenge
- Unconventional vehicle size and weight enforcement procedures, including but not limited to alternative performance-based programs
- Novel uses or applications of WIM data to support pavement design, bridge/structural design, traffic engineering, transportation planning efforts, or ongoing performance monitoring and evaluation of vehicle size and weight enforcement programs
- Innovative public-private funding mechanisms for vehicle size and weight enforcement technologies or programs

- Multinational programs to harmonize administrative and operational vehicle size and weight enforcement procedures or programs among member countries

Intrinsic benefits related to infrastructure preservation, enforcement efficiency and effectiveness, commercial motor vehicle productivity, emissions, safety, and data quantity and quality were considered concurrently in this investigation.

General Findings

General findings and observations resulting from the six-country scanning study are summarized below. Findings are generally categorized as enforcement technologies, enforcement procedures, unique data applications, public-private funding, and harmonization approaches.

Enforcement Technologies

- Two of the six countries visited use technology for commercial vehicle size enforcement; the Swiss use an automated profile measuring device in low-speed applications and the Germans use a gantry laser system in high-speed applications. In low-speed applications (less than 10 kilometers per hour (km/h)) suitable for legal enforcement, these systems were purported to provide a more complete and accurate dimensional picture of a vehicle and allow enforcement officials to focus on other aspects of inspection. In high-speed applications, these systems can be used to preselect size-questionable vehicles from the traffic stream.
- A bridge WIM system is being used successfully and extensively in Slovenia, is undergoing tests on several bridges in France, and is generating interest in several other countries visited. Primary applications include preselection for mobile enforcement activities; data support for planning, design, and structure analysis; overweight permit application processes; and monitoring of alternate routes (i.e., bypass detection). France is conducting a field trial to assess the accuracy and reliability of SiWIM™ technology and available devices and to extend application to other bridge types. To date, the Slovenian bridge WIM system has proven most successful on short, stiff bridge structures (i.e., integral concrete slabs). The Netherlands recently installed one bridge WIM system for testing under Dutch highway conditions and is now identifying potential bridges for implementation.
- Research into the accuracy and durability of fiber optic-based, high-speed WIM systems was carried out in France in the late 1990s. Upgrades of the performance and design of these systems have led to field-based testing. Fiber optic-based systems overcome detector interference challenges caused by magnetic interactions with reinforcement bars in portland cement concrete slabs.
- The use of technology to support commercial vehicle weight enforcement varies among the countries visited on implementation and application extent (the COST 323 Project lent consistency to deployment site selection and accuracy determination through development of a European WIM specification). A general consistency, however, was noted in the type of WIM sensor (i.e., piezoquartz or piezoceramic) used for roadway applications. Previously observed challenges with accuracy and maintenance are being addressed in the countries visited.
- In general, the accuracy levels attained by WIM systems are sufficient for preselection of vehicles to weigh on static or low-speed scales for enforcement, for infrastructure design and maintenance, and for planning and statistical purposes, but are not sufficient for direct, automated enforcement.[1] France is nearing use of low-speed WIM for legal enforcement (i.e., issuing citations based directly on low-speed WIM measurements). The United Kingdom and Germany reportedly are using low-speed WIM for direct enforcement already, although this was not observed during the scanning study.
- Both France and the Netherlands are investigating the use of multiple-sensor WIM to achieve sufficient per-truck accuracy levels to support direct, automated enforcement of commercial vehicle weight limits.
- For WIM systems, calibration procedures in use include (1) self- or autocalibration, (2) calibration with vehicles of a known weight, (3) calibration with instrumented vehicles using onboard WIM systems, and (4) continuous, ongoing calibration (during enforcement efforts) using sample vehicles from the traffic stream at the enforcement site weighed both statically and in motion. The Netherlands has developed a dynamic calibration vehicle that eliminates traditional dynamic-to-static measurement adjustments, particularly for multiple-sensor WIM installations.
- In general, the use of technology in enforcing both commercial motor vehicle size and weight is viewed as beneficial in enhancing effectiveness and efficiency. For vehicle size enforcement, technology was also purported to improve the accuracy of dimensional measurements.

Enforcement Procedures

- A greater use of mobile enforcement activities and few fixed roadside weigh facilities were consistently observed. This strategy results in a lower volume of trucks being processed and geographically and geometrically constrained inspection and offloading areas, but provides more flexibility to respond to industry loading and routing patterns and more efficient and effective enforcement action.

- A high level of collaboration in commercial motor vehicle size and weight enforcement activities was observed in several countries visited between similar agencies of different jurisdictional levels (e.g., national and regional law enforcement agencies) and between different agencies (e.g., transportation and law enforcement agencies). It was also observed that private sector entities work closely with government and research bodies to refine and enhance product performance and accuracy.
- Weigh-in-motion technology, commonly used with video technology, is used to support commercial vehicle weight enforcement through (1) real-time preselection for mobile enforcement, (2) scheduling time and location (to the extent possible) of enforcement activities, and (3) directing carrier/company advisory notices of non-compliance (i.e., warning letter) and preventive visits (this information is shared with enforcement personnel).
- All countries visited noted consistent or lower weight limits on secondary and local roads.
- Many countries visited had truck travel restrictions by day of the week (e.g., no truck travel allowed on Sundays) or hour of the day (e.g., no truck travel allowed after 10 p.m.).
- Many European enforcement entities have dedicated personnel for size and weight enforcement. Often, size and weight enforcement personnel are not authorized to perform duties beyond size and weight enforcement (i.e., not authorized to stop vehicles, carry firearms, perform arrests). If an obvious safety, credential, or criminal problem is noted, personnel authorized to address these issues are called to assist.
- Citation issuance procedures and fine amounts differed between and within the countries visited, varying by the assumed violator (i.e., driver, carrier, or both), unique procedures for foreign drivers and carriers, and the time allowed for establishing and responding to the fine (in many instances, the fine was immediate). In general, the citation amounts were reported to be sufficient as a deterrent.
- Fully automated commercial motor vehicle size and weight enforcement using high-speed WIM is estimated to be 5 to 20 years in the future, as purported in France and the Netherlands. Primary challenges for high-speed WIM applications include (1) attaining sufficient accuracy levels for the WIM systems (i.e., accuracy class A(5) with respect to the COST 323 European specification), (2) gaining certification approval from the national metrological bodies, and (3) modifying existing laws that require static weight measurements. France (as well as the United Kingdom and Germany) has obtained approval from the national metrology authority to certify low-speed WIM for use in enforcement, but related legal authority to introduce this application by statute is still required. In Belgium, low-speed WIM is used for direct enforcement, but it is unclear what legal or metrological changes were required to support this practice.
- In many of the countries visited, bypass of enforcement activities was discussed as a concern. Mobile enforcement activities, by their nature, are generally able to address any bypass-related challenges. France has integrated bypass considerations as part of its WIM site selection process (i.e., locating WIM systems to discourage obvious or convenient bypass).
- Unique procedures for addressing oversize/overweight (OS/OW) permitting in the countries visited focused on (1) the development and provision of Web sites allowing truck drivers to self-route based on origin, destination, and route restrictions (Switzerland), (2) the use of calibrated influence lines derived from bridge WIM to calculate safety of the bridge under the special transport using the exact axle loadings and spacing (France, Slovenia), (3) and remote field verification capabilities for OS/OW movements (Slovenia).
- Benefits from the technologies or procedures used are not yet precisely quantified. General benefits related to increased enforcement efficiency through the use of technology (i.e., providing greater enforcement effort with less human resource) were reported by Swiss, Dutch, and French representatives. The most common quantified benefit reported related to onsite enforcement efficiency—the number of overweight penalties issued (i.e., warning, citation, etc.) per total trucks inspected.

Unique Data Applications

- Real-time WIM system data are used most often for preselection during mobile enforcement operations and to a lesser extent for scheduling the best days, times, and locations for optimum mobile enforcement. Use of this data to support planning, historical trend analysis, policy and pricing decisions, design, structure analysis, permitting, etc., was more limited.
- Data exchange and sharing within the countries visited varies. Limited data are exchanged with the European Union under special efforts such as the European Control Route (ECR).
- Implementation of a European WIM database, as envisioned and initiated to a limited extent in the COST 323 and WAVE Projects, has not been fully realized.
- Data quality was reported to be largely sufficient for each of the various applications (i.e., preselection, planning, etc.). The most common shortcoming noted was geographic coverage.

Public-Private Funding

- Commercial motor vehicle size and weight enforcement is the responsibility of the public agencies (either police or transportation), with a few exceptions (the Netherlands, Slovenia, and Germany use limited authority enforcement personnel). Tolling activities have a higher involvement of private management partners.
- Several countries visited demonstrated a high reliance on private contractors for services (e.g., setting up systems, maintaining software, processing data). In the United States, private industry is more often involved through supply contracts than service contracts.
- Motivation for investment in commercial vehicle size and weight enforcement is often justifiable through environmental (e.g., noise, emissions, vibration), road safety (e.g., braking and stopping distances), and infrastructure (pavement and bridge lifetime preservation) impact considerations. The development of enforcement approaches, tools, and techniques is also driven by a desire to maintain fair competition among industry. In the United States, primary motivators include infrastructure preservation and safety, although the basis for safety benefits is not well quantified.
- A strong focus on modal shift to rail was observed in the countries visited. Low commercial motor vehicle weight limitations, nighttime travel restrictions, and strict requirements on drivers' rest periods in Switzerland result in significant movements by rail. Rail industry unions appear to have an equal or, in some instances, stronger voice than trucking industry unions. European rail infrastructure is largely government owned and operated. The Netherlands also reported a heavy reliance on inland waterways for moving freight.
- The countries visited use some form of tolling or pricing to help finance roadway operation, maintenance, or improvement, with a focus on heavy goods movement. The extent and nature (i.e., public-private system operation, weight- or size-based for heavy vehicle movements) of tolling systems varies from country to country, however. None of the tolling schedules observed is based on actual or real-time weights. More often toll schedules reflect a fixed registered weight capacity (e.g., trucks greater than 12 metric tons in Germany) and do not distinguish between fully loaded or empty transports. This latter trait encourages the trucking industry to operate more efficiently to avoid paying tolls for empty transports.
- Similarly, the fee structure for special permits is not always based on actual or real-time weights, but instead reflects a flat-fee structure.
- Emerging user fees (being investigated and developed as part of the European EUREKA Footprint Project) consider environmental impacts (e.g., noise, vibration, emissions) as well as infrastructure impacts for both road and rail.
- A noted sensitivity for fair competition among trucking companies exists in both industry and government. Industry is largely supportive of enforcement approaches, tools, and techniques that will help ensure fair competition.
- Despite industry support of enforcement efforts in the interest of fair competition, direct participation from the trucking industry to address commercial vehicle size and weight enforcement challenges was observed to be minimal. The Netherlands actively sought solutions from the trucking industry for size and weight enforcement challenges without any initial actionable feedback. Over time, the Dutch trucking industry has responded to enhanced commercial motor vehicle size and weight controls (e.g., through the use of WIM and weigh-in-motion with video (WIM/VID) systems) by developing new or adapting existing vehicle configurations (e.g., including additional axles) to increase compliance.

Harmonization Approaches

- Commercial vehicle size and weight limits are largely harmonized between member countries for cross-border travel. Country-imposed limits for national travel vary, but must not be lower than EU requirements except in cases where the infrastructure along secondary roads cannot support the load.
- A common goal or priority in decisionmaking for the countries visited is consistency within the European Union while maintaining the individual country's economic interests. This goal not only applies to commercial motor vehicle size and weight enforcement activities, but also to tolling.
- The European Traffic Police Network (TIPSOL) provides a framework for multinational, coordinated highway enforcement actions.
- In general, a greater focus on coordinated research efforts among EU member countries exists than among U.S. States. The European Union and Forum of European National Highway Research Laboratories (FEHRL) provide the framework for administration of large-scale, multiyear coordinated research efforts.
- The special permit process for oversize/overweight vehicles varied because of unique conditions in each country.
- The COST 323 European specification for WIM systems—calling for tender and test-based acceptance procedures—provides a common and widely accepted prestandard used by all parties since its inception in the late 1990s.

Team Recommendations

Based on these general findings and observations, the scan team ranked a preliminary list of European commercial motor vehicle size and weight enforcement technologies and procedures as having "high," "medium," or "low" interest levels for implementation consideration in the United States. These relative rankings did not recommend implementation of the various technologies or procedures, but instead indicated interest in further investigation.

After the scan, the scan tour implementation team (STIT) focused on implementation opportunities assigned a high interest level and worked further with scan team members to prioritize the 17 initial opportunities included in this category. Some opportunities were later combined because of perceived overlap. Through this process, the STIT identified seven specific implementation opportunities as having the greatest potential benefit to U.S. commercial motor vehicle size and weight enforcement procedures:

- Slovenia bridge weigh-in-motion (B-WIM, Slovenia, France)
- Swiss heavy goods vehicle control facility (Switzerland)
- Prescreening for mobile enforcement (Slovenia, Switzerland, the Netherlands, France)
- Applying WIM for direct enforcement: a template for implementation and certification (France)
- Behavior-based enforcement activities (the Netherlands, France)
- Synthesis of safety implications of oversize/overweight commercial vehicles (Belgium)
- Effective use of WIM data: the Dutch case study (Netherlands)

Specific strategies for advancing these implementation opportunities were also identified, with various scan team members assigned supporting action items. These implementation opportunities and strategies are detailed below.

Slovenia Bridge Weigh-in-Motion (Slovenia, France)

Bridge weigh-in-motion (B-WIM) was initially identified in the late 1970s in the United States and developed in the WAVE Project. European researchers continued to advance field testing and applied research into the concept, leading to its widespread deployment in Slovenia. B-WIM is a vital component of Slovenia's commercial motor vehicle weight monitoring system and is used to prescreen commercial vehicles for weight enforcement purposes. SiWIM in Slovenia was developed and implemented through a partnership between research staff at the National Building and Civil Engineering Institute's (ZAG) Research Department and a private engineering firm, CESTEL. Deployment of Slovenian SiWIM targets short-deck (5- to 10-meter) orthotropic bridges. Extensive research into the reaction of the bridge deck to weights has led to the ability to estimate, within acceptable levels of accuracy for prescreening, a vehicle's static weight. Analysis and data collection leading to this capability centered on the behavior of the "influence line" when truck weights are applied to the bridge's deck. Weight-detection instrumentation is applied at the under-deck location of the structure, eliminating the need to disrupt traffic flow during installation. Multiple sensors are used to monitor travel lanes and a sensor data hub or cabinet feature is used to draw readings from the individual sensors and composite the deck loading readings. Axle weights, gross vehicle weights (GVW), axle spacing, vehicle speed, and vehicle class are captured through this data collection approach.

The Netherlands is analyzing its inventory of structures to determine the number and location of bridges where B-WIM could be deployed. Recently, one bridge WIM system was installed for testing under Dutch highway conditions. In France, significant applied research efforts are concentrated on advancing the use of B-WIM on multiple-span, multiple-lane structures and steel orthotropic deck bridges. The filtering of sensor readings from several vehicles on the bridge deck simultaneously is the target of current research efforts. The scan team visited the Autreville orthotropic steel bridge site on the A31 motorway outside of Nancy, France. French hosts provided a tour of the site layout and demonstrated the SiWIM under testing.

Eliminating the need to disrupt traffic flow and minimizing worker risk when installing traditional roadway telemetry, B-WIM was seen to possess major benefits over current U.S. practices. Also, as seen in Slovenia, the time required for installation is not significant and, once bridge deck superstructures are instrumented, B-WIM is highly portable. In Slovenia, five SiWIM devices are used to collect data for 1 week at 30 locations twice a year. U.S. applications of B-WIM would enhance prescreening capabilities for commercial motor vehicle weight enforcement, as well as provide important information to bridge management systems. The choice of a suitable bridge and the development of an appropriate instrumentation plan and related calibration procedures may be challenging and require a high expertise level.

Implementation Strategy (George Conner, Pam Thurber, and Randy Woolley)

- Obtain detailed site layout specifications from Slovenian contacts.
- Synthesize the French experience and analyze the accuracy and performance results.
- Prepare and deploy a one-page information sheet

presenting a compelling case for pursuing B-WIM implementation in the United States.
- Present findings at AASHTO's Bridge Conference.

Deliverables
- One-page information sheet detailing B-WIM requirements and benefits
- Summary of French experience, including accuracy and performance results
- Transportation Pooled Fund Program study focusing on deployment opportunities in the United States
- Implementation of pilot B-WIM system (i.e., potential bypass route adjacent to enforcement location)

Swiss Heavy Goods Vehicle Control Facility (Switzerland)

To protect highway tunnel facilities and roadway infrastructure from the impacts of heavy trucks, Switzerland has developed and implemented an efficient and effective approach to simultaneously measuring commercial vehicle size and weight at stationary enforcement locations. The system also includes a high-speed weigh-in-motion (HS-WIM) and video (VID) technology component that is used to strategically select trucks requiring additional measurements.

The scan team had the opportunity to observe enforcement procedures at the control facility outside of Bern, Switzerland. Mobile enforcement details escorted vehicles into the facility for additional measurements using the HS-WIM/VID prescreening capability. Vehicles were directed onto a weigh bridge (i.e., static scale pad instrumented with several load cell scales) that provides simultaneous axle and gross vehicle weight measurements. An overhead gantry fitted with laser scanners capable of capturing commercial vehicle length, height, and width measurements is used simultaneously.

An attractive element of the Swiss heavy goods control facility operation is the user-friendly presentation of data to enforcement officers operating the system. A horizontal line on the computer screen represents legal axle and gross vehicle weight allowances with violations clearly presented as exceeding this allowance line. Size dimensions exceeding legal allowances are highlighted in red on a three-dimensional model of the vehicle. Size- and weight-related citations are generated automatically for issuance to the vehicle operator and submission to the appropriate judiciary officials. Swiss enforcement personnel described the advantages of this system over traditional portable scale and manual measurements efforts. More accurate measurements are conducted with less manpower, resulting in more effective enforcement performed in considerably less time. The Swiss operate three control centers, with additional centers in the planning and development stages. The scan team believes that U.S. deployment of such an enforcement station at key high-volume domestic or international land crossing locations would be beneficial.

Implementation Strategy (Jeff Honefanger and Tom Kearney)
- Obtain control facility weigh bridge and laser scanner gantry specifications from Swiss contacts (i.e., number and type of load cell scales, number and type of laser scanners).
- Evaluate domestic or international land-crossing locations as possible candidates for a model deployment pilot site.

Deliverables
- List of locations viable for model deployment
- Implementation of a control facility in the United States
- Documentation of timesaving benefits realized through pilot deployment

Prescreening for Mobile Enforcement (Slovenia, Switzerland, the Netherlands, and France)

A significant level of interest exists in the United States in the use of automation tools and technology to improve commercial motor vehicle size and weight enforcement. The scan team witnessed similar mobile enforcement activities in four of the six countries visited: Slovenia, Switzerland, the Netherlands, and France. Common features and elements were identified in each. High-speed WIM technology was used in each case for mainline prescreening of suspected overweight commercial motor vehicles. Video capture (i.e., digital photo images) of the vehicle was triggered by overweight detections. Both weight and image data were transmitted via short-range communications to enforcement personnel, allowing them to identify appropriate commercial vehicles in the traffic stream and escort them off the mainline for further investigation. Such systems are referred to as WIM/VID in Europe. Such approaches were embraced by the COST 323 action and are used widely by EU member nations.

U.S. States use elements of this approach to varying degrees. The scan team identified the need for a comparative analysis to measure the differences between the state of the practice for mobile enforcement in the United States and that observed in several European countries. The team believes that advancement of the most effective mobile enforcement practices could be supported and delivered most expeditiously once State-level variations are identified and compared to European practices.

Implementation Strategy (Ric Athey and John Nicholas)

- Survey U.S. States on mobile enforcement program components and aspects.
- Obtain specific detail on mobile enforcement tools and techniques in use from European contacts.
- Identify demonstration sites for a European mobile enforcement approach (may be combined with B-WIM deployment).

Deliverables

- One-page information sheet on U.S.-versus-European state of the practice
- Implementation of a pilot demonstration of European mobile enforcement approach

Applying WIM for Direct Enforcement: A Template for Implementation and Certification (France and the Netherlands)

In many cases, the difficulty in deploying advanced technologies stems from institutional barriers. The widespread deployment and use of technologies for commercial motor vehicle size and weight enforcement require support from both the metrological bodies responsible for equipment certification and judicial bodies responsible for related legal actions. Low-speed WIM systems can be tested and certified using similar methods as static weighing equipment, making deployment of the WIM systems a logical first step toward direct enforcement. The testing and certification process for high-speed WIM systems is more complex and requires the development of new acceptance methods.

French officials are leading in their efforts to overcome institutional challenges to the use of low-speed WIM systems for direct enforcement (i.e., gaining acceptance from the national metrology and judiciary communities). While the French are focused on the initial acceptance of low-speed WIM systems, the Dutch are focused on gaining acceptance of high-speed WIM.

Because a similar development process would be required in the United States, the scan team recommended an indepth review of the French and Dutch evolutionary process for acceptance of WIM systems for direct enforcement, with a concurrent review of the U.S. direct enforcement climate and requirements.

Implementation Strategy (Jodi Carson)

- Characterize the U.S. climate toward the use of WIM for direct enforcement.
- Identify issues that must be addressed to gain metrological and judicial acceptance in the United States.
- Identify and review successful European practices on direct weight enforcement using WIM technology.
- Establish legal basis and gain judicial support for citing overweight trucks directly from low-speed WIM initially and later from high-speed WIM.

Deliverable

- Modeled after the French and Dutch process, an outline of the required steps leading to legal acceptance of WIM technology for use in direct weight enforcement in the United States

Behavior-Based Enforcement Activities (the Netherlands and France)

Using the European WIM/VID (photo) approach of simultaneously capturing a digital image of the vehicle when an overweight condition is detected, officials in the Netherlands and France have gained additional knowledge of the trucking firms most frequently operating in an overweight condition. This information is captured continuously (i.e., 24 hours a day, 7 days a week), regardless of whether mobile enforcement activity is taking place. Historical WIM information is reviewed, typically on a monthly basis, to determine trucking firms that most frequently engage in overloading practices. Enforcement officials contact the most frequently offending firms to encourage compliant loading behavior. After this contact, the trucking firm begins a probationary period. If no positive change is observed through continued monitoring by WIM/VID systems, graduated enforcement actions are taken. France is beginning a 3-year study to determine the effectiveness of this process.

The scan team observed that this general process is similar to the safety inspection steps routinely followed by the Federal Motor Carrier Safety Administration (FMCSA) in its oversight of trucking firms operating commercial vehicle fleets. The application of this process to commercial motor vehicle weight enforcement in the United States shows promise for firms that could have reasonably brought their loading practices into legal compliance with relevant laws.

Implementation Strategy (Julie Strawhorn and Mike Onder)

- Obtain specific details on the behavior-based enforcement approach from Dutch and French contacts.
- Obtain estimates of approach effectiveness (i.e., percentage of reduction in the proportion of overweight trucks) from Dutch and French contacts.
- Coordinate with FMCSA officials to gain understanding of their behavior-based approach to commercial vehicle safety enforcement.

Deliverable

- One-page information sheet on behavior-based approach to commercial motor vehicle weight enforcement in the Netherlands and France

Synthesis of Safety Implications of Oversize/ Overweight Commercial Vehicles (Belgium)

In the United States, justification and authority for the conduct of commercial vehicle weight enforcement are vested in the public's interest in preserving highway infrastructure and promoting a climate of equity and fairness among trucking firms (i.e., not allowing violators to be rewarded at the expense of law-abiding firms). These same principles and interests were reported in each of the countries the scan team visited. In addition, several of the countries identified safety as a primary motivator for commercial vehicle size and weight enforcement. In Belgium, officials have linked weight enforcement activities to the public's interest in safe operating conditions on the highways. After years of weight and speed data collection and analysis, Belgian officials noted direct relationships between excessive speed by overweight vehicles involved in highway accidents and the frequency of fatalities occurring in accidents including such vehicles. As a result, they were able to build the case to legislative leaders that weight and speed needed to be aggressively regulated. Governors, or speed-monitoring devices, are installed on trucks to control their maximum speed. Speed violations are treated as criminal offenses, since excessive speeds can be achieved only by tampering with the speed-control devices.

The scan team indicated a desire to better understand the relationship between commercial motor vehicle weight condition and safety in the United States. While public concerns about the impact of overweight vehicles on bridge and pavement conditions and on equitable trade practices are valid, the safety benefits tied to commercial vehicle weight enforcement activities need to be better defined. The scan team proposes an assimilation of existing safety studies and research to improve understanding.

Implementation Strategy (George Conner and Mike Onder)

- Invite university research communities, via the University Transportation Research Consortium (UTRC) initiative, to conduct a synthesis effort on the linkages of overweight commercial motor vehicles and safety.
- Obtain detailed information on the use of safety as a compelling case for commercial motor vehicle weight enforcement from Belgium contacts.

Deliverables

- One-page informational sheet describing the basis for Belgium's regulations
- Synthesis of existing research describing relationships between commercial motor vehicle weight condition and safety in the United States

Effective Use of WIM Data: The Dutch Case Study (the Netherlands)

In the Netherlands, every Wednesday morning at 7 a.m., an e-mail with an attachment detailing the frequency of truck weight violations by location, time of day, and day of the week is distributed to enforcement personnel responsible for scheduling enforcement actions and transportation personnel charged with infrastructure condition monitoring and multimodal freight planning and forecasting. The data report is a product of a rather extensive database management operation constructed by Dutch officials. Extensive quality control and quality assurance protocols have been built into the operations of this data management system.

In the United States, State-level officials operate data management systems to manage highway and bridge programs and to monitor travel for supporting program and policy development. The scan team determined that documentation of the Dutch database management system could assist States in extracting greater value from the database systems they operate.

Implementation Strategy (David Jones and Tom Kearney)

- Obtain detailed information on the architecture and system specifications for the data model used in the Netherlands from Dutch contacts.
- Conduct a comparative scan of data management operations employed in the United States.
- Propose a National Cooperative Highway Research Project synthesis topic related to WIM database management and potential enhancements.

Deliverables

- Case study report on WIM data processing, reporting, and distribution opportunities based on findings from the Netherlands
- Presentation of case study report findings at the next scheduled North American Traffic Monitoring and Equipment Conference

Next Steps

Next steps include defining specific timeframes and funding requirements for implementation. Once defined, funding sources can be identified and secured.

Chapter 1

Introduction

Scan Purpose and Scope

Significant growth in domestic and international commerce, coupled with ever-increasing traffic congestion and delay on surface transportation networks, challenges the ability of industry to move freight economically without the use of larger and heavier loads. This trend also challenges limited enforcement resources tasked with monitoring vehicle size and weight compliance in the interest of infrastructure preservation. The American Association of State Highway and Transportation Officials' (AASHTO) Technology Implementation Group has identified the weigh-in-motion (WIM) concept and its capabilities as a focus technology for enhancing the effectiveness and efficiency of vehicle size and weight enforcement in the United States.

The potential benefits of technology-based vehicle size and weight enforcement extend beyond infrastructure preservation to include (1) improved delivery of enforcement services by enhancing effectiveness and efficiency, (2) improved commercial motor vehicle productivity (i.e., supply chain velocity) by reducing the number of vehicles required to stop for enforcement purposes, (3) fewer emissions by reducing unnecessary deceleration, idling, and acceleration of compliant vehicles, (4) higher commercial and general motor vehicle safety levels by controlling the operation of nonpermitted, noncompliant (i.e., overweight or oversize) vehicles, and (5) better data quantity and quality to support pavement design, traffic engineering, and transportation planning efforts, as well as ongoing performance monitoring and evaluation of vehicle size and weight enforcement programs.

In pursuit of these benefits, the scanning study on commercial motor vehicle size and weight (VSW) enforcement included a review and evaluation of contemporary European procedures and technologies for enforcing commercial motor vehicle size and weight laws and regulations. Specifically, the scanning study considered the following, as applied in Europe:

- Emerging vehicle size and weight enforcement technologies, including but not limited to third-generation weigh-in-motion (WIM) devices that can produce reliable evidence of violations capable of withstanding legal challenge
- Unconventional vehicle size and weight enforcement procedures, including but not limited to alternative performance-based programs
- Novel uses or applications of WIM data to support pavement and bridge design, traffic engineering, or transportation planning efforts (e.g., freight modeling and forecasting) or ongoing performance monitoring and evaluation of vehicle size and weight enforcement programs
- Innovative public-private funding mechanisms for vehicle size and weight enforcement technologies or programs
- Multinational programs to harmonize administrative and operational vehicle size and weight enforcement procedures or programs among member countries

Intrinsic benefits related to infrastructure preservation, enforcement efficiency and effectiveness, commercial motor vehicle productivity, emissions, safety, and data quantity and quality were considered concurrently in this investigation.

Scan Team Members

The scanning study was conducted by a team of experts in commercial motor vehicle size and weight enforcement. The 10-member team included three representatives from the Federal Highway Administration (FHWA), five from State departments of transportation (DOTs), one from law enforcement, and one from academia. Scan team members and affiliations are listed below:

Jeff Honefanger (AASHTO cochair)
Manager, Special Hauling Permits Section
Ohio Department of Transportation

Julie Strawhorn (FHWA cochair)
Office of Freight Management and Operations
Federal Highway Administration

Jodi L. Carson (report facilitator)
Associate Research Engineer
Texas Transportation Institute

Ric Athey
Assistant Director, Motor Vehicle Division
Arizona Department of Transportation

George Conner
Assistant State Maintenance Engineer–Bridges
Alabama Department of Transportation

David Jones
Office of Policy
Federal Highway Administration

Tom Kearney
Statewide Planner, New York Division
Federal Highway Administration

John Nicholas
Program Manager, Commercial Vehicle Division
Washington State Patrol

Pam Thurber
Bridge Management and Inspection Engineer
Vermont Agency of Transportation

Randy Woolley
Division of Research and Innovation
California Department of Transportation

Jeff Honefanger and Julie Strawhorn, acting as AASHTO and FHWA cochairs respectively, led the scan team. In addition to breadth across agency types, the team had expertise in commercial motor vehicle size and weight technologies, procedures, data applications, public-private involvement, and harmonization.

Scanning Study Site Selection

Sites for inclusion in the scanning study were determined using information from four primary sources: (1) reports on prior related scanning studies, (2) published literature, (3) various Internet sites, and (4) U.S. and European experts in the field. Past scan reports and published literature provided a historic chronology of vehicle size and weight enforcement research and development. Internet sites provided information on more recent developments in vehicle size and weight activities, including ongoing projects and points of contact. Countries that exhibited a long history of enforcement technology or program development and led current research and development efforts ranked highest for potential scanning study site visits. These recommendations were confirmed through discussions with U.S. and European experts, many of whom had been directly involved in vehicle size and weight enforcement efforts in Europe. More specific information provided by these sources is described below.

Prior Scanning Studies

A review of scanning study reports (available at *www.international.fhwa.dot.gov)* revealed six prior scan topics related to this investigation (see table 1):

- ***Freight Transportation: The European Market—*** The most recent related report documents the challenges facing Europe as a result of the global marketplace encouraged through the formation of the European Union (EU) and describes the response to these challenges by various sectors of the transportation community (i.e., private sector, public sector, local government, member states, European Union). This report provided useful insight into differences between North America (United States, Canada, and Mexico) and Europe and historic methods to address differences and achieve harmonization in freight movement among disparate countries.[2]
- ***European Traffic-Monitoring Programs and Technologies—***Despite significant technological advancements since the time of publication, this report provided a historical perspective of early traffic-monitoring technology deployment (including WIM) in various European countries.[3]
- ***Advanced Transportation Technology—***Similarly, this report described the use of early traffic-monitoring technology (including WIM) in various European countries.[4]
- ***Highway/Commercial Vehicle Interaction: North America and Europe—***Though more focused on EU member state disparities in truck design and configuration, infrastructure design and condition, and size and weight regulations, this report described resulting challenges to enforcement, infrastructure preservation, safety, and industry productivity.[5]
- ***Commercial Vehicle Safety: Technology and Practice in Europe—***Though less directly related to the current investigation, this report addressed the interrelationship between enforcement (including vehicle size and weight enforcement) and safety and described several model enforcement programs in various European countries.[6]
- ***Emerging Models for Delivering Transportation Programs and Services: A Report of the Transportation Agency Organization and Management Scan Tour—***With a broader focus than commercial motor vehicle size and weight enforcement, this report considered novel public-private partnerships in delivering and maintaining transportation facilities.[7]

Literature Review

To supplement the review of scan tour reports, a review of related published literature was conducted with particular emphasis on recent (since 1997) publications.

Table 1. *Prior related scan tour reports.*

	Austria	Belgium	Denmark	France	Germany	Italy	The Netherlands	Sweden	Switzerland	United Kingdom
Freight Transportation: The European Market (2002)		x			x	x	x		x	
European Traffic-Monitoring Programs and Technologies (1997)				x	x		x		x	x
Advanced Transportation Technology (1994)			x	x	x		x			
Highway/Commercial Vehicle Interaction: North America and Europe (1996)		x		x	x		x	x		x
Commercial Vehicle Safety: Technology and Practice in Europe (2000)				x	x		x	x		
Emerging Models for Delivering Transportation Programs and Services: A Report of the Transportation Agency Organization and Management Scan Tour (1999)								x		x

To accomplish this review, researchers relied largely on the Transportation Research Information Services (TRIS) Online and Transport databases. TRIS Online, the bibliographic database of transportation research information produced by the Transportation Research Board, provides useful links to full-reference texts, but lacks comprehensive references from Europe. Transport is derived from TRIS, but includes references from Europe contributed by the International Transport Research Documentation (ITRD) database. The larger ITRD database has transportation research from 23 countries, including most of Europe, Australia, Latin America, Canada, China, and Japan, and contains abstracts in one of four languages: English, French, German, or Spanish.

Nearly all of the recent findings on commercial motor vehicle size and weight enforcement in Europe were discovered and published under the auspices of two significant pan-European studies coordinated by the Laboratoire Central des Ponts et Chaussees in France: (1) COST 323, Weigh-in-motion of Road Vehicles, conducted from 1993 to 1998 and involving 19 European countries, and (2) WAVE, Weigh-in-motion of Axles and Vehicles for Europe, conducted from 1996 to 1999 and involving 10 European countries.[1,8] The scope and results of these studies are in the "Notable Historic Pan-European Projects" section of this chapter.

These seminal studies also resulted in more than 100 conference proceedings and journal articles in publication venues, including the First, Second, Third, and Fourth International Conferences on Weigh-in-Motion; the National Traffic Data Acquisition Conference; the World Congress on Intelligent Transportation Systems; *Traffic Technology International;* and *International Journal of Heavy Vehicle Systems*. These more narrowly focused publications address WIM system topics related to user perspectives, bridge and pavement applications, field tests, technology developments, enforcement applications, data applications, calibration, standards, and specifications. An abbreviated list of publications is in the "Bibliography" section, with a focus on enforcement and data applications. Key findings from this review are described in this report.

Internet Review

The Internet proved a useful tool in selecting scanning study sites, supporting the review of prior scan reports and published literature and the identification of U.S. and international experts. In addition, numerous Web sites provided a broad range of information on Europe and the European Union, government and academic organizations, transportation-related statistics, private industry product vendors, and technical conferences and activities.

One Web site, the "European Weigh-in-motion pages" *(wim.zag.si),* was particularly useful. This site was developed to support information exchange among participating countries during the COST 323 Project and the subsequent WAVE Project. The site provides general

WIM technology information, detailed descriptions for the COST 323 and WAVE Projects (including links to completed deliverables and points of contact), the European WIM specification, a multilingual glossary of WIM terms, historic and forthcoming WIM events, an e-mail network *(wimusers.free.fr)* of more than 300 WIM users or experts from 50 countries, a list of WIM vendors, and a library of WIM-related documents. A drawback of the site is that it lacks substantive information following completion of the COST 323 and WAVE Projects (from 1999 to the present).

More recent online information on WIM-based commercial motor vehicle size and weight enforcement in Europe was obtained through a review of recent International Conference on Weigh-in-Motion (ICWIM) programs *(www.ctre.iastate.edu/ icwim/index.htm* and *wimusers.free.fr/icwim4/index.htm).* The 2008 conference, jointly organized with the Tenth International Symposium on Heavy Vehicle Weights and Dimensions, will be in Paris, France *(hvparis2008.free.fr).* Other information came from a review of various WIM vendor Web sites, including Golden River Traffic–Europe™, IRD™, Central Weighing™, ECM™, Kistler™, and Cestel, d.o.o. Cestel provided the most information on its Web site *(www.siwim.com/index.htm)* about recent WIM implementations, predominantly in Slovenia but also in Sweden.

This information, combined with advice from U.S. and European experts, helped the team finalize the recommendations for scanning study site visits.

U.S. and European Expert Advice

U.S. and European experts in commercial motor vehicle size and weight enforcement in Europe were identified based on (1) the reporter's knowledge, (2) recommendations from other noted experts in the field, and (3) recent publication records and participation in COST 323 or WAVE activities, related e-mail networks, related conference-organizing committees (e.g., ICWIM). Table 2 provides a list of individuals contacted, via e-mail, to support identification and selection of scanning study sites. Highlighted individuals provided feedback. This list is not comprehensive; knowledgeable individuals identified later in the scanning study are not listed here.

Site Selection

Table 3 assimilates the information gathered from related scanning study reports, published literature, Internet sites, and U.S. and European experts. Factors viewed favorably in the decision on which sites to visit in the scanning study included (1) active participation in pan-European research efforts, (2) recent related research and advancements in the topic area, (3) direct attention to one or more

Table 2. *U.S. and international experts.*

COUNTRY	CONTACT	EMPLOYER	EMAIL
Austria	Blab, Ronald	TU-Wien, Technische Universitat Wien	*rblab@istu.tuwien.ac.at*
Belgium	Jehaes, Sophie	BRRC, Belgian Road Research Centre	*crr@skypro.be*
Czech Republic	Doupal, Emil	Transport Research Centre	*doupal@cdv.cz*
France	Jacob, Bernard	LCPC, Laboratoire Central des Ponts et Chaussees	*jacob@lcpc.fr*
	Dolcemascolo, Victor	LCPC, Laboratoire Central des Ponts et Chaussees	*victor.dolcemascolo@lcpc.fr*
Germany	Meschede, Ralph	BASt, Bundesanstalt für Straßenwesen	*meschede@bast.de*
Ireland	O'Brien, Eugene	UCD, Department of Civil Engineering, University of Dublin	*eugene.obrien@ucd.ie*
Slovenia	Znidaric, Ales	Slovenian National Building and Civil Engineering Institute	*ales.znidaric@zag.si*
Spain	Leal, Jesús	CEDEX, Centro de Estudios y Experimentación de Obras Públicas	*jleal@cedex.es*
Switzerland	Caprez, Markus	ETH, Swiss Federal Institute of Technology	*caprez@igt.baug.ethz.ch*
Switzerland	Poulikakos, Lily	Empa, Swiss Federal Laboratories for Materials Testing and Research	*lily.poulikakos@empa.ch*
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Table 3. *Summary of site recommendation factors.*

	Austria	Belgium	Czech Republic	Denmark	France	Germany	Ireland	The Netherlands	Slovenia	Sweden	Switzerland	United Kingdom
Pan-European projects												
COST 323	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗	✗
WAVE		✗			✗	✗	✗	✗	✗	✗	✗	✗
TOP TRIAL						✗		✗			✗	
REMOVE					✗	✗		✗				✗
Recent research												
MS-WIM					✗	✗		✗				
Bridge WIM					✗		✗		✗	✗		
Automated enforcement					✗			✗				
VSW scanning study topics of interest												
Enforcement technologies		✗		✗	✗	✗		✗	✗	✗	✗	✗
Enforcement procedures		✗	✗		✗			✗	✗		✗	
Data applications					✗				✗		✗	
Public-private funding	✗							✗				
Harmonization											✗	
WIM deployment (limited or extensive)	L	L	L	L	E	E	L	L	E	L	L	E
Expert recommendation					✗			✗	✗			
Prior scanning studies												
Freight Transportation (2002)		✗				✗		✗			✗	
Traffic Monitoring (1997)					✗	✗		✗			✗	✗
Transportation Technology (1994)				✗	✗	✗		✗				
Highway/Vehicle Interaction (1996)		✗			✗	✗		✗		✗		
Commercial Vehicle Safety (2000)					✗	✗		✗		✗		
Emerging Models for Delivering Transportation Programs and Services (1999)										✗		✗

of the five topics of interest identified for the scanning study, (4) sufficient WIM deployments to support observation and experience, and (5) expert recommendation. Participation in prior scanning studies was viewed less favorably.

Based on these decision factors, the following sites, in order of preference, were recommended as part of the scanning tour:

- **The Netherlands—**Work conducted in the Netherlands is purported to be the most advanced in supporting automated VSW enforcement. The Netherlands shows a strong history of development using high-speed weigh-in-motion (HS-WIM) and video, as well as multiple-sensor WIM.
- **France—**The French have a strong history of WIM system research (Laboratoire Central des Ponts et Chaussees (LCPC) in France coordinated the COST 323 and the WAVE European projects) and implemented the largest European WIM network (Système Informatisé de REcueil de DOnnées (SIREDO), including 150 WIM systems on national roads and about 50 WIM systems

on concessionary motorways). In addition, the French are establishing an automatic overloading control test site to move toward automated VSW enforcement and have had a strong history in multiple-sensor WIM (MS-WIM) research and development since 1993.

- **Slovenia—**Slovenia has an extensive network of portable bridge WIM systems that have achieved impressive accuracy results. This system may have applications in rural or remote areas of the United States. In addition, Slovenia is using WIM data to support other applications (e.g., planning, maintenance). Slovenia has not been a participant in any prior related scanning study.
- **Switzerland—**Switzerland is using WIM to prescreen overloaded commercial vehicles at border tunnels. Also, as a non-EU country, Switzerland may provide an interesting perspective on efforts to harmonize administrative and operational activities related to VSW enforcement.
- **Germany—**Germany was the site of the TOP TRIAL Project and has been involved in developing WIM standards for automated VSW enforcement, though not as actively as the Netherlands or France.

In addition to these five sites, it was recommended that the scan team meet with members of the European Union Transport and Tourism Committee in Brussels, Belgium, to gain additional perspective on efforts to harmonize VSW enforcement activities among different countries.

Scanning Study Site Visits

Slovenia

Slovenia, bordered by Austria, Croatia, Italy, Hungary, and the Adriatic Sea, is 20,273 square kilometers in size (slightly smaller than New Jersey) with just over 2 million in population. The capital of Slovenia, Ljubljana, is geographically centered. Slovenia joined the European

Figure 1. *Slovenia: proximity and road network.*

Union in 2004 and is generally governed by a prime minister and other ministers responsible for oversight of finance, the interior (home affairs), foreign affairs, justice, defense, labor, family and social affairs, the economy, agriculture, forestry and food, culture, environment and spatial planning, transport, education and sport, higher education, science and technology, health, and public administration. For this investigation, commercial vehicle size and weight enforcement is affected primarily by actions and activities of the Ministry of Transport and the Ministry of the Interior.

Despite its small size, Slovenia controls some of Europe's major transportation routes (see figure 1). The European Transport Corridor V provides access from the Slovenian Port of Koper northward. The European Transport Corridor X provides east-west travel through the country. Slovenia's national road network compromises 6,349 kilometers (km), of which 5,892 km are managed by the Directorate of the Republic of Slovenia for Roads (Direkcija Republike Slovenije za Ceste) under the Ministry of Transport and 457 km are managed by the Motorway Company in the Republic of Slovenia (Družba za avtoceste v Republiki Sloveniji, DARS). These roadways are more specifically classified according to function as motorways, expressways, main roads (category I or II), regional roads (category I, II, or III), regional tourist roads, and interchanges. An additional 32,172 km of municipal roads (local roads and public paths) are the responsibility of the municipalities. Most directly related to this investigation, the Directorate for Roads is responsible for overseeing the issuing of licenses to perform road transport and allocation of permits for international road transport of goods, ensuring adequate training and qualifications for transport companies and drivers, and developing relations with other countries in the area of road transport (the country has 42 bilateral agreements on road transport).

The Ministry of the Interior provides public safety and security, which is attained through preventive rather than repressive actions of the law enforcement agencies. The ministry is also responsible for the coordination of European affairs and international cooperation in the field of security. The police, an autonomous body within the Ministry of the Interior, perform tasks at three levels: state, regional, and local. Under the Uniformed Police Directorate, the Traffic Enforcement Section is responsible for controlling and regulating traffic (including commercial motor vehicles) on public roads and noncategorized roads used for public traffic, protecting the state border, and performing border control, among other duties.

Supporting the efforts of the Ministry of Transport and the Interior, Slovenia's National Building and Civil Engineering Institute (Zavod za gradbenistvo Slovenije, ZAG) conducts related research and development activities, operating as a government-owned, nonprofit public research institute. Formerly the Institute for Testing and Research in Materials and Structures, ZAG focuses on the following activities:

- Certification and attestation of conformity of products, materials, and executed works
- Fundamental and applied research in the fields of materials and structures
- Precompetitive development of new materials
- Development of new methods of testing
- Tests, measurements, and monitoring of structures
- Tests, measurements, and monitoring of the external and internal building environment
- Research, measurements, and monitoring in the field of efficient use of energy and renewables
- Engineering tests and analyses
- Revisions of building, civil engineering, and technological designs and designs for transport devices
- Calibration and verification of measures, standards, and reference materials
- Control, calibration, and attestation of conformity of measuring devices, apparatus, testing machines, and individual elements of industrial systems
- Training of research and technical staff in particular technical fields
- Participation in the preparation of technical codes and standards

Related to this investigation, ZAG (in partnership with Cestel, a private manufacturing company) has developed a bridge WIM system, SiWIM™, which is showing high accuracy in recent European installations. The SiWIM system also touts a wide range of applications, including (1) capture of traffic- loading data to support planning, maintenance, or special studies, (2) weight data to support preselection or automated enforcement, and (3) weight and volume data to support structural bridge analysis.

As part of this scanning study, the scan team visited the SiWIM production facilities at Cestel and a SiWIM installation at Postojna, southwest of Ljubljana. In addition, the scan team heard presentations by representatives from ZAG, the Ministry of Transport, the Directorate for Roads of the Road Maintenance Sector, and the Ministry of the Interior's Traffic Police Section.

Switzerland

Switzerland, bordered by Austria, France, Italy, Lichtenstein, and Germany, is 41,290 square kilometers in size (slightly less than twice the size of New Jersey) with more than 7.5 million in population. Bern is the capital of Switzerland. While not an EU member, Switzerland does participate as a member of the European Free Trade Association (EFTA) and has recently brought its economic practices largely into conformity with the European Union's to enhance its international competitiveness.

Switzerland has 71,220 km of roadways, including 1,706 km of national roads and 2,300 km trunk roads (see figure 2). The roadways are classified as national roads, main roads, and municipal/local roads. The mountainous topography in Switzerland required the construction of 2,976 bridges and 244 tunnels totaling 338 km in length. The main north-south and east-west routes carry up to 75,000 vehicles per day. The Swiss philosophy is aimed at coordinating an optimum use of capacity for different modes of transport, seeking an appropriate balance between truck and rail transport of freight. For trucks, weight limitations, nighttime travel restrictions, and strict requirements on drivers' rest periods result in reduced heavy vehicle traffic passing through Switzerland.

The Swiss Federal Roads Authority (FEDRO), under the Department of Transportation, Communication, and Energy (one of seven federal departments), is responsible for the Swiss national roadway system, although the actual owners and operators of the network are the 26 cantons (equivalent to U.S. States) in which the roads are located.[4] Under FEDRO and related to this investigation, the Road Traffic Management Information System (MISTRA), in cooperation with the cantons, operates an eight-station network of WIM systems on the Swiss national roads. MISTRA is responsible for central data acquisition and processing and operational maintenance,

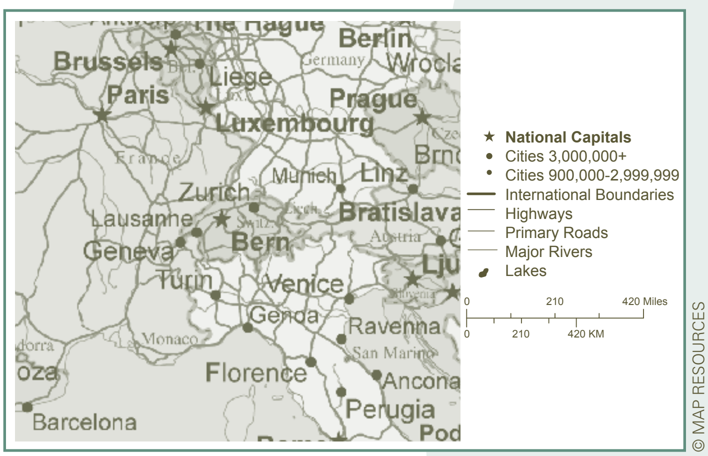

Figure 2. *Switzerland: proximity and road network.*

while the respective cantons are responsible for construction maintenance.

Traffic enforcement, including commercial motor vehicle size and weight enforcement, is the responsibility of the 26 cantons, each of which has its own police department. Canton police are responsible for enforcing federal law as well as additional laws at the canton level. Canton laws cannot be more restrictive than federal laws. Funding for commercial motor vehicle size and weight enforcement is provided through general taxes directed to the cantons. Local communes also provide limited police resources. At all levels, resource constraints result in increased breadth and scope of officer duties (e.g., a single officer may be responsible for traffic safety, criminal investigations, etc.).

Supporting the efforts of FEDRO and the cantonal police, Empa conducts related research and development activities. Empa is one of four independent federal research institutions under the ETH domain (which also includes two Federal Institutes of Technology, ETH Zurich and EPF Lausanne). Empa is organized into five research and engineering departments, supported by 27 laboratories, and cross-linked within five strategic research programs to foster interdisciplinary and transdisciplinary approaches. Empa focuses primarily on applied research, interfacing science and its real-life applications.

As part of the scanning study, the team visited two field sites: (1) a demonstration site in Schafisheim (northeast of Bern) for the Eureka Logchain Footprint Project, which aims to deliver the scientific basis for a heavy goods vehicle surcharge similar to that already in force in Switzerland and (2) an overloading enforcement center near Winterthur. In addition, the team heard presentations by representatives from FEDRO and Empa.

Germany

Germany is Europe's largest economy and most populous nation, with more than 82 million people. It is 357,021 square kilometers in size (slightly smaller than Montana) and is bordered by Austria, Belgium, Czech Republic, Denmark, France, Luxemburg, the Netherlands, Poland, and Switzerland. Germany is divided into 13 läender (similar to U.S. States) and three free läender. Berlin is the capital of Germany, which is an EU member.

The country is generally governed by a chancellor and various federal ministers responsible for oversight of labor and social affairs; foreign affairs; interior; justice; finance; economics and technology; food, agriculture, and consumer protection; defense; family affairs, senior citizens, women, and youth; health; transportation, building, and urban affairs; environment, nature conservation, and nuclear safety; education and research; and economic cooperation and development.

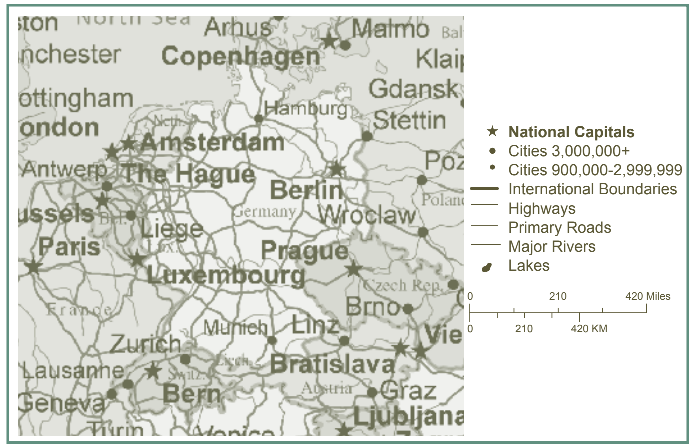

Figure 3. *Germany: proximity and road network.*

Germany has 231,581 km of roadways, including 12,037 km of expressways (see figure 3). The roadway system is more specifically categorized as federal autobahns, nonurban federal highways, läender (state) highways, district roads, and local jurisdiction (municipal) roads.

Germany's Federal Ministry of Transport, Building, and Urban Affairs is responsible for the autobahn and national road networks, including financing, design and planning, and provision of legal and technical supervision of their construction and operation. The actual construction, operation, and administration of these roads are performed by the Bundeslande on behalf of and with funding from the national government.[4] Commercial motor vehicle size and weight enforcement is provided by traditional police forces, while the German Federal Office for Transport of Goods (BAG), under the Federal Ministry of Transport, Building, and Urban Affairs, provides enforcement for the Toll Collect system.

Technical support, analysis, and research are provided by the Federal Highway Research Institute (Bundesanstalt fur Strassenwesen, BASt) under the Federal Ministry of Transport, Building, and Urban Affairs. A focal point of BASt's work results from the role it plays in formulating specifications and standards applying to all highway-related fields. These tasks are undertaken in close collaboration with the Road and Transportation Research Association (Forschungsgesellschaft für Straßen- und Verkehrswesen), the German Institute for Standardisation (Deutsches Institut für Normung, DIN), the German

Institute for Construction Technology (Deutsches Institut für Bautechnik), the German Road Safety Council, (Deutscher Verkehrssicherheitsrat), competent läender highway authorities, universities, associations, and the highway industry.

As part of a public-private partnership (PPP) program, Germany's Federal Ministry of Transport, Building, and Urban Affairs recently partnered with Toll Collect to initiate a distance-based tolling system for heavy vehicles. Toll Collect is a consortium formed by Daimler-Chrysler, Deutsche Telecom, and Cofiroute. As part of this scanning study, the team visited a gantry and downstream enforcement site that support the distance-based toll program. In addition, the team heard presentations by representatives from Toll Collect, the Federal Ministry of Transport, Building, and Urban Affairs, and BASt.

The Netherlands

The Netherlands, bordered by Belgium, Germany, and the North Sea, is 41,526 square kilometers in size (slightly less than twice the size of New Jersey) with about 16.5 million in population. Amsterdam is the capital of the Netherlands, which is an EU member. The Port of Rotterdam is one of the busiest in the world. As such, the Netherlands experiences significant freight movement to and through the country.

The road system, comprising 104,850 km of paved roads, is divided into three organizational levels: national, provincial, and municipal (see figure 4). The national road network is constructed, operated, and maintained by the Ministry of Transport through eight regional administrations. All road miles in the national system are freeways, with funding provided by the national government. Provincial and municipal roads are the responsibility of local governments. The national government does not allocate funds to local government for construction, repair, or maintenance of roads.[4]

Commercial motor vehicle size and weight enforcement is primarily the responsibility of the Netherlands National Police Agency (Korps Landelijke Politiediensten, KLPD) and the Inspectorate of Transport, Public Works, and Water Management (Inspectie Verkeer en Waterstaat, IVW) in the Transport Division of the Ministry of Transport, Public Works, and Water Management (Ministerie van Verkeer en Waterstaat). The Transport Inspectorate oversees the transport of persons and goods on the road and supervises the transport of dangerous goods in aviation, shipping, and inland shipping and over roads and railways. Supervision involves vehicles, cargos, drivers, and businesses.

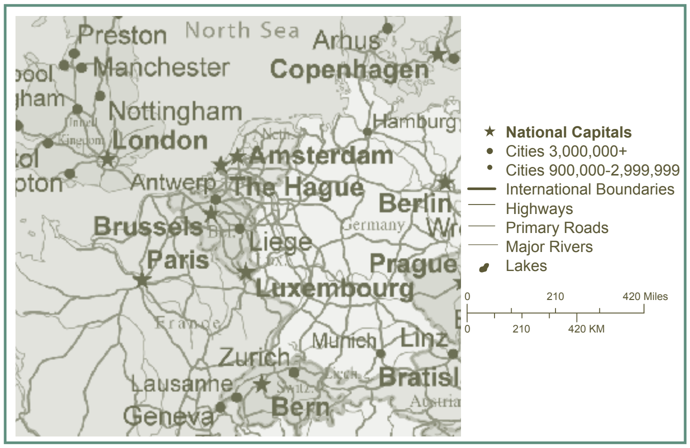

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Figure 4. *The Netherlands: proximity and road network.*

Technical assistance is provided by the Ministry of Transport, Public Works, and Water Management's Road and Hydraulic Engineering Institute (DWW) and Transport Research Center (AVV). Duties of the DWW and AVV include providing policy recommendations, acting as knowledge transfer points, and providing information and basic data on traffic and transport to the ministry.[4]

As part of the scanning study, the team visited an overloading enforcement center near Delft and observed a specially designed calibration vehicle capable of relating dynamic load measurements to true dynamic (rather than static) loads. In addition, the team heard presentations by representatives from the Dutch Ministry of Transport, Public Works, and Water Management; Road and Hydraulic Engineering Institute; and the Dutch National Police Agency's Traffic Police Department.

Belgium

Belgium, bordered by France, Germany, Luxembourg, the Netherlands, and the North Sea, is 30,528 square kilometers in size (about the size of Maryland) with nearly 10.5 million in population. Brussels is the capital of Belgium, which is an EU member.

The road system in Belgium comprises 150,567 km of paved roadways, including 1,747 km of expressways/motorways, 12,531 km of regional roads, 1,349 km of provincial roads, and 134,940 km of municipal roads (see figure 5, next page). Seven international expressways connect the country to the French, German, and Dutch motorways. Because of this connectivity, Belgium experiences high volumes of transit traffic passing through the country.

Belgium is administratively divided into three regions (Flanders, Wallonia, and Brussels), 10 provinces, and 589

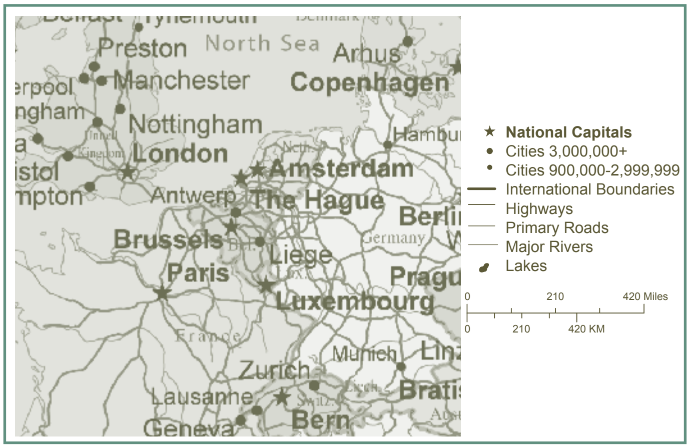

Figure 5. *Belgium: proximity and road network.*

communes. The decisionmaking power in Belgium is distributed between the federal and regional governments. In general, the design, construction, management, and maintenance of the road network, including national roads and motorways, are the responsibility of the regions. The federal government harmonizes these activities with the Highway Code, vehicle regulations, traffic safety, etc. Decisions affecting local road networks are made by local authorities.

Commercial motor vehicle size and weight enforcement is the primary responsibility of the Belgian Federal Police Services and the regional road administrations. In 2001, the three principal police forces in Belgium—the municipal police, the state police (Gendarmerie), and the judicial police (assigned to the offices of the public prosecutors)—gave way to an integrated police service structured on two levels (a federal level and a local level). A general commissioner heads the organization. His role is to coordinate the work of five general police directorates: administrative, judicial, operational support, logistics, and human resources. Moreover, the general commissioner has a number of departments reporting directly to him that are responsible for communication with the local police, international cooperation, integrated police operations, and the coordination of external communication. The Federal Police is basically charged with executing particular missions (including those overlapping more than one locality) of administrative and judicial police, as well as providing specialized support to the local police and the Federal Police itself. The Federal Police limits vehicle size and weight enforcement activities to the national roads and motorways.

Highway inspectors, employed by the regional road administrations and jointly responsible for commercial motor vehicle size and weight enforcement, possess the same judiciary powers as the Federal Police.

The efforts of the Belgian Federal Police Services and the regional road administrations are supported by the Belgian Road Research Center (BRRC), a public utility research institute aimed at promoting research in industry. BRRC provides impartial and progressive research on road design, construction, and maintenance and has extended its expertise to road safety, mobility, and environment-friendly road construction. Recently, technical committees have been formed to enhance dialogue with various transportation industry stakeholders. Historically, the focus of such committees has been on construction. Recent committees, however, will focus on a broader set of topics, including traveler mobility, traffic safety, environmental issues and recycling, concrete and asphalt roads, and road asset management.

As part of the scanning study, the team heard presentations by representatives from the Federal Police Services, the Flemish (Flanders Region) Road Administration, and BRRC. In addition, the team met with representatives from the European Union and the Forum of European National Highway Research Laboratories (FEHRL).

France

France, bordered by Andorra, Belgium, Germany, Italy, Luxembourg, Monaco, Spain, Switzerland, the Atlantic Ocean, and the Mediterranean Sea, is 547,030 square kilometers in size (slightly less than twice the size of Colorado) with nearly 61 million in population. Paris is the capital of France, which is an EU member.

France has four levels of government: the national government, 22 regions, 100 departments (equivalent to U.S. counties), and 36,400 communities. These levels are generally grouped as federal and local (encompassing all three lower levels of government) when considering responsibilities. In addition, there are eight tollway authorities.

The road system in France comprises 891,290 km of paved roadways (see figure 6). French roadways fall under the jurisdiction of the Ministry of Transport, which has seven administrations. The Surface Transportation Administration is the agency primarily concerned with freight movement, including driver hours of service, establishing and enforcing weight laws, and ensuring fair competition in freight transportation. Despite the Surface Transportation Administration's interest in freight movement, a different administration, the Traffic and

Safety Administration, is primarily responsible for heavy vehicle data collection.

These administrations are aided by several government-supported technical institutes and laboratories. The Central Laboratory for Bridges and Roads (Laboratoire Central des Ponts et Chaussees, LCPC) has been most involved with commercial vehicle size and weight enforcement-related research. The Infrastructure Technical Research Institute East Laboratory (Centre d'Etudes Techniques de l'Equipement de l'Est, CETE Est) has also become involved. In addition to research, these organizations conduct a significant amount of data collection, analysis, and reporting for the national government.[4] Efforts are also supported by seven governmental regional information centers that support not only the Ministry of Transportation, but also the Ministry of Police and the Ministry of Defense.

As part of this scanning study, the team visited overloading enforcement centers along motorway A31 near Fays, Lesmenil, and Autreville. In addition, the team heard presentations by representatives from the CETE East Laboratory in Metz and the LCPC in Paris.

Notable Historic Pan-European Projects

Like the United States, Europe has seen a rapid increase in commercial motor vehicle traffic on its roads in recent decades. Europe is similarly challenged in its efforts to efficiently enforce the size and weight of commercial motor vehicles. Related technology development has been ongoing for the past 20 years, with France and the United Kingdom leading early European research on and deployment of WIM systems.[3] Limited advances in WIM system accuracy, cost efficiency, and durability resulted in restricted deployment outside of France and the United Kingdom; only six or seven European countries were using WIM systems by the late 1980s. By the late 1990s, more than 20 European countries were using WIM systems. This evolution is largely attributable to two pan-European projects:

- COST 323, Weigh-in-Motion of Road Vehicles, conducted from 1993 to 1998 and involving 19 European countries
- WAVE, Weigh-in-Motion of Axles and Vehicles for Europe, conducted from 1996 to 1999 and involving 10 European countries

More recent pan-European projects, including the TOP TRIAL and REMOVE Projects, furthered these seminal efforts.

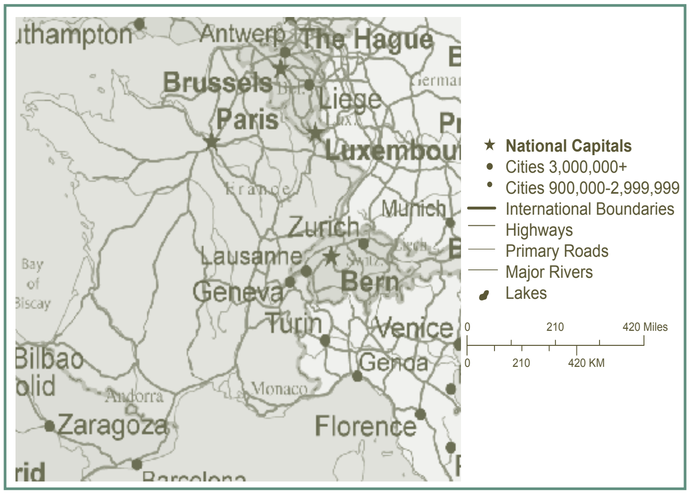

Figure 6. *France: proximity and road network.*

COST 323

In 1992, the Forum of National Highway Research Laboratories (FEHRL) proposed a program of strategic research—COST 323, Weigh-in-Motion of Road Vehicles—to the Directorate General of Transport of the European Commission (DGVII). The action was coordinated by the French LCPC *(cordis.europa.eu/cost-transport/src/cost-323.htm)*. The main objectives of this program were the following:

- Produce an inventory of WIM needs and requirements in Europe.
- Collect information on and evaluate WIM systems and sensors.
- Develop a European technical specification for WIM and a companion glossary of terms.
- Agree on the mechanisms and protocols for a pan-European database of WIM sites and data.
- Produce state-of-the-art reports and recommendations on the application of WIM to traffic management, bridge and pavement engineering, and enforcement.
- Collect and disseminate technical information, including exchange with the Organisation for Economic Co-operation and Development's (OECD) Dynamic Interaction between Vehicles and Infrastructures Experiment (DIVINE) Project from 1993 until 1996.[9]

Nineteen countries participated in the COST 323 Project, including Austria, Belgium, Czech Republic, Denmark, Germany, Finland, France, Hungary, Iceland, Ireland, Italy, the Netherlands, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, and the United Kingdom, and the output of the action is reported in a comprehensive 538-page book.[1]

In direct response to the predefined project objectives, key products of the COST 323 Project included the following:

- A database of European WIM sites
- A glossary of WIM terms in 10 languages
- European WIM specifications
- Results from field test trials, including portable and multiple-sensor WIM systems trials in Trappes, France, in 1996; WIM system application on an urban road in Zurich, Switzerland, from 1993 to 1995; the Continental Motorway Test (CMT) conducted on a busy motorway in eastern France from 1997 to 1998; and the Cold Environment Test (CET) conducted in northern Sweden under cold, adverse conditions from 1997 to 1998
- The conduct of and documented proceedings from the First and Second International Conferences on WIM (ICWIM) in Zurich, Switzerland, in 1995 and Lisbon, Portugal, in 1998[10,11]

The European WIM specification provides comprehensive guidance on the following:

- Site selection
- Onsite system checks and calibration
- System approval procedures
- Accuracy class tolerances (see table 4) and appropriate applications (see table 5)
- Accuracy verification procedures
- Data storage, processing, and transmission requirements
- Vehicle classification schemes

WAVE

Concurrently with the COST 323 Project, the more comprehensive WAVE (Weighing-in-Motion of Axles and Vehicles for Europe) Project began in 1996, also coordinated by the LCPC, with the following objectives:

- Improve the accuracy of WIM systems.
- Improve WIM system durability, particularly in harsh climates.
- Develop new WIM technologies, including multiple-sensor, instrumented bridge and fiber-optic WIM.
- Develop quality assurance methods for WIM databases.[8]

The WAVE Project concluded with an international workshop in May 1999 in Paris, France.[12]

At the close of the COST 323 and WAVE Projects, WIM system use for commercial motor vehicle size and weight enforcement had high importance but required additional research to improve the WIM system accuracy up to Class A(5) in the European specification. Additional work was also required to solve some legal aspects of enforcement (e.g., to allow nonstatic weighing for this purpose) *(wim.zag.si).*

TOP TRIAL

Beginning in 2000, the 2-year TOP TRIAL Project was initiated under the Fifth Framework Program of the European Union. TOP TRIAL involved four participating countries (Germany, the Netherlands, Portugal, and Switzerland) and was intended to (1) improve the accuracy of weight measurement of truck loads to cover future regulation aspects and (2) recommend future European standards as a basis for enforcement. A test site was established along the motorway A9 near Bavaria using staggered multiple-sensor WIM systems *(www.cordis.lu/data/MSS_PROJ_PT_FP5_NEW/ACTIONeqDndSESSION eq25096200595ndDOCeq6ndTBLeqEN_PROJ.htm).*

Table 4. *Allowable tolerances by accuracy class.*

CRITERIA (Type of measurement)	DOMAIN OF USE	ACCURACY OF CLASS: Confidence interval width δ(%)						
		A(5)	B+(7)	B(10)	C(15)	D+(20)	D(25)	E
Gross weight	>3.5 tonnes	5	7	10	15	20	25	>25
Axle load	>1 tonnes							
Group of axles		7	10	13	18	23	28	>28
Single axle		8	11	15	20	25	30	>30
Axle of a group		10	14	20	25	30	35	>35
Speed	>30 km/h[1]	2	3	4	6	8	10	>10
Interaxle distance		2	3	4	6	8	10	>10
Total flow		1	1	1	3	4	5	>5

[1] This condition applies only for sensors/systems that do not work statically or at very low speed.

SOURCE: Weigh-in-Motion of Road Vehicles—Final Report of the COST 323 Action

Key recommendations from the TOP TRIAL Project related to the following:

- WIM sensor array layout (a minimum of six sensors per lane was recommended to achieve desired accuracy levels; system reliability is still challenging)
- Methods for achieving acceptance of WIM systems within the enforcement of overloading in Europe
- Test procedures for approval of WIM systems for automatic enforcement of overloading

The project concluded with two international workshops in March 2002 in Delft, Netherlands, and in September 2002 in Munich, Germany.

REMOVE

Most recently (initiated in 2004 and completed in 2006), the REMOVE (Requirements for Enforcement of Overloaded Vehicles in Europe) Project, led by a consortium of enforcement agencies, transportation agencies, technical experts from the research community, and transport industry from 15 countries, departed from previous studies by focusing on technology application rather than technology performance. The objective of the REMOVE Project was to provide a legal framework in which both new and existing WIM systems and technologies can operate at strategic and tactical levels across the European community, with the intention of reducing the danger and damage caused by overloaded vehicles.[13]

The project recognized an evolution in the use of technology in commercial motor vehicle size and weight enforcement, beginning with manual selection and the use of size and weight data for planning and statistical purposes only to preselection and problem solving to direct enforcement and intelligence (see figures 7 and 8 on next page). Researchers characterized the current situation as controlling less than 5 percent of the trucks, incidental use of WIM technology, and a focus on enforcement. Near full evolution, the target situation is characterized as controlling 95 percent of the trucks, intelligent enforcement mix, and a focus on both prevention and enforcement. This evolutionary process will be challenged by various legal, technical, operational, and cost-benefit issues. A 12-year timeline is estimated for overcoming these challenges and achieving full implementation of direct enforcement.[13]

Table 5. *Accuracy class requirements by application.*

Accuracy Class	Application
A(5)	Legal purposes such as enforcement of legal weight limits and other particular needs; and to provide reference weight values for in-service checks, if the classes B(10), C(15), D+(20), or D(25) are required for all of the traffic flow vehicles (assuming that it is not possible to weigh in static such a large population)
B+(7)	Enforcement of legal weight limits in particular cases, if the class A requirements may not be satisfied and with a special agreement of the legal authorities; efficient preselection of overloaded axles or vehicles; and to provide reference values for in-service checks, if the classes C(15), D+(20) or D(25) are required for all the traffic flow vehicles (assuming that it is not possible to weigh in static such a large population)
B(10)	Accurate knowledge of weights by axles or axle groups and gross weights for infrastructure (pavement and bridge) design, maintenance, or evaluation, such as aggressiveness evaluation, fatigue damage and lifetime calculations; preselection of overloaded axles of vehicles; and vehicle identification based on the loads
C(15) or D+(20)	Detailed statistical studies, determination of load histograms with class width of one or two tonnes, and accurate classification of vehicles based on the loads; infrastructure studies and fatigue assessments
D(25)	Weight indications required for statistical purposes, economical and technical studies, and standard classification of vehicles according to wide weight classes (e.g., by 5 tonnes)
E	Indications about traffic composition and the load distribution and frequency.

SOURCE: Weigh-in-Motion of Road Vehicles—Final Report of the Cost 323 Action

Specific challenges and observations noted through this investigation are as follows:

- Disparity exists on how overloaded vehicles are dealt with across the European Union.
- A vast array of weighing devices is used across the European Union.
- Little regard is taken of the expanding European Union in terms of road transport.
- WIM devices can be shown to be effective enforcement devices, but this depends on the location of the station.
- The level of damage to the road infrastructure and bridges by overloaded vehicles is significant.
- Significant benefits could be achieved in road safety with the introduction of effective strategies to reduce overloaded vehicles.
- Overloaded vehicles would appear to gain a significant fiscal advantage when compared with operators who operate ethically.
- A disparity exists in how each member state regards the issue of overloaded vehicles.
- The lack of effective cross-border enforcement is a significant issue.
- A wide variety of tolerances and sanctions is applied to overweight vehicles.
- A common and legally accepted method of vehicle identification needs to be established across the member states.
- The use-case stepwise approach and the resulting user requirements have drawn together a true

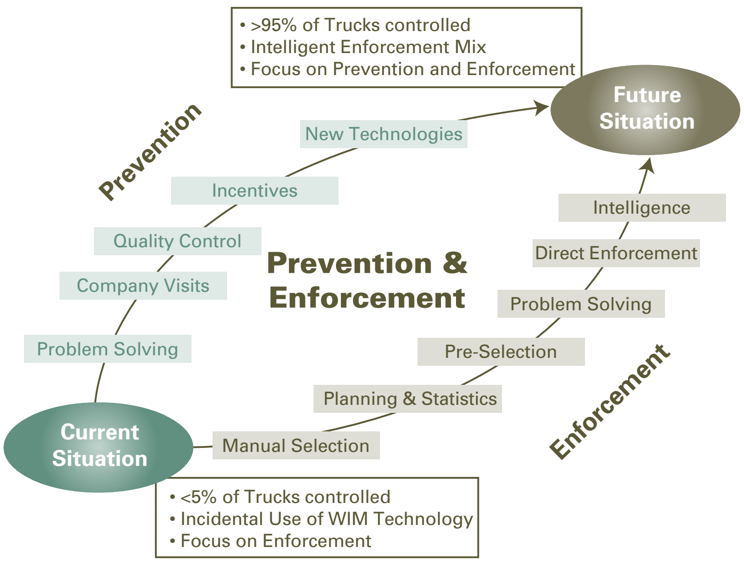

Figure 7. *Dual enforcement/prevention approach.*

representation of the requirements of the enforcement community. This provides a framework in which both new and existing weigh technology can be operated at a tactical and strategic level across Europe.

- The inventory of the current situation has shown a wide variance in fiscal penalties that could be imposed. In reality, however, the actual fines imposed in practice are very similar.
- Member states do not regard overloaded vehicles as a high priority.
- The issue of liability is a complex issue and not satisfactorily addressed by existing rules.

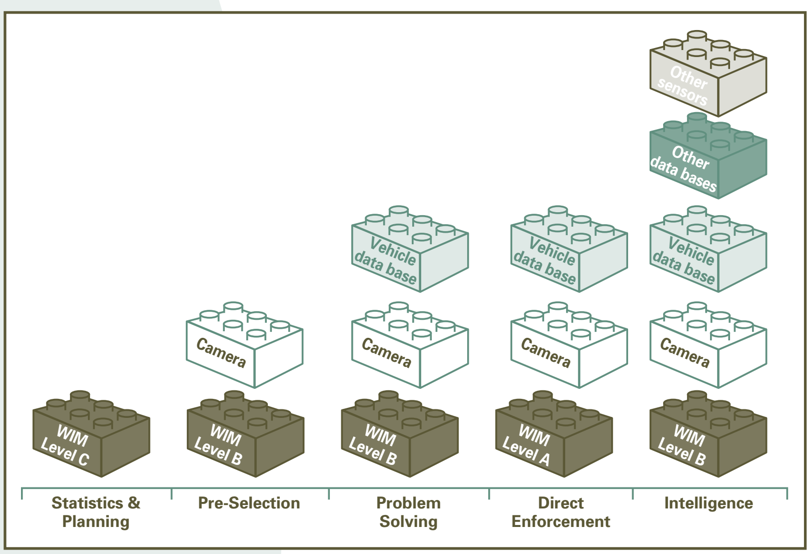

Figure 8. *Lego approach to enhancing enforcement efficiency through technology.*

- The road transport industry is generally in favor of a preventive, problem-solving approach as a means to achieve compliance.
- Existing methods of enforcement may involve additional cost to legitimate haulers where they are unnecessarily screened by conventional weighing devices.[13]

In response to these challenges and observations, a number of recommendations have been tasked to the European Commission:

- Determine the impact of heavy goods vehicles on the European road network.
- Identify and quantify the potential benefits from the increased safe usage of heavy goods vehicles achieved through compliance with legislation.
- Produce a full version of the Virtual Annex (i.e., cost-shared or task-shared project requiring support from at least two countries) for high-speed axle weighing to ensure a common approach across the European Union.
- Identify and promote good practice in the field of prevention and detection of overloaded vehicles.
- Develop detection and monitoring devices for heavy goods vehicles to prevent overloading and encourage operators to invest in such systems.
- Find effective solutions to cross-border enforcement.
- Adopt a legally accepted standard for vehicle identification that includes country identification across the European Union.
- Adopt the United Nations classification of vehicles and unify with the classification proposal from the TOP TRIAL project.
- Require member states to look to existing legislation for suitability to deal with automated enforcement.
- Recognize the needs of the weight enforcement community when promoting the development and standardization of weighing devices.
- Encourage member states to harmonize the fine levels for offenses by overloaded vehicles.
- Promote European Directive 96/53 as the definitive constituent of an overloaded vehicle.
- Impose sanctions in a common fashion across the union.
- Coordinate member state activity for overloaded vehicles.
- Define and promote a chain of responsibility.
- Explore collaboration with the International Organization of Legal Metrology (OIML) and

European Committee for Standardization (CEN) working groups.
- Harmonize WIM system specifications.
- Harmonize accuracy testing for all weighing devices.
- Support understanding of the different possible applications of WIM technology as identified through the cases and user requirements in this project through additional project work.
- Encourage member states to set targets to reduce road maintenance budgets in line with an effective compliance strategy for overloaded vehicles.[14]

Combined, these recommendations reflect the state of the practice for commercial motor vehicle size and weight enforcement in Europe at the time of this investigation.

Enforcement Technologies

Existing and Emerging CMV Size Enforcement Technologies

Traditional means for capturing commercial motor vehicle (CMV) size include using a measuring tape and a measuring bar to manually determine and document a vehicle's size in three dimensions. Several shortcomings have been associated with these traditional methods. First, the task requires an initial subjective assessment by an enforcement officer to determine what measurements are required. Second, the process of capturing the measurements is time consuming, keeping an officer from performing other enforcement-related duties. Third, some aspects of vehicle size are difficult for the enforcement officer to physically or safely determine (e.g., the highest point of an irregular load). Lastly, as with any manual measurement process, the determination and documentation tasks are open to errors.

Despite these known shortcomings, only two of the six countries the scan team visited use some form of technology to improve commercial motor vehicle size enforcement: Switzerland and Germany. Slovenia, Belgium, and France reported using only traditional means for capturing vehicle size, including a measuring tape and a measuring bar. Typically, enforcement officers carry these instruments in self-contained mobile enforcing units or smaller police vehicles or they are securely stored at common mobile enforcement sites.

Although height-detection equipment is not yet in regular use, the Netherlands is experimenting with it, considering both gantry-mounted systems and joint height-detection/WIM systems with a focus on tunnel infrastructure. One early finding is that the best locations for height-detection systems (e.g., just preceding tunnels) do not often correspond to the best locations for WIM systems, so combined systems may not be cost effective.

Switzerland

As part of a larger system supporting an enforcement strategy for remote Alpine region tunnels, the Swiss have used infrared detectors to check vehicle height and variable traffic signals to provide adaptive control.[15,16] Height sensors are placed upstream of tunnels. If the sensors identify a vehicle as overheight, a red light is activated indicating that the driver should divert.

Most recently and in an alternate application, Swiss cantonal police have used dimensional measuring devices in conjunction with their heavy goods vehicle (HGV) enforcement sites, which rely on laser scan technology *(www.ectn.com/html/pdf/Profiler.pdf)* to obtain a full three-dimensional profile of the vehicle (see figure 9 on this page and figure 10 on the following page). Tested for 2 years to ensure adequate performance, the vehicle profiler system is now used by cantonal police at four

Figure 9. *Switzerland: vehicle profiler system.*

Figure 10. *Switzerland: vehicle profiler system.*

HGV enforcement sites in Switzerland: two in Zurich, one in Erstfeld, and one in Unterrealta.

The Swiss have used the vehicle profiler system, in conjunction with static scales and at vehicle speeds less than 5 km/h (the maximum manufacturer-specified driving speed of the vehicle), for direct enforcement of commercial motor vehicle size since September 2005. System accuracy has rarely been challenged in court and has been readily defensible when called into question. The Swiss allow the following measurement tolerances when issuing citations from the vehicle profiler system: 5.00 centimeters (cm) for vehicle height, 4.00 cm for width, and 10.00 cm for length. No tolerances are allowed when measurements are taken manually. Swiss enforcement officers report overall time savings, greater accuracies, higher certainty in court, and the ability to process a higher volume of trucks. Despite these gains in efficiency, two officers continue to be used per site. The vehicle profiler technology has simply freed up officer time for other enforcement duties.

The vehicle profiler system is estimated to cost $250,000 as a stand-alone system. A facility similar to Swiss HGV enforcement sites, which include full gross vehicle weight static scales, is estimated to cost $700,000.

Germany

Germany is using a similar gantry-mounted vehicle profiler system as part of its Toll Collect system, but with a different application. Instead of using the vehicle profiler system at low speeds for direct enforcement of commercial motor vehicle size, the Germans measure vehicle size at high speeds to preselect potentially oversized vehicles from the traffic stream. If a vehicle is identified as potentially oversized, the driver is directed off of the main roadway for manual measurement and subsequent enforcement action.

Existing and Emerging CMV Weight Enforcement Technologies

The use of technology to support commercial vehicle weight enforcement varies among the countries visited on implementation and application extent (the COST 323 Project lent consistency to deployment site selection and accuracy determination through development of a European WIM specification). A general consistency, however, was noted in the type of WIM sensor (i.e., piezoquartz or piezoceramic) used for roadway applications, and the countries are addressing previously observed challenges with accuracy and maintenance. Piezo-based systems have several advantages, including lower procurement, installation, and maintenance costs with limited disruption to traffic during installation. As such, these systems can be more widely implemented, providing greater geographic coverage for enforcement and data collection. Bridge WIM systems are also generating interest in several of the countries visited.

Emerging technologies are focused on fiber optic-based, high-speed WIM systems and the use of multiple-sensor WIM to achieve sufficient per-truck accuracy levels to support direct, automated enforcement of commercial vehicle weight limits. Existing accuracy levels attained by WIM systems are sufficient for preselection of vehicles to weigh on static scales for enforcement and for planning and statistical purposes, but are not sufficient for direct, automated enforcement.

Calibration procedures mimic those in the United States: (1) self- or autocalibration, (2) calibration with vehicles of a known weight, and (3) continuous, ongoing calibration (during enforcement efforts) using sample vehicles from the traffic stream at the enforcement site weighed both statically and dynamically. Recently, the Netherlands developed a dynamic calibration vehicle that eliminates traditional dynamic-to-static measurement adjustments, particularly for multiple-sensor WIM installations.

Slovenia

Slovenia has emerged as a leader in the development of bridge WIM system technology, which relies on the instrumentation of existing roadway structures (i.e., bridges, culverts). In brief, bridge WIM systems use strain transducers (or strain gauges) to capture bridge deflection measurements under moving loads. Axle measurements can be captured through traditional portable or permanent axle sensors or through Nothing-on-the-Road (NOR)/ Free-of-Axle Detector (FAD) systems, which require no axle sensors on the road surface.

In the early 1990s, early prototypes of bridge WIM systems were developed independently in Slovenia and Ireland. Bridge WIM systems were considerably enhanced through the COST 323 and WAVE Projects, with bridge WIM projects concentrated in Slovenia, Ireland, France, and Germany. Before these efforts, knowledge was based on U.S. experiences with bridge WIM in the late 1970s, but the cost and insufficient sophistication of software driving those early systems likely contributed to their lack of popularity. More recent efforts, however, resulted in (1) increased accuracy of results, (2) extended applicability to a wide range of bridge types, such as short concrete slabs, box culverts, integral construction, and long-span bridges (including box girders and orthotropic decks), (3) development of NOR/FAD systems, and (4) development of SiWIM, a prototype of the next-generation bridge WIM system developed in Slovenia *(www.siwim.com/).* In 1999, the Slovenian National Building and Civil Engineering Institute (ZAG) partnered with Cestel, a private manufacturing company, to commercialize the SiWIM prototype. Today, more than 60 SiWIM sites are fully operational in Slovenia, Sweden, France, the Netherlands, Croatia, and India. In Canada, Denmark, Austria, and Hungary, SiWIM is used in a more limited application.

The SiWIM system operates as follows: As a vehicle passes over the bridge, a series of strain transducers, mounted below the bridge and invisible to the vehicle driver, measures the vehicle's "weight" as a voltage output from the transducer (see figures 11 and 12). This voltage measurement is not transformed to strain measurement units. The signals from each sensor (typically 16 sensors per two lanes of traffic) are amplified and converted from analog to digital. All are stored in a file and used to support system calculation of axle loads, axle spacing, gross vehicle weight, etc. The transducers are self-temperature compensating to enhance accuracy. In addition, the system includes input for up to five thermocouples that measure the temperature of the structure and compute applicable correction factors. The system can be equipped with a camera to capture a video image of each vehicle crossing the bridge (see figure 13). The video image and weight data can be transmitted to enforcement officers in support of a downstream

Figure 11. *Slovenia: bridge WIM system.*

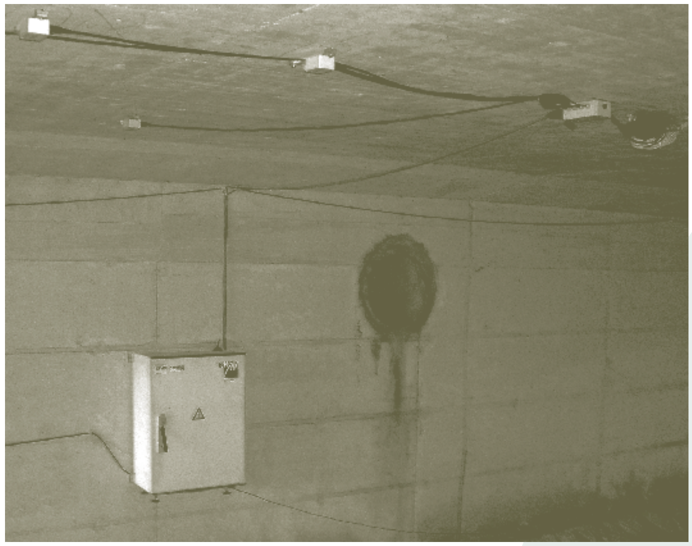

Figure 12. *Slovenia: bridge WIM system.*

Figure 13. *Slovenia: bridge WIM system.*

enforcement site (enforcement officers use handheld or portable computers equipped with General Packet Radio Services (GPRS) for IP packet transmissions and Windows® CE operating systems) if mobile enforcement activities are underway or stored for later use.

The SiWIM data acquisition system differs from typical modular data acquisition systems in that custom software to perform the vehicle classification analysis resides on the system, not on the PC. Data are stored in a temporary queue. When a transducer meets trigger conditions, the system looks back in the queue a sufficient period of time to find a pre-event voltage reading. That reading becomes the "zero" reading and is subtracted from subsequent readings for that event. A new "zero" voltage is established for each weighing event, essentially eliminating concerns about gauge drift. The SiWIM-E (engine), developed on a Microsoft® Windows® NT platform, is the heart of the SiWIM system. SiWIM-F (front end) software is used to configure and calibrate the system, calculate influence lines, monitor the operation of the system, and transfer the data. SiWIM-D is a stand-alone Windows-based application that provides additional reporting features such as gross vehicle and axle load histograms and overloading summaries.

For weight accuracy, the SiWIM system achieved Class B(10) accuracy levels, and sometimes A(5) to B+(7) for some criteria, when installed on a simply supported reinforced concrete slab bridge 5 to 10 meters (m) long. Weight accuracy for the SiWIM system for other bridge types is under investigation inside and outside Slovenia (e.g., results in Canada prove that beam bridges are suitable for NOR installation with B(10) accuracy levels attained and approved). In general, bridge WIM weight accuracy depends on (1) the installation procedure, including the type of bridge, the selection of the influence line, and fine-tuning of the weight parameters, (2) the smoothness of the pavement, particularly leading up to the bridge deck, and (3) the accuracy of the static weighing procedure providing the "true" comparative weight. The optimum bridge span for WIM applications is 5 to 10 m, although bridge spans of 2 to 20 m are acceptable.

For vehicle classification, the NOR/FAD systems capture more than 95 percent of all axles on stiff slab bridges, but misclassify some of the vehicles. A self-correcting module is under development to improve this accuracy. NOR/FAD systems show more success on beam-deck bridge types; ZAG reports the system classifying 261 instead of the true 260 vehicles classified. If reasonable accuracy can be achieved for additional bridge types, NOR/FAD systems provide several benefits, including improved durability, easier installation, no traffic delays, and invisibility to the motoring public.

The Slovenian SiWIM system is calibrated using preweighed trucks or comparative data from static scales for sampled trucks from the traffic stream. The COST 323 European specification states that 60 percent of the calibration runs must be made at the prevailing traffic speed, 20 percent at higher speeds, and 20 percent at lower speeds.

The hardware components of the SiWIM system do not reflect significant advancements in technology. Instead, potential benefits of the SiWIM system include the ability to develop calibrated influence lines; the system-based, rather than PC-based, functionality; and the system's portability and minimal impact on traffic. A drawback of the system is its use of noncalibrated transducers, which limits the value of WIM data for later structural assessments. Under the existing design, transducers must be calibrated to produce strain data. Minimal effort may be required to transform the existing voltage readings into strain measurements when the data are collected. This feature would simplify the use of WIM-generated data, enhancing the system's attractiveness for structural or bridge engineers. An additional drawback is that bridge WIM systems in general require a suitable bridge located where weight measurements are also desired.

Switzerland

Historically, Switzerland has focused on the development and testing of WIM systems rather than on their deployment and use. A number of WIM systems were installed at the Hagenholz ETH test facility near Zurich. In a large-scale COST 323 test, six WIM systems and four additional sensors were installed and monitored on an urban roadway in Zurich. Gross weights from thousands of statically weighed vehicles were used to determine the levels of accuracy for each system; the accuracy of axle weights was not tested.[17] The Swiss also participated in the TOP TRIAL Project, with test sites in Germany.

Concurrently, a Swiss company, Kistler, developed a quartz-based piezo sensor that demonstrated the following advantages:

- Insensitivity to temperature (unlike piezoelectric sensors)
- Ability to be statically calibrated in the field
- Insensitivity to horizontal stresses induced in the road surface
- Ability to function as a true pressure sensor, without having to account for differences in pavement strain or be separated from the roadway by an external frame

Initial performance results from the Hagenholz test site were positive and led to further implementation and testing in Europe, the United States, and other locations worldwide. Some of these initial deployments in Europe and the United States experienced durability problems, resulting in high piezoquartz sensor replacement rates between 1995 and 2005. Kistler reported that the new generation of sensors resolved the durability problem.

In all new Swiss installations of WIM facilities, piezoquartz technology is deployed exclusively. Typically, two sensors are configured 7 m (23 feet (ft)) apart in each lane, although the use of alternate arrays is being explored. While the selection of technology is consistent, the level of deployment within the country varies. Each canton is responsible for implementing and using WIM systems. The Swiss Federal Roads Authority (FEDRO) does not and will not mandate their use.

Despite the reported higher accuracy and increased reliability of the Kistler WIM sensors, cantonal police continue to use traditional static scales (e.g., platform scales, weigh bridges, axle load scales, and wheel load scales) to enforce commercial motor vehicle weight and WIM systems only for preselection. The dynamics of the vehicle (i.e., suspension, load, acceleration, wind) lead to higher-than-desired standard deviations of measurements from WIM systems. In addition, frequent snowfall challenges the accurate capture of data from WIM systems because vehicles cannot distinguish designated lanes during snowfall.

The Swiss report low maintenance with their WIM facilities. The sensors must be inspected periodically (annually) for wear. Calibration is also performed annually, using about 15 staff members for 1 to 2 days per year (i.e., about 120 to 240 person-hours). Calibration assessment and analysis are conducted in accordance with the COST 323 European specifications. About 40 to 50 vehicles in excess of 3.5 metric tons are diverted from the local traffic stream to be statically weighed. Data measured at the static site include number of axles, distance between all axles, distance from front of vehicle to first axle, distance from last axle to rear of vehicle, overall length, individual axle load, and overall weight. In addition, a photo is taken of the vehicle. Static measurements are relayed to personnel at the WIM site using unique vehicle identification information to allow for immediate adjustments.

Germany

Historically, Germany has conducted and participated in research to improve the accuracy of WIM systems, participating in both the COST 323 and WAVE Projects. In the early 1990s, the German Federal Highway Research Institute (BASt) conducted studies to investigate the performance of various systems, including a Golden River capacitance strip sensor, an ECM piezoelectric sensor, and a PAT bending plate system. During this same time, the TOP TRIAL Project, with four participating countries (Germany, the Netherlands, Portugal, and Switzerland), was initiated to (1) improve the accuracy of weight measurement of truck loads to cover future regulations and (2) recommend future European standards as a basis for enforcement. The test site was established along the motorway A9 near Bavaria using staggered multiple-sensor WIM systems. Most recently, Germany has been investigating the performance of an integrated matrix (IM) WIM sensor.[18]

Based on the results of these early tests, Germany began installing bending plate WIM technology in the Rhein-Main area.[19] By 1999, more than 15 WIM systems were installed. In 2000, Germany commissioned a Swiss-based company, Kistler, to install its piezoquartz WIM sensors at 13 WIM stations. Today, Germany has a network of about 40 WIM systems, using both bending plate and piezoquartz sensor technology.

The current WIM sites are used for both preselection for weight enforcement and statistical data gathering. WIM systems are commonly installed in the right lane or right two lanes only with traffic sensors (i.e., electronic loops) installed across all lanes. This layout strategy significantly reduces capital installation costs while still capturing weight data for an estimated 80 percent of the heavy traffic.

BASt researchers concluded in earlier investigations that WIM systems, regardless of sensor design, needed periodic, independent calibration and recommended calibration at least twice per year. The calibration of WIM systems can be maintained by monitoring the axle load distribution for each site, although the distribution varies from site to site. Additional calibration checks were recommended whenever axle-weight distributions at a site change.[19] Current calibration procedures use two trucks of known weight—half loaded and fully loaded—performing 15 runs each.

The recent Toll Collect system includes 300 "toll checker" gantries strategically located throughout the country and equipped with infrared (IR) detection equipment and high-resolution cameras able to profile trucks and record number plates. These gantries do not include any weight capture capabilities (e.g., WIM). WIM installation would have greatly increased the cost of the system and was not required to support the German toll schedule, which relies on a truck's weight capacity rather than observed weight. Integration of WIM would allow real-time weight-distance tolling, but is not currently being used in Germany.

The Netherlands

In the Netherlands, WIM systems began to generate significant interest only when groups other than the pavement design and maintenance community became interested in the information available from these systems. As recently as 1996, no operational WIM systems were in use, although several systems had been purchased from various vendors for testing. At that time, plans were to install 40 to 60 WIM sites, with the first five installations occurring in 1997.[3]

Funded through the Ministry of Transport, WIM installations are prioritized and must compete with other transportation needs of the nation. As of 2006, the Dutch reported only six WIM system installations nationwide, concentrated around the Port of Rotterdam along the major motorways. Two WIM system sites were under construction. Like many of the other countries visited, the Netherlands uses Kistler piezoquartz sensors, but has experienced some problems with durability, attributable partly to the porous asphalt design of its roads.

Despite their limited deployment of WIM systems, the Dutch have made significant advancements in technology performance and its use in automated enforcement, participating in the COST 323, WAVE, and TOP TRIAL Projects. In recent studies, including the WIM-HAND and WIM-HAND2 Projects (described in the "Fully Automating CMV Size and Weight Enforcement" section of Chapter Three), the Dutch have focused on the use of high-speed, multiple-sensor WIM systems to achieve the required accuracy levels to support automatic enforcement of overloading. In addition, these efforts have focused on defining procedures for acceptance of WIM systems intended for use in automatic enforcement. Key issues are accuracy, certainty of the measurements from the WIM system, reliability of the acceptance test, and use of static axle loads as an accepted reference.[20,21]

As part of these latter efforts (i.e., WIM-HAND and WIM-HAND2), the Dutch constructed a specially designed calibration vehicle (see figures 14, 15, and 16). Because metrological laws and specifications are based on static weight, typical calibration methods for WIM convert dynamic loading to a static measure. Ideally, every sensor should be reading the most accurate dynamic load possible rather than correcting to an average static value. No such vehicle was available to calibrate the dynamic measure to the true dynamic load. The newly designed Dutch calibration vehicle measures, while driving, the dynamic forces exerted on the WIM system by the measurement axle. The calibration vehicle compares its own measurements with those of the WIM system integrated into the road. During the design phase, the most important requirements for the calibrating vehicle were the following:

- The ability to measure at speeds of 10 to 100 km/h
- The ability to measure axle loads varying between 5 and 15 tons
- A measuring accuracy of plus or minus 5 percent

Figure 14. *The Netherlands: dynamic calibration vehicle.*

Figure 15. *The Netherlands: dynamic calibration vehicle.*

Figure 16. *The Netherlands: dynamic calibration vehicle.*

The calibration vehicle was commissioned by the Road and Hydraulic Engineering Institute of the Dutch Ministry of Transport, Public Works, and Water Management. Kalibra International built the vehicle, while TNO Automotive provided the measuring technology.

The calibration vehicle has a special exemption allowing it to travel with higher axle loads and at higher speeds. Since WIM systems are not calibrated more than a few times per year, the calibrating vehicle is used to calibrate traditional static weigh bridges the rest of the year.

The Slovenian bridge WIM system (SiWIM) is being tested in the Dutch highway environment. A bridge WIM system was recently installed along the A-4 highway from Amsterdam to Den Haag. The purpose is to test equipment performance under severe Dutch highway conditions. Measurements from the bridge WIM system will be compared to WIM system measurements from a conventional installation a few kilometers upstream from the bridge site and, when possible, static measurements resulting from control activity performed by the National Police.

Belgium

Belgium participated in both the COST 323 and WAVE Projects, though to a lesser extent than some other project partners. The Belgian Road Research Center (BRRC) conducted the analysis for the Continental Motorway Test (CMT) and the Cold Environment Test (CET), which were intended to determine the reliability and accuracy of marketed high-speed WIM systems under variable traffic and climatic conditions. The test sites were near Metz, France (CMT), and Lulea, Sweden (CET).

Belgium relies predominantly on the use of static or low-speed WIM systems for enforcement. The Walloon Region is the only region in Belgium actively deploying high-speed WIM systems. At the time of the scanning study, six Electronic Control Measure (ECM)™ piezo-ceramic WIM systems were in operation. These systems are used predominantly to collect data for statistical planning purposes rather than for preselection for weight enforcement. Although some systems attained A(5), B+(7), or B(10) accuracy levels using the COST 323 procedures, other systems were only able to attain between C(15) and D(25) accuracy levels for gross vehicle weight. These latter accuracy classes show sufficiency for statistical planning purposes only. Site conditions (i.e., less-than-ideal road environments) at these locations were thought to affect the accuracies observed.

Other challenges associated with these systems were reported as follows:

- Maintenance of the stations is quite laborious.
- Calibration is required at least once per year.
- Reliance on automatic calibration leads to a progressive drift at some stations.
- At one site, the automatic calibration feature stopped working because of a serious rutting condition and manual calibration was required.

The initial manual calibration was performed using three preweighed test vehicles typical of the local traffic stream. At least 10 passes per vehicle were performed, with at least five passes per vehicle performed a minimum of 2 weeks later for validation purposes. The systems (including devices and communications) are maintained annually. Calibration is performed using preweighed test vehicles.

France

Nationwide, France uses 170 WIM systems to collect weight data and provide statistical planning support through the SIREDO (Système Informatisé de REcueil de DOnnées) Network.[22] These systems rely largely on automatic self-calibration and a comparative review of static weight data (captured during enforcement activities) to meet data quality requirements. The combination of autocalibration and static weight data comparative procedures has eliminated the need for resource-intensive manual calibration conducted typically on an annual basis.

Historically, the French have been actively involved in advancing the accuracy of WIM equipment (since the late 1970s) and have conducted several notable field studies as part of the COST 323 and WAVE Projects:

- **Portable and multiple-sensor WIM test near Trappes—**In June 1996, a trial of four portable piezoceramic WIM systems, set in a multiple-sensor weigh-in-motion (MS-WIM) array, was performed on a heavily trafficked highway near Trappes. During the 3-day experiment, 116 runs were made with two preweighed test vehicles, 92 trucks in the traffic stream were stopped randomly and statically weighed upstream of the test site, and the axle loads and gross weights of almost 4,000 trucks were recorded in the traffic stream by the MS-WIM system. This sample of data was used to assess the accuracy of the portable WIM systems.[23]

- **Continental Motorway Test on Motorway A31 near Metz—**In March 1997, the Continental Motorway Test (CMT) was initiated to determine the reliability and accuracy of six WIM systems from four European manufacturers. Five systems used piezoceramic bars and the sixth used a capacitive mat. The WIM systems were installed in the slow lane of a busy motorway in northeast France and monitored over a 17-month period. Findings were based on a sample of 700 trucks, weighed both statically and by each of the systems.[24]
- **Continental Motorway Test on Motorway A31 near L'Obrion, Phase II—**As a follow-on study, CMT Phase II was initiated in October 1998 and allowed the testing of the same WIM systems, following manufacturers' improvements, as well as additional systems. The test took place at L'Obrion on the Motorway A31 between Metz and Nancy in northeast France and allowed performance checking of seven different WIM systems.[24]

As part of the WAVE Project, the French examined fiber-optic strip sensors to improve WIM technology at two separate test sites: along RN 10 near Trappes and at the Alcatel plant in Saintes. Fiber-optic cable technology was proven to have several advantages, including good metrological accuracy and low temperature dependence, operation capabilities in both static and high-speed conditions, electromagnetic immunity, timesaving installation, near real-time processing, and future capabilities of capturing tire pressure, vehicle acceleration, and other dynamic effects.[8]

Historically, the French have focused on the use of high-speed, multiple-sensor WIM systems to achieve the required accuracy levels to support automated enforcement of overloading. Using a multiple-sensor WIM site on A31, French researchers are investigating the effects of individual axle sensor accuracy, static weight estimation algorithms (SAve, SR, or ML1/2), and array design (~ 5–15 piezoelectric bars) on overall system performance.[25] The minimum required accuracy to achieve automated enforcement is estimated at A(5), according to COST 323 European specifications.

In addition to continued testing of multiple-sensor WIM systems, two prototype VIDEO-WIM systems were installed and are being used for (1) real-time preselection of overloaded vehicles from the traffic stream for enforcement, (2) prevention of overloading behavior through targeted company contacts, and (3) forecasting problematic locations to support scheduling of mobile enforcement patrols. Direct enforcement occurs at various fixed static enforcement sites or through mobile enforcement activities, although the final objective of these prototype systems is aimed at fully automated enforcement.

As part of the VIDEO-WIM system evaluation, two different WIM systems provided by ECM and STERELA were tested.[26] The ECM system is located along RN83 in the south-north direction about 6 km away from a static weighing area. The STERELA system is located along A31 in the north-south direction. In each case, only one lane was equipped with piezoceramic sensors. Other system components included electromagnetic loops for vehicle detection, monochromatic high-definition video camera and license plate recognition software, a local processing unit, and communications to transmit data. Neither system performed initially to the accuracy levels expected. The ECM system achieved C(15) accuracy for single axles and D+(20) accuracy for axle groups, using the COST 323 European specifications. For the STERELA system, the accuracy for axles in a group reached B(10) accuracy, while single axles and axle groups achieved C(15). Gross vehicle weight accuracy reached only D+(20). This underperformance on accuracy was attributed to the poor road structure at each site. Despite the compromised accuracy, the efficiency of the systems was proved, resulting in significant benefits for preselection. A total of 81 percent and 100 percent of the trucks stopped for static measurement were confirmed as overloaded, respectively, and 64 percent and 67 percent of these overweight trucks were fined based on the degree of overload, respectively (a 5 percent tolerance is allowed before a fine is implemented).

The success of these two prototype VIDEO-WIM systems has resulted in a call for tender, won by STERELA, to implement 10 to 40 similar systems throughout France. The final number of sites implemented will be determined by available funds. Any less than 10 sites results in system development costs that are too high. The systems will use high-speed WIM for preselection and either static or low-speed WIM for enforcement. Other specifications include the use of two strip sensors of unspecified technology but capable of achieving a minimum of Class C(15) accuracy; 1.6- to

4-m spacing between sensors (France typically uses 1.8 m), depending on pavement quality, sensor type, etc.; a communication link between the prescreen site and enforcement area; and a second video camera a minimum of 200 m downstream of the WIM video to allow for vehicle speed measurement and calculation.

Unique to France is its focus on low-speed WIM as an opportunity to move toward automated enforcement (in both Belgium and Switzerland, vehicles are allowed to roll over static scales at very low speeds (5 km/h), but it is unclear whether any adjustments have been made to the weight capture algorithms to reflect this "dynamic" weight measure or what legal or metrological changes were required to support this practice). The accuracy of these systems is typically A(3) to A(5), according to COST 323 European specifications, which complies with enforcement requirements. France has recently received approval for legal metrology of low-speed WIM and is now working to change the law allowing direct citation issuance based on low-speed WIM measurements. Until the law is changed, portable static scales must be used for citation issuance. The use of low-speed WIM will allow enforcement officers to process up to 10 times more vehicles, even with vehicle speeds constrained to less than 10 km/h. A tolerance of 5 percent is now provided for portable static measurements. The same tolerance will be used for low-speed WIM measurements.

To bring together these three technology applications—video-based preselection systems, multiple-sensor WIM, and low-speed WIM—a test site is being developed to perform efficient overloading controls while developing future automatic systems for enforcement. The automatic overloading control test site will be located along the RN4 between Nancy and Paris (Maulan and Rupt-aux-Nonains). The preselection system will be modeled after the two prototype systems described previously along RN83 and A31. The multiple-sensor WIM system (to be located in Maulan) will consist of a 16 piezoceramic sensor array, two wheel transverse location detection systems (to account for wheels passing too closely to the WIM sensor edge and to apply correction factors due to the transverse sensitivity of the sensors), and a temperature sensor. The low-speed WIM system will be installed at a newly constructed rest area at Rupt-aux-Nonains. Variable message signs (VMS) and bicolored (red and green) lights will direct approaching and onsite drivers, depending on their status (i.e., suspected overloaded, confirmed overloaded, etc.). A video camera with license plate recognition capabilities will allow for complete automated enforcement of commercial motor vehicle weight.

France is also testing the Slovenian bridge WIM system (SiWIM) on alternative bridge structures. Previous tests determined that the SiWIM system could achieve C(15) accuracy for a short-span integral concrete bridge (along RN4, Rosay-en-Brie) and B(10) accuracy for another short-span integral concrete bridge (along RN19, Nogent-sur-Seine) with better road smoothness. France is now testing this system on orthotropic steel bridge structures (see figures 17 and 18 on this page and figure 19 on the following page). Unlike concrete bridge behavior, orthotropic structure behavior is locally independent of span length. Early challenges relate to installation; the strain transducers used in the SiWIM system do not adequately

Figure 17. *France: bridge WIM system test site.*

Figure 18. *France: bridge WIM system test site.*

Figure 19. *France: bridge WIM system test site.*

adhere to steel. The transducers were initially glued directly to the steel. Instead, the transducers could be secured to metal plates using screws, which are then affixed to the steel structure. The use of strain gauges could also overcome this issue.

Technology's Role in CMV Size and Weight Enforcement

In general, the use of technology for enforcing both commercial motor vehicle size and weight was viewed as beneficial in enhancing effectiveness and efficiency. For vehicle size enforcement, technology was also purported to improve the accuracy of dimensional measurements. Motivated by a desire to ease the burden of enforcement officers, representatives in many of the countries visited expressed a desire to see the use of technology for commercial motor vehicle size and weight enforcement increase.

Comparison/Contrast with the United States

Few wholly new technologies for commercial motor vehicle size and weight enforcement were observed in the countries visited. One exception is the automated vehicle profile measuring device used in Switzerland and Germany. No such technology is known to be in use in the United States for commercial motor vehicle size enforcement.

Many technologies observed for weight enforcement, while not wholly novel to the United States, offer enhancements in application that are new to this country. For example, software enhancements available through the SiWIM system, particularly the ability to develop calibrated influence lines, may make bridge WIM systems a more attractive tool than when first introduced in the late 1970s. Also, using multiple WIM sensors instead of a single sensor to achieve sufficient per-truck accuracy levels has not been widely pursued in the United States. Low-speed WIM, used in early preselection efforts in the United States, is seeing renewed application in the countries visited as a step toward automated enforcement.

Enforcement Procedures

A greater use of mobile enforcement activities and few fixed roadside weigh facilities were consistently observed in the countries visited. This strategy results in a lower volume of trucks being processed and geographically and geometrically constrained inspection and offloading areas, but it provides more flexibility to respond to industry loading and routing patterns and more efficient and effective enforcement action.

Many European enforcement entities have dedicated personnel for size and weight enforcement. Often, size and weight enforcement personnel are not authorized to perform duties beyond size and weight enforcement (i.e., not authorized to stop vehicles, carry firearms, perform arrests). If an obvious safety, credential, or criminal problem is noted, personnel authorized to address these issues are called to assist. A high level of collaboration in commercial motor vehicle size and weight enforcement activities was observed in several of the countries visited between similar agencies of different jurisdictional levels (e.g., national and regional law enforcement agencies) and between different agencies (e.g., transportation and law enforcement agencies). It was also observed that private sector entities work closely with government and research bodies to refine and enhance product performance and accuracy.

Citation issuance procedures and fine amounts differed between and within the countries visited, varying by the assumed violator (i.e., driver, carrier, or both), unique procedures for foreign drivers and carriers, and the time allowed for establishing and responding to the fine (in many instance, the fine was immediate). In general, the citation amounts were reported to be sufficient as a deterrent.

Integrating Technology in CMV Size and Weight Enforcement

In the countries visited, WIM technology is used predominately to support commercial vehicle size and weight enforcement through (1) real-time preselection for mobile enforcement, (2) scheduling time and location (to the extent possible) of enforcement activities, and (3) directing carrier/company advisory notices of noncompliance (i.e., warning letter) and preventive visits (this information is shared with enforcement personnel).

Slovenia

Slovenia uses several roving enforcement vehicles operated by the Traffic Enforcement Section, under the Uniformed Police Directorate of the Ministry of the Interior, to provide commercial motor vehicle size and weight enforcement. The country has no fixed weigh facilities. In addition to size and weight measuring capabilities, the vehicles have equipment to check emissions, perform a full safety check, and communicate with the central office for credential checks (see figure 20 on this page and figure 21 on the following page). These vehicles patrol the motorways and, when appropriate, the secondary roads, targeting areas where violations are observed or suspected. The Traffic Enforcement Section is supported by CESTEL personnel who install, maintain, and process data for the bridge WIM systems.

In recent years, these roving enforcement vehicles have integrated technology, including bridge WIM systems (SiWIM), into their operations in two ways: (1) to support

Figure 20. *Slovenia: mobile enforcement vehicle.*

Figure 21. *Slovenia: mobile enforcement vehicle.*

real-time preselection for mobile enforcement and (2) to support scheduling time and location (to the extent possible) of mobile enforcement activities.

Preselection. To preselect an overloaded vehicle from the traffic stream, the SiWIM systems are used in conjunction with a video camera and a handheld or portable computer capable of receiving both the weight data and the vehicle image. Vehicle information—including vehicle class, gross weight, axle loads, overloading status, time of arrival, lane, and speed—and a video image of the vehicle allow enforcement officers to escort suspected noncompliant vehicles off the main roadway to the mobile enforcement site for static weighing and additional inspection (see figures 22 and 23). This preselection method reportedly results in high efficiencies; more than 80 percent of vehicles preselected for inspection by the SiWIM system are confirmed as overweight and are ticketed. The SiWIM system is used only as a prescreening tool to select vehicles for further inspection and evaluation. No citations are directly issued using SiWIM system data.

Scheduling of enforcement activities. To support scheduling of mobile enforcement patrols, historical SiWIM data are used. Mobile enforcement units, working closely with the Directorate of the Republic of Slovenia for Roads and Cestel (for SiWIM system data analysis and installations), determine a location and time for enforcement one month in advance. Three groups, composed of enforcement and Cestel personnel, are at different locations each day, controlling the main roads and the borders. Well-informed truck drivers limit the amount of time that can be effectively spent at each mobile enforcement site. Nonetheless, these three teams controlled more than 6,200 trucks in 2005. Fifty-six percent of captured trucks were overloaded in 2005, up from 18 percent in 1998.

Particular industries in Slovenia, such as quarries, gravel pits, and construction areas, pose special problems and need to be enforced more often. At one observed site, 73.9 percent of overweight vehicles were attributable to these. Slovenian officials reported that the low fines for overloaded travel are relatively ineffective deterrents and recommend the use of SiWIM data to support development of an inversely exponentially increasing fine structure ranging from €200 to €3,000 for gross offenders. SiWIM data suggest that the majority of vehicles (nearly 60 percent) modestly exceed (by less than 10 percent) axle load limits. About 5 percent of the vehicles, however, exceed axle load limits by more than 40 percent.

Switzerland

Several formal sets of guidelines support traditional commercial vehicle size and weight enforcement:

- Section 132 Traffic Registration Act (Verkehrszulassungsverordnung, *www.admin.ch/ch/d/sr/c741_51.html*)
- Calibration Act of December 12, 1984 (Eichverordnung, *www.admin.ch/ch/d/sr/c941_210.html*)
- Regulation of Non-Automatic Scales of April 16, 2004 (Verordnung über nichtselbständige Waagen, *www.admin.ch/ch/d/sr/c941_213.html*)
- Directives Regarding Police Weight Checks (Weisungen über polizeiliche Gewichtskontrollen, *www.astra.admin.ch/media/pdfpub/2004-07-15_2339_d.pdf*)

Directives on the recently implemented vehicle profile measurement devices are under development.

Preselection. More informally, relying on the performance achieved by piezoquartz sensors and multiple-sensor arrays to further enhance accuracy, the Swiss have developed an enforcement strategy for remote Alpine region tunnels.(15,16) The system consists of multiple quartz-based WIM sensors, infrared height detectors, video cameras, and variable traffic signals for adaptive control. Weight, height, and video data are transmitted to a central traffic control center, enabling identification of overloaded or excessive height vehicles. These data are simultaneously transferred to the next police enforcement site downstream, equipped with a weighing system certified for enforcement.

A similar process is followed at routine enforcement locations. Swiss cantonal police use WIM systems for preselection along the main roadways. If suspected as overweight, a vehicle is escorted by police to an offsite but nearby fixed weigh facility where it is statically weighed and measured either manually or with a vehicle profiler system (see figure 24). If a vehicle is confirmed to be overweight or oversize, the driver and/or company is issued a citation accordingly or required to offload the vehicle before proceeding.

The use of WIM for preselection is reported to increase Swiss cantonal police enforcement effectiveness and efficiency for commercial motor vehicle size and weight. The Swiss do not define specific numeric metrics to ensure that a sufficient number of vehicle checks are conducted. As police continue to spread their time over many activities, truck weight enforcement will continue to decline in importance. For this reason, the Swiss would like to see the use of technology for this application increase.

Germany

Preselection. For day-to-day operations, Germany uses a system of about 40 WIM sites that support mobile enforcement efforts, as well as statistical data gathering. The WIM sites commonly use sensors in the right lane or right two lanes only with traffic sensors (i.e., electronic loops) installed across all lanes. This layout plan significantly reduces capital installation costs while still capturing weight data for an estimated 80 percent of the heavy traffic.

As part of the Toll Collect system, the German autobahn system has 300 "toll checker" gantries strategically located throughout the country and equipped with IR detection equipment and high-resolution cameras able to profile trucks and record number plates. These gantries do not include any weight capture capabilities (e.g., WIM), but are capable of prescreening for potentially oversized vehicles.

In addition to the gantries, Toll Collect also relies on specially assigned mobile patrols consisting of a fleet of 300 vehicles with 540 officers from the German Federal Office for Transport of Goods (BAG) (see figure 25 on next page). Video and license plate information captured at the gantries can be sent to downstream mobile enforcement units. The officers patrol the autobahns, checking vehicles and drivers to see if they have paid the toll or have

Figure 22. *Slovenia: mobile enforcement.*

Figure 23. *Slovenia: mobile enforcement.*

Figure 24. *Switzerland: fixed weight-size facility.*

Figure 25. *Germany: mobile enforcement vehicle for Toll Collect system.*

onboard units (OBUs) installed (these enforcement vehicles are equipped with infrared dedicated short-range communications (DSRC) systems that can be used to scan and monitor trucks in motion).

While BAG officers have police powers to request trucks to stop for examination any time during their journey, they are not authorized to conduct size or weight enforcement. If a truck is stopped for a toll violation and an oversize or overweight violation is suspected, alternative mobile police units must be dispatched for enforcement of size and weight. These alternative mobile police units similarly do not have authority to enforce tolling. Political motivations separated toll enforcement from regular police forces. As reported by German officials, enforcement efforts are not well coordinated. A vehicle driver may experience a special or classical (full) control by enforcement officials and toll control within a few kilometers.

The Netherlands

In the Netherlands, the National Police Agency (KLPD), the Inspectorate of Transport, Public Works, and Water Management (Transport Inspectorate), the Public Prosecution Service, and the Ministry of Transport, Public Works, and Water Management (Ministry of Transport) are partners in enforcing commercial motor vehicle size and weight regulations. To ensure that commercial motor vehicle size and weight enforcement is a continued priority, particularly among police agencies, the Ministry of Transport funds additional police officers who focus about 40 percent of their time on weight enforcement and 60 percent on anticongestion and incident-management activities. This special project detail has about 100 officers who are trained in 80 percent of full police officer duties. They do not carry firearms or drive motorcycles, which require a special permit. These officers are always paired with a fully trained police officer for safety, which increases the overall cost of the program. The Transport Inspectorate is an independent inspection entity of the Dutch Ministry of Transport tasked with promoting safety in transport. Inspectorate personnel can perform commercial vehicle size and weight enforcement duties, but are also tasked with monitoring and enforcing regulations on vehicle insurance, fleet maintenance, vehicle safety, and environmental conditions. This partnership supports commercial motor vehicle enforcement activities related to (1) real-time preselection for mobile enforcement, (2) scheduling time and location (to the extent possible) of enforcement activities, and (3) directing carrier/company advisory notices of noncompliance (i.e., warning letter) and preventive visits (this information is shared with enforcement personnel).

Preselection. In the late 1990s the Dutch developed an innovative WIM and video system (WIM/VID) at a test site on the highway between Antwerp and Rotterdam to support preselection of overweight vehicles from the traffic stream.[27] Technologies and procedures developed at the initial WIM/VID test site have been integrated into routine commercial motor vehicle size and weight enforcement activities. Each WIM/VID site is equipped with piezoquartz WIM sensors in the right two lanes, two cameras on each side of the road to capture the vehicle image, and cameras above each lane to capture license plates. Electronic loops and cameras in the third lane and right shoulder detect bypassing vehicles. Enforcement officers from the National Police Agency use laptops in their mobile units to receive information (data and video) from the upstream WIM site (see figures 26, 27, and 28). Overweight determination is processed within 15 seconds. The officer at the mobile enforcement site contacts onroad colleagues to intercept the overloaded vehicle and escort it for further inspection and evaluation. At the mobile enforcement site, static axle loads are captured (see figure 29 on page 40). Modest checks for registration and safety are also conducted as part of the weight enforcement effort.

If a vehicle is confirmed to be overweight, the appropriate citation is issued to the company.

- Vehicles determined to be less than 10 percent axle/axle group or 5 percent gross vehicle weight overweight are issued a warning.
- Vehicles determined to be 10 to 20 percent axle/axle group or 5 to 10 percent gross vehicle weight overweight are issued an official citation report.
- Vehicles determined to be greater than 20 percent axle/axle group or 10 percent gross vehicle weight overweight are issued an official citation report and required

to transfer the load until full compliance is achieved (vehicle must be brought into full compliance, not just less than 20 percent or 10 percent overweight, respectively).

If the fine goes unpaid, the company owner is required to appear before the prosecutor. Enforcement officials try to balance enforcement activities with the prosecution system. If enforcement officials are highly productive but the prosecution system is not, the effort may be wasted. Revenue from commercial motor vehicle size and weight enforcement efforts is deposited in the general government budget.

This preselection process has been credited with increasing officer efficiency (i.e., the number of citations issued compared to the number of vehicles stopped) from about 40 percent to more than 80 percent. The trucking industry is reacting to these preselection controls by using bypass routes or, more positively, by investing in new vehicle configurations (e.g., with additional lightweight axles) and in-vehicle weighing systems to better self-monitor loading behavior. These actions are limited, however, since outside of the six enforcement control points, the odds of being detected when traveling overweight are minimal.

Scheduling enforcement activities. In addition to using technology to support preselection activities, the Dutch use historical WIM data to support the scheduling of the time and location (to the extent possible) of enforcement activities. Using the most recent week and the past 6 weeks of WIM data, the time of day, day of the week, and location of high overweight vehicle activity are determined. For example, just before the morning rush hour (i.e., 5 to 7 a.m.) is commonly the worst period for overloading at one site in the Netherlands. In the near future, the enforcement activities of the National Police and the Transport Inspectorate will be coordinated. National Police officers will focus on the highway network (at preselection sites) and the Inspectorate officers will focus on the secondary road network with particular focus on bypass routes for the preselection sites.

Directing preventive company contacts. While officials from both the Dutch National Police Agency and the Transport Inspectorate have the authority to conduct roadside commercial motor vehicle size and weight enforcement, the advent of the WIM/VID systems has allowed the Transport Inspectorate to shift its focus from performing roadside inspections to conducting carrier/company advisory notices of noncompliance and/or preventive visits. In the Transport Inspectorate's view, preventive company contacts are more efficient than

Figure 26. *The Netherlands: mobile enforcement.*

Figure 27. *The Netherlands: mobile enforcement.*

Figure 28. *The Netherlands: mobile enforcement.*

Figure 29. *The Netherlands: mobile enforcement.*

roadside inspections because a single contact can reach companywide rather than a single driver. In addition, application of the WIM/VID system for company contacts allows for 100 percent capture and review of overloads (i.e., 24-hour-a-day, 7-day-a-week monitoring). Roadside inspections are effective only when enforcement officials are present.

The general process is as follows:

- Using data from the WIM/VID systems, the Inspectorate reviews information on a monthly basis to determine the offending vehicles and their companies. WIM sensors provide the weight-related information and the video image of the license plate/truck provides the company identifier.
- Using the license plate number, the Inspectorate can access additional information about permits, the vehicle, maintenance, etc. Actual permitted axle weights for a particular vehicle are more valuable than assumed average axle weights.
- Transport companies with the highest monthly offenses are added to the "black list" and categorized as Code Red. They are sent a written notice of the violations with a summary of observed violations for the prior three months.
- Once the company receives a written notice, the Inspectorate arranges an onsite visit to review the violation history, describe the WIM/VID system, review how overloads may be caused, and make an agreement to work cooperatively to prevent future overloading.
- Following the onsite visit, the transport company begins a 2-month compliance monitoring period, during which overloading offenses are monitored with the intent of observing a positive change in loading behavior.
- If a positive change in loading behavior is observed, the company is removed from the black list and recategorized from Code Red to Code Yellow, indicating that the company will still be monitored but not as intensely as before. If the behavior remains positive, the company is categorized as Code Green with other compliant companies.
- A list of companies with no positive change in loading behavior is sent to both Inspectorate and Police personnel, who will stop all company vehicles, loaded or empty, for further inspection through the roadside inspection process.
- For particularly problematic companies, scales may be placed at the company's entrance or exit to ensure that no overloaded vehicles are released from the facility. Ultimately, the company may be put out of business.

The company contact procedure is only effective for Dutch companies. No mechanism exists to conduct preventive contacts with foreign companies. The program is well received by industry, although noncompliant companies are less receptive as the latter phases of the process are implemented.

Belgium

The Walloon Region is the only one in Belgium actively deploying WIM systems, with six piezoceramic WIM systems in operation. These systems are used predominantly to collect data for statistical planning purposes, not enforcement. The Belgian Federal Police Services recognize the potential for benefit from the use of WIM systems for preselection and hope to move toward this application. A test site modeled after the WIM/VID systems in the Netherlands is under development in the Flemish Region.

Under current operations, enforcement officials, from the Federal Police Services to the regional road administrations, rely only on fixed and mobile enforcement, using shared public or private static weigh bridges or low-speed WIM systems. Enforcement officials allow vehicles to roll at very low speeds (less than 5 km/h) over the WIM systems for weight capture using load cell technology. Vehicles carrying liquids or shifting loads are required to come to a complete stop on the scales for accurate measurement. A 3 percent tolerance is allowed for citation issuance.

Currently, a citation is issued to the driver, although pending regulations will allow both the driver and the company to be cited. Fines range from €55 to €55,000. Enforcement officers cannot collect the fee at the enforcement site, except in the case of foreign vehicles.

A prosecutor must determine the fine amount for noncompliant domestic vehicles. Grossly overloaded vehicles (more than 20 percent overloaded) can be required to be fully unloaded to allow the vehicle to undergo a complete inspection of brakes, suspension, etc. The driver may also go to jail.

Unlike the countries visited that have specially trained personnel dedicated primarily to commercial motor vehicle size and weight enforcement, the Belgian Federal Police Services perform a more complete inspection for every vehicle stopped, checking driving and resting hours, vehicle tachograph readings, criminal use, etc. Priorities for enforcement in Belgium include driving and resting time, in-between distance, and weight. Vehicle size limits are not usually checked unless a recognized problem exists.

France

Similar to the Netherlands, technology is being used to broadly support commercial vehicle size and weight enforcement through (1) real-time preselection for mobile enforcement, (2) scheduling time and location (to the extent possible) of enforcement activities, and (3) directing carrier/company advisory notices of noncompliance (i.e., warning letter) and preventive visits (this information is shared with enforcement personnel).

Preselection. France has two prototype VIDEO-WIM systems, with plans for expanded implementation at 10 to 40 sites. Using these systems, a picture of a suspected overloaded vehicle (as determined by the WIM sensors) is immediately transmitted by radio waves or telephone lines to enforcement officials (either transport inspectors from the Ministry of Transportation or police officers from the Ministry of Police) at a static weighing area (see figure 30). Once identified, enforcement officials escort the vehicle to the static site for further inspection and evaluation (see figure 31). Vehicles that are confirmed to be overloaded using the static scales are fined accordingly. The prescreening system is set to flag (i.e., image is captured and a record is made) every vehicle suspected as over legal limits. The enforcement officer still uses discretion to determine whether to pull the vehicle in, based on the available storage space of the facility, knowledge of the company, etc.

Static weighing can be accomplished at any of the country's fixed static enforcement sites, located most commonly near toll areas and along national roads. In addition, 219 mobile enforcement units (vans, light vans, etc.) can set up temporary sites for static weighing wherever sufficient space exists using portable static scales. Mobile

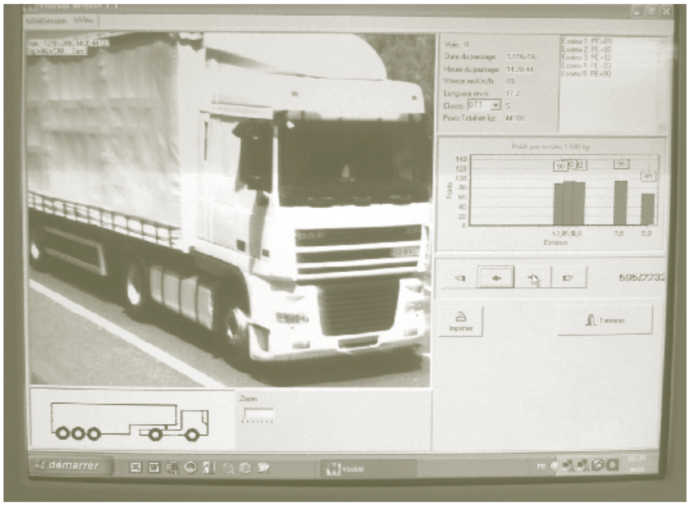

Figure 30. *France: mobile enforcement.*

Figure 31. *France: mobile enforcement.*

enforcement requires a space 30 meters long with nearby parking lots or rest areas for vehicle storage (see figure 32 on following page).

The use of low-speed WIM systems in place of static scales for citation issuance was recently approved in France, allowing up to 10 times more vehicles to be processed. Following extensive testing to prove system acceptability, enforcement officials received approval from the National Metrological Organization and the two first systems are being installed along the RN4 at Rupt-aux-Nonains and nearby Châlon-sur-Saône.

Directing preventive company contacts. In addition to using the two prototype VIDEO-WIM systems to support preselection activities, the French use them to direct carrier/company advisory notices of noncompliance and

Figure 32. *France: mobile enforcement.*

preventive visits. Using data from the prototype WIM systems, enforcement officials can determine common offending vehicles and their companies. WIM sensors provide the weight-related information and the video image of the license plate/truck provides the company identifier. Warning letters are issued regularly to the top 10 offending companies. While no citation is issued based on the WIM system data, companies are made aware that their loading behavior is being monitored. France has initiated a 3-year study to determine the effect of these preventive company contacts on loading behavior.

Scheduling enforcement activities. The French also use historical WIM data to support the scheduling of the time and location (to the extent possible) of enforcement activities, relying not only on the two prototype sites, but also on the full network of 170 WIM systems. Overweight commercial motor vehicle characteristics are summarized and reported to police officials through SIREDO by month, day of the week, and hour of the day to support scheduling of mobile enforcement efforts.

Fully Automating CMV Size and Weight Enforcement

Fully automated commercial motor vehicle size and weight enforcement using high-speed WIM is estimated to be 5 to 20 years in the future, according to officials in France and the Netherlands, the emergent leaders in automating enforcement efforts. Primary challenges for high-speed WIM applications include (1) attaining sufficient accuracy levels for the WIM systems, (2) gaining certification approval from the national metrological bodies, and (3) modifying existing laws that require static weight measurements (or low-speed weight measurements in high-speed applications). In addition, the complexity of high-speed WIM system technology requires development of new test procedures for certification.

France (as well as Germany and the United Kingdom) has obtained approval from the national metrology authority to certify low-speed WIM for use in enforcement. Belgium is also using low-speed WIM systems for direct enforcement, although it is unclear what legal or metrological changes were required to support this practice. Low-speed WIM systems differ from high-speed systems in technology, certification, and application. The test procedure required for certification of a low-speed WIM system is similar to that of a static weigh system, making it relatively simple for and familiar to the National Metrology Institute.

Slovenia's legislature does not yet allow use of WIM data for direct enforcement of overloaded vehicles. The Swiss report concerns about high standard deviations for accuracy from high-speed WIM systems that would require sizable tolerances for enforcement. According to the Swiss, high tolerances in size and weight limits would not act as a sufficient deterrent for ensuring compliant commercial vehicle behavior. The Germans cited the costs associated with multiple-sensor WIM, continued challenges with reliability, and remaining legal roadblocks as reasons for not pursuing automated enforcement of commercial motor vehicle size and weight. Further, if a truck is detected as overweight or overloaded, facilities are still required downstream from the automated enforcement site to allow for offloading or other action.

Despite these shortcomings, the use of high-speed WIM systems for automated commercial motor vehicle enforcement would greatly increase the number of vehicles monitored (i.e., to 100 percent along an instrumented route), the proportion of overloaded vehicles detected in the traffic stream, and the number of overloaded vehicles appropriately cited. High-speed WIM systems also support identification of habitual noncompliant carriers for whom compliance can be further encouraged through preventive company contacts. If a grossly overloaded vehicle (i.e., requiring offloading) is detected, manual enforcement action is still required. If manual enforcement methods were used exclusively in this instance, the vehicle may have gone undetected unless active patrols were in place along the route and officers were already checking other vehicles, or if officers did not perceive the vehicle to be overloaded.

The Netherlands

The success of the WIM/VID system for improved targeting of overloaded vehicles motivated the initiation of the Overbelading (Overloading) Project, consisting of a number of smaller projects. One of these projects, WIM-HAND, sought to achieve true automated enforcement of overloaded vehicles. WIM/VID enhanced targeting of overloaded vehicles, but required static weighing for citation issuance. Automatic enforcement means that when the WIM system detects an overloaded vehicle (or axle), prosecution of the vehicle owner is directly based on the measured axle loads combined with the recorded video images of the vehicle (including the license plate).[28]

The WIM-HAND Project focused only on the technical measurement process. Data processing or integration of the systems into the operational process of the enforcing authorities was not part of this project. However, preparation of the metrological certification for the developed measuring system for use in direct enforcement was considered part of the project's scope.

At the onset of the WIM-HAND Project, the following WIM system general minimum accuracy requirements for automated enforcement were defined:

> A WIM system with an inaccuracy of less than 10 percent and a degree of certainty of more than 99 percent is deemed feasible from a technical viewpoint and deemed employable for use in automatic enforcement.

To achieve these accuracy levels, researchers focused on the development of a multiple-sensor WIM system using piezoquartz sensor technology at a single test site along the northern carriageway of the A12/A50 highway near Arnhem. For such a system, determining the proper layout of the sensor array is essential. The objective is to maximize accuracy and reliability while minimizing the number of sensors used. In this case, the number of sensors was limited by the available budget, so 16 rows of WIM sensors were used. Because the WIM system was used for research and not enforcement, the system was installed in the right lane only.

The test site was divided over three locations: (1) the dynamic weighing location where the WIM sensors and the video cameras were installed, (2) the static weighing location where vehicles are escorted for static reference measurement, and (3) the data analysis location where all measurement data are stored for further analysis.

During the WIM-HAND Project, unfortunately, initial problems with the WIM sensors precluded any practical tests of the system. Hence, the study objective shifted to focus on national and international acceptance of WIM for direct enforcement of commercial motor vehicle size and weight. According to the Dutch, before WIM systems can be used for automatic enforcement of overloading, the following technical and nontechnical issues must be addressed:

- Vehicle classifications are not accurate and not detailed enough to directly correspond to overloading laws of trucks and axles.
- Some vehicles have lower limits for axle load and gross weight, denoted only in the vehicle's registration documents. These lower legal limits are not denoted by a unique license plate or other readily visible cue detectable by an automated enforcement system.
- WIM systems require metrological certification for direct enforcement applications. To date, the requirement for certification of this type of equipment does not exist in the Netherlands.
- It is unclear which government organization will be made responsible for automatically enforcing overloading.
- No significant international exchange of information occurs in the European Union on procedures or standardization of laws on overloading.

The calibration, testing, and processing of measurement results from the WIM-HAND test site are being investigated in a follow-up project, WIM-HAND2.

France

Historically, France has focused on achieving automation in commercial motor vehicle size and weight enforcement. These efforts have been challenged by the ability to define required accuracy levels to provide defensibility in court and determine the legal weight for a vehicle. Factors other than axle configuration are used to determine the allowable load on a vehicle (e.g., the French have three different legal gross vehicle weights (GVWs) for a two-axle truck).

Recently, France established an automatic overloading control test site to advance the use of WIM systems for automated enforcement.[29] The site, located along the RN4 between Nancy and Paris, will bring together video-based preselection systems, multiple-sensor WIM systems, and low-speed WIM systems. The preselection system will be modeled after the two prototype systems described previously along RN83 and A31. The multiple-sensor WIM system will consist of a 16 piezoceramic sensor array, two wheel transverse location detection systems (to account for wheels passing too closely to the WIM sensor edge and to apply correction factors due to the transverse sensitivity of the sensors), and a temperature sensor. The low-speed WIM system, to be installed at a newly constructed rest area, will be used for direct enforcement (France has recently received approval for legal metrology of low-speed WIM). Variable message signs (VMS) and bicolored (red and green) lights will direct approaching and onsite drivers, depending on their status (i.e., suspected overloaded, confirmed overloaded). A video camera with license plate recognition capabilities would allow complete automated enforcement.

The certification of low-speed WIM systems for direct enforcement by the National Metrology Institute represents a significant advancement toward automated enforcement in France. Until now, the metrological community was unwilling to recognize dynamically captured measurements as true measurements. The use of low-speed WIM will allow enforcement officers to process up to 10 times more vehicles, even with vehicle speeds constrained to 10 km/h, greatly enhancing the efficiency of commercial motor vehicle weight enforcement.

Preventing Weigh Station Bypass

In many of the countries visited, bypass of enforcement activities was discussed as a concern. Mobile enforcement activities, by their nature, are generally able to address any bypass-related challenges. As the Swiss continue to expand their permanent enforcement centers on the motorways, one future operational strategy may be to use mobile enforcement on secondary parallel routes. Both France and the Netherlands have integrated bypass considerations as part of their WIM site selection process, locating WIM systems to discourage obvious or convenient bypass (e.g., near river crossings or mountain passes).

Accommodating Legally Permitted Oversize/Overweight CMVs

Unique procedures for addressing OS/OW permitting in the countries visited focused on (1) the development and provision of Web sites allowing truck drivers to self-route based on origin, destination, and route restrictions (Switzerland), (2) the use of calibrated influence lines derived from bridge WIM to calculate safety of the bridge under the special transport using the exact axle loadings and spacing (Slovenia), and (3) the remote field verification capabilities for OS/OW movements (Slovenia).

Ensuring that intended legally permitted OS/OW vehicles are in fact legal poses a bigger challenge. In the Netherlands, it is estimated that 40 percent of special transport (e.g., OS/OW) trucks do not operate with proper credentials. Officials opted for the public relations approach (e.g., company profiling and educational contacts) rather than the enforcement approach to educate this sector of the industry. Slovenia experiences similar challenges with special transport vehicles. When observed in the field, more than 70 percent of special transports had at least one violation. When observed before transport, more than 50 percent had at least one violation. Of these movements, 47 percent of special transports were found to be overweight. The remaining percent had permit issuance or other violations.

Benefits Resulting from Technology Use

Benefits from the technologies or procedures used were largely anecdotal, and only limited quantified benefits were provided. Anecdotal benefits related to increased enforcement efficiency through the use of technology (i.e., providing greater enforcement effort with fewer human resources) were provided by Swiss, Dutch, and French representatives. The most common quantified benefit reported related to onsite enforcement efficiency—the number of overweight penalties issued (i.e., warning, citation) per total number of trucks inspected.

In Slovenia, an analysis of WIM data conducted in 2003 revealed that current static weight enforcement methods capture less than 0.5 percent of all overloaded vehicles *(www.siwim.com)*. With appropriate WIM system tolerances, the sum of overloading fines could exceed €300 million, which is about 30 times more than is collected now from static weight controls. These findings, combined with reported enhancements to enforcement efficiency, suggest significant benefits from WIM systems for preselection applications.

Comparison/Contrast with the United States

A greater use of mobile enforcement activities and few fixed roadside weigh facilities were consistently observed in the countries visited. This strategy results in a lower volume of trucks being processed and geographically and geometrically constrained inspection and offloading areas, but it provides more flexibility to respond to industry loading and routing patterns. The United States, on the other hand, relies heavily on its network of fixed facilities and less on mobile enforcement activities, although the trend is moving toward a greater use of mobile enforcement.

As in the United States, WIM system technology is commonly used in the European countries visited for real-time preselection of overloaded vehicles from the traffic stream for enforcement. In addition, many of the countries use WIM systems to (1) support scheduling of the time and location (to the extent possible) of enforcement activities (i.e., when fixed facilities should be open or when and where mobile enforcement units should be dispatched), and (2) direct carrier/company advisory notices of noncompliance (i.e., warning letter) and preventive visits. This latter application mimics the compliance reviews performed by the Federal Motor Carrier Safety Administration in the United States to enhance motor carrier safety through prevention. The use of WIM data for enforcement scheduling applications varies throughout the United States.

In many of the countries visited, bypass of enforcement activities was discussed as a concern. Mobile enforcement activities, by their nature, are generally able to address any bypass-related challenges. Hence, the countries visited may be better positioned to address bypass than the United States with its network of fixed facilities.

Unique procedures for addressing OS/OW permitting in the countries visited focused on (1) the development and provision of Web sites allowing truck drivers to self-route based on origin, destination, and route restrictions (Switzerland), and (2) the use of calibrated influence lines derived from bridge WIM to calculate safety of the bridge under the special transport using the exact axle loadings and spacing (Slovenia). In the United States, some States have developed similar routing Web sites with a focus on intrastate travel.

The primary performance metric related to commercial motor vehicle size and weight enforcement was enforcement efficiency—the number of overweight penalties issued per total number of trucks inspected. It was not uncommon to have efficiencies of more than 80 percent with WIM systems used for preselection. In the United States, the fixed-scale facilities are able to process a high volume of trucks, but few are found to be in violation (limitations to U.S. fixed-scale enforcement efficiencies include restricted hours of operation, bypassing, and storage limitations at the facility). The Netherlands is focused on achieving aggregate overload reductions through both prevention and enforcement measures.

Unique Data Applications

Real-time WIM data are used most often for preselection during mobile enforcement operations and, to a lesser extent, for scheduling the best days, times, and locations for optimum enforcement. The use of these data to support planning, historical trend analysis, policy and pricing decisions, design, structure analysis, permitting, etc., was observed to be more limited. Data quality was reported to be largely sufficient for each of the various applications (i.e., preselection, planning). The most common shortcoming noted was geographic coverage.

Data exchange and sharing within the countries visited vary, and limited data are exchanged and shared with the European Union under special efforts such as the European Control Route (ECR), an international review panel dedicated to improving commercial motor vehicle size and weight enforcement. Implementation of a European WIM database, as envisioned in the COST 323 and WAVE Projects, has not been fully realized.

CMV Size and Weight Data Collection and Use

Slovenia

Over the last 3 years and with the advent of the SiWIM system, a network of 30 data collection sites has been established to cover all major routes of the state road network in Slovenia with portable bridge WIM systems. Five SiWIM systems are used to collect data at these sites twice per year for 1 week (the same approach is used Sweden and Croatia). This network coverage has allowed Slovenia to better monitor traffic and apply this knowledge to improve roadway planning and maintenance activities.[30]

More specifically, SiWIM data—including axle loads, gross vehicle weights, axle spacing, speed, vehicle class, lane of travel, and time and date of passage—have been or are now being used to support the following activities:

- Bridge structural assessments
- Bridge safety assessments
- Aggregate and site-specific traffic loading
- Dynamic loading
- Load testing
- Road planning
- Special transport applications

Bridge structural assessments. For bridge structural assessment, three questions are of interest:

1. What is the carrying capacity of the bridge (i.e., age, condition)?
2. How does the bridge really behave (i.e., influence lines, traffic load distribution)?
3. What is the real loading (i.e., dynamic amplifications)?

Using traditional procedures, new bridges are designed very conservatively because of uncertainties about future traffic loading conditions and the expense of adding capacity after construction (i.e., adding capacity during the initial construction process is relatively inexpensive). Proper assessment and monitoring can prove that many existing bridges are safe in their current condition for their current loading, justify optimal rehabilitation measures, and save significant money on unnecessary or premature rehabilitation.

For existing bridges, capacity and loading can be measured and monitored directly using bridge WIM to avoid unnecessary or premature rehabilitations. Bridge WIM can provide both improved traffic loading data and improved structural data (to support the determination of influence lines, load distribution factors, and dynamic amplification factors). The use of SiWIM systems is being investigated as a tool for optimized assessment in a larger project, Sustainable and Advanced Materials for Road Infrastructure (SAMARIS), involving 23 partners and 16 countries.

Bridge safety assessments. Bridge safety assessments verify that a structure has adequate capacity to safely carry or resist specific loading. SiWIM system data have been used to determine current bridge capacity and safety under specific loading conditions.

Aggregate and site-specific traffic loading. SiWIM has been used to demonstrate different aggregate traffic loading patterns in various countries in Europe.

Dynamic loading. Historically, the dynamic amplification factor (DAF)—the ratio between maximum dynamic and static loadings—has been conservatively assumed in bridge structural design. The use of models to improve the accuracy of these factors is time consuming and difficult because of many unknowns. Bridge WIM can be used to improve the estimation of DAFs. In initial investigations, the DAFs using SiWIM data for extreme load cases are considerably lower than those specified in the design codes.

Load testing. Load testing of bridges is required when (1) seemingly sufficient bridges fail to pass assessment calculations, (2) bridge models do not adequately match the behavior of the real bridge (i.e., optimization of the structural model), or (3) data about the bridge structure are insufficient. Load testing can optimize bridge assessment by finding reserves in load-carrying capacity, often resulting in less severe rehabilitation measures, fewer traffic delays, and significant cost savings. Traditional load testing, using preloaded vehicles, is costly to perform and may result in damage to the structure. SiWIM systems can support "soft" load testing using normal traffic data and the observable structural behavior of the bridge.

Road planning. Traffic loading calculations to support road planning typically rely on the use of expansion factors applied to finite traffic count samples. These factors are often obsolete and do not account for overloading. In Slovenia, traffic loading estimates using SiWIM system data compared to estimates using traditional traffic loading calculation methods differ in the range of minus 10 percent to plus 278 percent (e.g., in the worst case, the pavement carried almost three time heavier traffic loading than was planned during its design).

Special transport applications. SiWIM systems are being used to calculate the safety of a particular bridge or bridges under special transport loading using the exact axle loading and axle spacing. In addition, these systems are being used to field verify OS/OW movements remotely.

Switzerland

In Switzerland, commercial motor vehicle weight and size data are collected at the national level and compiled in FEDRO's Road Traffic Management Information System (MISTRA) database. The WIM-system data include axle configuration, vehicle type, individual axle load, and gross vehicle weight. Only vehicles weighing in excess of 3.0 metric tons are stored (calibration is limited to vehicles over 3.5 metric tons). These data are voluntarily shared with internal customers, research institutes, contracted engineer offices, and domestic and international customers. There are no regulation-based data-sharing obligations.

Historically, these data have been used to support the following:

- Preselecting overweight vehicles during enforcement activities
- Determining the need for enforcement of overloaded vehicles
- Determining damage factors and road usage for dimensioning roads and bridges, with a particular focus on trans-Alpine goods traffic
- Renovating engineering structures
- Attaining the Swiss Transitioning Policy (i.e., Goods from Road to Rail)
- Related research efforts

The sufficiency of data quantity (i.e., geographic coverage, sample sizes) and level of detail are the topics of investigations as part of WIM Concept Switzerland. With these investigations still underway, no formal guidance or standards exist on commercial motor vehicle size and weight enforcement data collection and quality.

Germany

WIM system data, available from 40 sites in Germany, are largely used to support statistical reporting and special scientific investigations. Aggregate data include axle and gross vehicle weight frequencies in several load classes and the number of overloaded vehicles, in addition to more routine traffic data.

Data collected from the Toll Collect system in Germany are largely underused. This newly introduced system has significant potential to provide systemwide, route-specific, or segment-level commercial motor vehicle data. When asked if the data were being used for any purpose other than administering tolls, Toll Collect representatives indicated that the government owned and would determine the future of the data. Data are being captured and stored, however, with the understanding that there may be a potential future application outside of toll collection.

The Netherlands

In the Netherlands, commercial motor vehicle size and weight data from six sites are collected in a central database maintained by the Ministry of Transport. These data are provided, by request, in a variety of formats

(Microsoft® Excel®, Adobe® PDF, XML, HTML) and unfiltered or filtered according to vehicle size, vehicle weight, vehicle status (e.g., overweight), vehicle class, etc., depending on need.

At least weekly, the quality of the data is reviewed. A data quality statement is issued each week to police officials, who use the data to schedule their mobile enforcement efforts. These quality statements include the number of axles measured and compared to static weights, the period of measure, and the inaccuracy for every weigh point. If any unusual change in data quality is observed, the problem can be quickly remedied. In general, vehicle classification data have error rates ranging from 2 to 4 percent. Error rates for the WIM system cannot exceed plus or minus 2 percent for speed and plus or minus 15 percent for axle load for 95 percent of the vehicles measured (in aggregate).

While the data quality is carefully monitored, the limited geographic coverage precludes a wider application of the data. Example applications, should more WIM systems be installed nationally, include monitoring of the following:

- Overloaded heavy freight vehicles on the national level
- Goods traffic on the national level (not just overloaded vehicles)
- Transportation of dangerous goods on the national level (WIM can be used to identify hazardous material transporters and pull them in for either further inspection or identification)

The Dutch recently used the data from the WIM/VID systems to monitor special transports via desk research. Nearly 40 percent of the special transports observed did not, in fact, possess the appropriate paperwork. In this application, these observations were viewed as an educational opportunity.

Recently, Rijkswaterstaat (part of the Ministry of Transport, Public Works, and Water Management) started to more actively monitor the effectiveness of commercial motor vehicle size and weight enforcement efforts, identify any related problems and needs, and work with partner agencies to resolve issues. This effort, entitled the Business Intelligence Monitoring WIM (MoWIM) Project, provides a mechanism for assimilating, monitoring, and mining WIM data and generating guiding reports to help achieve the project's objectives of reducing overloads by 20 percent per year on the national highway network (in the proximity of WIM systems only).

As part of this project, monthly reports from the National Police Agency, the Transport Inspectorate, and the Ministry of Transport are entered into the MoWIM database. Reports include the following:

- Total GVW and axle overloads by month, WIM site, and type of vehicle (used to direct officer-based selection procedures)
- Number of static measurements per employee per week, month, and location (used more to evaluate enforcement site functionality (i.e., how far do trucks have to travel to reach the site?) than officer performance).

A reduction over time in the amount and frequency of weight overages suggests benefits from enforcement efforts.

Belgium

In the Walloon Region, the Ministry of Infrastructure and Transport has developed a long-term policy for collecting detailed traffic data on roadways under its jurisdiction. This data collection activity is being largely accomplished by the six WIM systems now in operation. These systems provide reliable statistics on heavy goods vehicle traffic and the weights transported, supporting roadway design and maintenance efforts in the region.

France

France has an extensive national traffic monitoring system, SIREDO (Systeme Informatise de REcueil de DOnnées), that collects data to support both real-time traffic monitoring and non real-time transportation planning. SIREDO includes a national network of 1,830 data collection stations, 170 of which include WIM systems for weight capture. Loops and pressure cells are used to count vehicles and axles and to record speed, vehicle length, headway, and mean speed. Some stations also collect weather information and axle weights. The geographic coverage and the level of data available from SIREDO are unparalleled in the other countries visited.

For statistical planning purposes, the Ministry of Transport receives summary reports annually or more frequently by request. Other data applications require more frequent reports, and data are transmitted to traffic management centers every 6 minutes for near real-time display. France has also explored alternative uses of WIM data. Jacob explored the use of WIM data to (1) support the calculation of fatigue damage and bridge lifetimes, (2) calibrate the conventional fatigue load models in the codes (and Eurocodes), and (3) check existing bridge reliability.[31,32,33]

Altogether, most of the motorway concessionary companies installed about 50 WIM systems on the network to collect weight data throughout the year. The data are used to assess heavy vehicle traffic intensity and loads and to plan pavement maintenance or replacement operations. Moreover, these data provide useful tools for the motorway operation.

Comparison/Contrast with the United States

Similar to the United States, European countries use real-time WIM data most often for preselection during enforcement operations. With few exceptions, however, the United States has not fully realized the potential of using WIM data to schedule the best days, times, and locations for optimum mobile enforcement. One concern in the United States is that widespread use of WIM data for enforcement could disturb the integrity of the planning data (because truckers will bypass). This application was widespread in the countries visited, and this practice has only been experimentally studied in a limited fashion in the United States.

The accuracy and portability of bridge WIM systems have the potential to cost effectively generate significantly more field-based weight and load data for pavement, bridge, and asset management than is now generated in the United States. In addition, the unique data applications (i.e., special transport certification and verification) demonstrated in Europe may have merit.

Public-Private Funding

Motivation for investment in commercial vehicle size and weight enforcement is often justifiable through environmental (e.g., noise, emissions, vibration) and safety (e.g., braking and stopping distances) impact considerations. Emerging user fees (being investigated and developed as part of the European EUREKA Logchain Footprint Project) consider environmental impacts (e.g., noise, vibration, emissions) as well as infrastructure impacts for both road and rail. In the United States, primary motivators include infrastructure preservation and safety, although the basis for safety benefits is not well quantified.

Investment is also driven by a desire to maintain fair competition among industry. A noted sensitivity for fair competition among trucking companies exists in both industry and government. Industry is largely supportive of enforcement approaches, tools, and techniques that will help ensure fair competition.

A strong focus on modal shift to rail was also observed in the countries visited. Low commercial motor vehicle weight limitations, nighttime travel restrictions, and strict requirements on drivers' rest periods in Switzerland result in significant movements by rail. Rail industry unions appear to have an equal or, in some instances, stronger voice than trucking industry unions.

Unique Funding Sources

Much of the available funding to support commercial motor vehicle size and weight enforcement activities in the countries visited comes from traditional funding sources, including fuel-, heavy vehicle-, and mileage-related taxes and overweight or oversize citations and fines. Significant variability was observed in the penalty structure and fine amounts among the countries visited. Consistently, however, heavy vehicle taxes were assessed according to weight capacity rather than actual observed weight. Additional sources of more general transportation funding include a motorway vignette—a ticket purchased when a vehicle enters the country—and tolling revenues. Each of the countries visited uses some form of tolling or pricing, although the extent and nature of tolling systems varies from country to country.

The countries visited use some form of tolling or pricing to help finance roadway operation, maintenance, or improvement, with a focus on heavy goods movement. The extent and nature (i.e., public-private system operation, weight- or size-based for heavy vehicle movements) of tolling systems vary from country to country, however. None of the tolling schedules observed is based on actual or real-time weights. More often, toll schedules reflect a fixed registered weight capacity (e.g., trucks greater than 12 metric tons) and do not distinguish between fully loaded or empty transports. This latter trait encourages the trucking industry to operate more efficiently to avoid paying tolls for empty transports. Similarly, the fee structure for special permits generally is not based on actual or real-time weights, but instead reflects a flat-fee structure. Germany has recently implemented an extensive and advanced tolling system, Toll Collect, which has demonstrated significant success in generating revenue to support transportation systems. This system is detailed below.

In addition, emerging user fees, being investigated and developed as part of the EUREKA Logchain Footprint Project, uniquely consider environmental impacts (e.g., noise, vibration, emissions) as well as infrastructure impacts for both road and rail. More accurately assessing a user fee based on environmental impact and across different modes has the potential to recover transportation costs equitably. This effort is also described in more detail below.

Switzerland

In its *White Book Mobility 2001,* the European Union set clear targets to establish a Europe-wide road toll for vehicles weighing more than 3.5 metric tons by 2015 to encourage a mode shift to rail. Currently, only 15 percent of goods moved in Switzerland travel by rail. The technical basis for this process is to be supplied by the Eureka Logchain Footprint Project. More specifically, the Footprint project aims to deliver the scientific basis for a heavy goods vehicle (HGV) surcharge similar to that in force in Switzerland since 1998 (i.e., the Swiss Heavy Vehicle Fee, LSVA). The Footprint surcharge will consider the dynamic load of the vehicle captured through WIM, tire pressure, audible noise, ground-borne vibration, and gaseous emissions. The LSVA considers a vehicle's weight capacity rather than observed weight, distance traveled, and the European emissions rating of the engine and does not consider noise or vibration effects.(34) A similar analysis will be conducted for rail, with comparable impact measures.

Several road and rail Footprint Monitoring Sites (FMS) have been established throughout Europe. On the A1 motorway toward Bern near Lenzburg, Empa is operating a barely visible measuring station, which records the footprint of each vehicle that passes over it. The measurement station in Lenzburg is limited to heavy vehicles (more than 3.5 tonnes) only. The parameters recorded include not only dynamic load, ground vibration, and noise, but also the deformation, humidity, and temperature in various layers of the road surface. New technologies used at this measuring station include a stress-in-motion (SIM) sensor developed by Kistler that measures the tire pressure distribution over the road surface using two sensors, each consisting of 32 individual channels positioned parallel to the roadway (see figure 33). In addition, Empa developed a novel sensor that detects deformation within the road surface (see figure 34). Operated by Baas Engineering, a measuring station for rail has been installed in Zevenhuizen, Netherlands, to systematically measure the environmental footprint of rail vehicles, based on the same criteria as those to be applied by Empa in Switzerland. This allows road and rail transport to be compared on an equal basis.

With a focus on heavy trucks, preliminary observations from the Footprint Project at the A1 motorway site include the following:

- Maximum axle load, gross vehicle weight, vibration, and noise do not occur simultaneously (i.e., the noisiest vehicles are not the heaviest vehicles).
- For road vehicles, axle load, European gas emissions rating, and noise should be used as environmental friendliness criteria (vibration effects will continue to be investigated at alternate sites but did not exceed problematic thresholds at this site).
- Axle load is the preferred dynamic load metric for determining environmental effect rather than gross vehicle weights because high gross vehicle weights do not coincide with high axle loads. Maximum axle loads are caused by four-axle vehicles.
- Axle loads less than 10 metric tons are considered environmentally friendly. Further investigation will be conducted for axle loads in excess of 10 metric tons to determine the extent of damage.
- Even at the most conservative limits for vibration effects (ranging from perception to architectural damage), ground-borne vibrations were not problematic.
- Noise levels, however, have been observed to be problematic. No trend was observed between either axle load or gross vehicle weight and noise. Hence, it was recommended that noise from road vehicles be considered as a separate factor from WIM, vibration, and gas emissions. Noise emission is primarily caused by Swiss Class 8 and 9 vehicles.

Figure 33. *Switzerland: Eureka Logchain Footprint Project test site.*

Figure 34. *Switzerland: Eureka Logchain Footprint Project test site.*

Research institutions, governmental bodies, and companies from eight European Union countries are also participating in the overall project, with the United Kingdom acting as project coordinator. Data from the Swiss and Dutch measurement stations and other sources will be used to develop cost evaluation models. At the close of the 3-year study, data will be provided to support development of a pan-European heavy goods vehicle surcharge, with its value determined by the unique environmental effects of a particular vehicle.

Germany

In January 2005, a new toll system was introduced on 12,000 kilometers of German autobahn for all trucks with a maximum weight capacity of 12 metric tons and above. Previously, Germany had only a few bridges or tunnels that were tolled. Before the implementation of this toll system, toll roads totaled 24,000 kilometers in Europe. An increase of 50 percent in tolled road kilometers was accomplished through the addition of a single additional toll operator. The system is operated by Toll Collect, a consortium formed by DaimlerChrysler, Deutsche Telecom, and Cofiroute. Toll Collect levies tolls on behalf of the government through a public-private partnership. Toll Collect is contracted for services to the Federal Ministry of Transport, Building, and Housing's Federal Office of Goods Transport. Toll Collect returns toll revenue to the government each night before midnight for more than 800,000 trucks in the system. Private industry, which provided funding to establish Toll Collect, obtains returns on investment.

Tolls, based on the distance driven in kilometers, the number of axles, and the emission category of the truck, vary from 9 to 14 eurocents (10 to 16 U.S. cents) per kilometer, with higher tolls during congested traffic conditions to encourage truckers to avoid congested highways. The tax is levied for all trucks with a weight capacity of 12 metric tons and above using German autobahns, whether they are traveling full or empty. This latter policy—charging the same toll rate for both empty and full runs—encourages the trucking industry to become more efficient in its operations by reducing the number of empty runs. Toll Collect estimates a 15 percent reduction in empty runs and a 7 percent jump in container traffic on the nation's railroads.

Some discussion is underway on the tolling of lighter trucks (7.5 to 12 metric tons). While European law allows tolls for truck with a weight capacity of less than 12 metric tons, Germany is concerned about a greater volume of heavy trucks using bypass routes (secondary roads, design, congestion, etc.) to avoid tolls.

The German system is the first to use advanced Global Positioning System (GPS) technology to collect tolls depending on the weight of a truck and the route it uses. The toll system operates via several methods:

- Onboard units (OBUs)
- Manual payment terminals
- Internet

OBUs work via GPS and the onboard odometer or tachograph as a backup to determine how far the trucks have traveled by reference to a digital map and the Global System for Mobile Communications (GSM) to authorize the payment of the toll via a wireless link. The GPS system is supplemented with mobile beacons in a few locations (e.g., tunnel locations, locations where parallel routes exist) for real-time differential correction for travel distance. Trucks on a nontoll parallel route may be incorrectly detected because of GPS inaccuracies.

The GSM network provides cellular communication with the vehicle that is not necessarily in real time. If communication fails initially because of black areas, another attempt is made later. Communication with the trucks occurs over the cellular network, resulting in costs associated with roaming and communication activities. It is not clear, at this time, who should pay for these costs—the user or the government.

As of January 2005, more than 300,000 vehicles had been fitted with OBUs. The target for the end of the year is more than 500,000. The user does not pay for the OBU, but does pay for installation. Service providers do not charge a fixed fee for installation, so users can negotiate an installation rate. Toll Collect defined an appropriate timeframe for installation as 3 to 4 hours, and the average cost for installation is €50 to €70 per hour. Because the installation of OBUs has a dramatic effect on the accuracy and success of the system, Toll Collect selected 1,900 service partners and trained them in proper OBU installation. Only these service partners are certified and allowed to install the Toll Collect OBUs. The number of service partners will go down as truck manufacturers include OBUs in new truck designs. About two-thirds of the vehicles obtaining OBUs are German and the remaining one-third are foreign. The OBU will also be able to work with the new Galileo satellite system, which is being developed in Europe as a more accurate alternative to GPS and is expected to be fully operational in 2008.

Manual payment is available for vehicles not equipped with an OBU. There are more than 3,500 toll payment terminals at motorway service stations or rest areas where drivers can enter the details of their journey, pay the toll in advance (in euros only if it is cash, or with a credit card or oil company/fuel card), and receive a ticket receipt. Drivers who would like to pay the toll well in advance have the option of paying via the Internet.

Toll operators report that the manual payment terminals and Internet access were important for the interim implementation of the program. As confidence in the system grew, more trucking industry representatives were willing to use OBUs. Since inception, the use of OBUs among the trucking industry has gradually increased from 72 percent to more than 99 percent. The use of other methods, including manual payment terminals or the Internet, has decreased comparatively.

Toll Collect's first-year toll revenue was U.S.$3.5 billion. Comparatively, the project's reported development and implementation costs were $9.8 billion, with an expected service life of 12 years. Annual program operating costs are estimated at $944 million. Many of the development and maintenance activities result from the need for an accurate digital roadway network map. Toll Collect surveyed and digitized the entire network of 24,000 km of roadway, 2,600 junctions, 600 parking areas and service facilities, and all parallel roads in a corridor 250 meters to the right and left of the motorway. Toll Collect personnel regularly drive and survey the motorway network to ensure accuracy.

With this level of effort, Germany reports a high system accuracy (i.e., the system correctly identifies the vehicle and assesses a toll) of 99.2 percent. A 0.1 percent change in accuracy (e.g., 99.2 to 99.3 percent) results in a €2.5 million increase for government. Toll Collect receives a bonus for improved accuracy. Of the 1.4 billion toll statements processed, about 9,000 resulted in claims. None of these claims, however, has been successful. The tolls collected are used by the government on road improvements and new road construction, 51 percent to fund road infrastructure projects and 49 percent to fund improvements on the rails and inland waterways.

Private Sector's Role in CMV Size and Weight Enforcement

Commercial motor vehicle size and weight enforcement is almost always the responsibility of the public agencies (either police or transportation) with few exceptions (the Netherlands, Slovenia, and Germany use some limited-authority enforcement personnel). Tolling activities have a higher involvement of private management partners.

Several countries visited demonstrated a higher reliance on private contractors to set up commercial motor vehicle size and weight enforcement systems, maintain software, process, etc. For example, public enforcement officials in Slovenia rely heavily on private CESTEL personnel to transfer, install, and operate the portable bridge WIM systems, process data for mobile enforcement scheduling and dispatch, perform remote field verifications for OS/OW movements, and more. This involvement of private agencies frees up public personnel to focus on enforcement activities. In the United States, private industry is more often involved through supply contracts than service contracts.

Trucking Industry's Role in CMV Size and Weight Enforcement

A noted sensitivity for fair competition among trucking companies exists in both industry and government. Industry is largely supportive of enforcement approaches, tools, and techniques that will help ensure fair competition. Despite industry support of enforcement efforts in the interest of fair competition, direct participation from the trucking industry to address commercial vehicle size and weight enforcement challenges was observed to be minimal. The Netherlands actively sought solutions from the trucking industry for size and weight enforcement challenges without any initial actionable feedback. Over time, the Dutch trucking industry has responded to enhanced commercial motor vehicle size and weight controls (e.g., through the use of WIM and WIM/VID systems) by developing new or adapting existing vehicle configurations (e.g., including additional axles) to increase compliance.

Unlike in the United States, where qualifying members of the commercial motor vehicle industry can pay a voluntary fee to participate in a weigh station bypass program, the commercial motor vehicle industry in the countries visited does not have an opportunity to participate in a similar program. A strong focus on modal shift to rail was observed in the countries visited, so programs that would benefit movement by truck would be counter to efforts to encourage rail transport. Rail industry unions appear to have an equal or, in some instances, stronger voice than trucking industry unions. European rail infrastructure is largely government owned and operated. The Netherlands also reported a heavy reliance on inland waterways for moving freight.

Comparison/Contrast with the United States

More than the United States, the countries visited use some form of tolling or pricing to help finance roadway operation, maintenance, or improvement, with a focus on heavy goods movement. The extent and nature of tolling systems vary from country to country, however. None of the tolling schedules observed is based on actual or real-time weights. More often, toll schedules reflect a fixed registered weight capacity and do not distinguish between fully loaded or empty transports. This latter trait encourages the trucking industry to operate more efficiently to avoid paying tolls for empty transports. Similarly, the fee structure for special permits generally is not based on actual or real-time weights, but instead reflects a flat fee structure.

Motivation for investment in commercial vehicle size and weight enforcement is often justifiable through environmental (e.g., noise, emissions, vibration) and safety (e.g., braking and stopping distances) impact considerations. In the United States, primary motivators include infrastructure preservation and safety, although the basis for safety benefits is not well quantified.

Like in the United States, European industry and government are sensitive to fair competition among trucking companies. Industry is largely supportive of enforcement approaches, tools, and techniques that will help ensure fair competition. Despite support of enforcement efforts in the interest of fair competition, trucking industry participation in addressing commercial vehicle size and weight enforcement challenges was observed to be minimal.

A strong focus on modal shift to rail was observed in the countries visited. Rail industry unions appear to have an equal or, in some instances, stronger voice than trucking industry unions. Unlike in the United States, European rail infrastructure is largely government owned and operated.

Several countries visited demonstrated a high reliance on private contractors in a service capacity (e.g., setting up systems, maintaining software, processing data). In the United States, private industry is more often involved through supply contracts than service contracts.

Harmonization Approaches

A common goal or priority in decisionmaking among the countries visited is consistency within the European Union while maintaining each country's economic interests. This goal applies not only to commercial motor vehicle size and weight enforcement activities, but also to tolling.

European Union's Role in CMV Size and Weight Enforcement

The major focus of initial related EU efforts was on developing free competition and interoperability of transportation systems, including promoting the development of necessary infrastructure and consistency in member nation laws. In addition, the European Union identified priority investment projects that would best enhance the connectivity and interoperability of the European transportation system. These projects originally focused on infrastructure development, but more recently included system management and intelligent transportation system (ITS) integration. The European Union has also supported research efforts, including the COST 323, WAVE, and REMOVE Projects. Perhaps most important, however, the European Union has been advantageous for transportation in its collective efforts to reduce cross-border obstacles and raise transportation issues to international and national political levels.[(2)]

EU directives are developed by a codecision process involving the European Parliament (EP) and the European Commission (EC) or through a single commission agreement. When developed, the directives are communicated to member states, who must implement the directives in their operations. Member states are required to inform the EC of compliance and implementation. If a directive is not implemented effectively within the allotted time, a member state may be brought before the European Court of Justice.

A key directive related to commercial motor vehicle size and weight enforcement is Council Directive 96/53/EC, which defined the maximum authorized weights and dimensions for commercial motor vehicles traveling between EU member states. This directive was amended by Directive 2002/7/EC, but the amendment only affected the authorized bus dimensions and made no changes to truck dimensional limits. These directives apply to Class M2 and M3 vehicles (i.e., passenger transport with more than nine seats, including the driver) and Class N2 and N3 vehicles (i.e., trucks in excess of 12 metric tons). These directives provide maximum length (for various vehicle types and combinations), width, and height. Noncompliant vehicles registered before September 1997 are allowed to operate under a grandfather clause, but no new vehicles registered after 2006 (a transition period was allowed) will be allowed to operate without meeting the length, width, and height requirements.

In addition, these directives define the maximum gross vehicle and axle or axle group weights for international travel. Country limits for national (intrastate) travel can be higher. For example, international traffic is limited to 40 metric tons, while Belgium allows legal gross vehicle weights of 43 or 44 metric tons, based on the type of suspension. Member states may also limit the weight or dimensions of vehicles on certain roads or civil structures in a nondiscriminatory way (e.g., because of construction, weather, bridge structural constraints). Abnormal transports are allowed only for indivisible loads and through a special permit process.

Member states may allow vehicle or vehicle combinations used for goods transport to exceed the maximum authorized dimensions for certain national transport operations that do not significantly affect international competition. For example, the Nordic countries pushed for special national transport for logging operations. Had logging companies in other countries been adversely affected, this could have been problematic.

The European Union does not actively monitor the application of directives. Once implemented, the member states are required to enforce the directives within their countries. No monitoring or reporting obligations to the European Union on day-to-day operations exist. Usually, the European Union is notified of a problem through the complaint process. When a complaint is filed, the appropriate European Commission notifies the member state involved, requests an explanation, and, if appropriate, initiates an infringement procedure for nonapplication of an EU directive. This process follows a judicial procedure through the EU Court of Justice.

State of Harmonization Within and Among EU Members

Commercial vehicle size and weight limits are largely harmonized between member countries for cross-border travel. Country-imposed limits for national travel vary for each country, but must not be lower than EU requirements except in cases where the infrastructure along secondary roads cannot support the load. Each country is obligated to enforce both its own and EC commercial motor vehicle regulations. The Committee on Transport and Tourism (XI) under the European Parliament has made significant strides in establishing a legal framework for uniformity. In general, the Transport and Tourism Committee is responsible for matters relating to the development of a common policy for rail, road, inland waterway, maritime, and air transport and in particular for (1) common rules applicable to transport within the European Union, (2) the establishment and development of trans-European networks in the area of transport infrastructure, (3) the provision of transport services and relations in the field of transport with third countries, (4) transport safety, and (5) relations with international transport bodies and organizations *(www.europarl.eu.int/activities/expert/committees/presentation.do?committee=1242&language =EN).*

Harmonizing citation rates was reportedly not feasible because of the unique economic status and structure in each member country. Each country's fee and fine structure and resulting revenue generated by commercial motor vehicle size and weight violations are inextricably related to the country's reliance on this revenue to support transportation developments, operation, and maintenance. If the fee and fine structure could be empirically related to some metric, such as pavement damage, potential was thought to exist for harmonization. Differences in pavement designs and consequent damage were reportedly less variable than economic status and structure.

Notable Harmonization Measures

Historically, a landmark effort by the Transport and Tourism Committee included the *International Convention on the Harmonization of Frontier Controls of Goods,* which was signed at Geneva, Switzerland, on October 21, 1982; approved on behalf of the European Community by Council Regulation (EEC) on April 10, 1984; and entered into force on September 12, 1987. The Harmonization Convention introduced measures designed to facilitate and develop international trade through harmonization (where appropriate) of various frontier controls and the removal of technical obstacles to the movement of goods.[35]

An example in this convention is the International Vehicle Weight Certificate (IVWC). The objective of the IVWC is to facilitate border-crossing procedures and, in particular, to avoid repetitive weight measurements of motor vehicles en route. If a vehicle is weighed in a certifiable fashion at the start of a trip, presentation of the IVWC would eliminate additional weight check stops for the duration of the trip. Authorities may still perform random checks and controls in the case of supposed irregularities. The use of the IVWC by transport operators is optional. As drafted in 1982, the weighing instruments must conform to one of the following to be certifiable:

- OIML Recommendation R 76 "Non-automatic weighing instruments," accuracy class III or better.
- OIML Draft Recommendation "Automatic instruments for weighing road vehicles in motion," accuracy classes 0.5, 1, 2, or better, resulting in maximum permissible errors of plus or minus 2 percent, 1 percent, and 0.5 percent or less. Higher error values may apply in the case of individual axle weight measurements.[35]

More recently, the COST 323 action provided the European WIM system specification calling for tender and test-based acceptance procedures. This prestandard provides common and widely accepted procedures used by all parties since its inception in the late 1990s. Some efforts are underway through the EUREKA Logchain Footprint Project and FEHRL to move toward a process of WIM standardization in Europe.

A single additional noteworthy example of harmonization was uncovered. Historically, legal truck weights in Switzerland were lower than weight limits in most of the rest of Europe. Until 2000, Switzerland did not allow truck weights over 28 metric tons, while in Europe the weight limit was 40 metric tons. Switzerland is not an EU member, but the Swiss truck weight limit was made consistent with the European standard through a negotiated agreement. In return, the Swiss raised the heavy vehicle tax (LSVA) from $90 to $200 per truck to compensate for additional road damage. Even with this increased cost, it is cheaper for German and Italian truck freight movement to go through Switzerland.[2]

The Swiss continue to deemphasize road travel by encouraging the piggybacking of heavy vehicles on rail cars for transit through the country. Trucks moved in this fashion carry loads that are by Swiss law too heavy but are legal outside of Switzerland. Such vehicles are placed on trains to traverse the country and continue their movement by road.[2]

Coordination/Communication Procedures and Challenges

Coordination and communication among EU member states is facilitated through multinational organizations such as the Forum of European National Highway Research Laboratories (FEHRL), the European Traffic Police Network (TIPSOL), and the European Control Route (ECR).

Forum of European National Highway Research Laboratories

FEHRL is a consortium of national highway research institutes focused primarily on Europe, with interest in increased partnership and information exchange with the United States and China. FEHRL is the primary conduit to European programs. The Sixth Framework Program research budget is €20 billion. In the Seventh Framework Program, the budget will increase to €50 billion, with €6 billion dedicated to transport research.

FEHRL is funded through a membership fee. Advantages for member states include access to technical expertise, available dedicated research personnel, enhanced efficiency through cooperative research, and enhanced collaboration with other nations. In all, 29 research centers participate with the intent of cooperating while maintaining identity (i.e., languages, political climates). Because of its multinational involvement, FEHRL can maintain a holistic approach that extends beyond the EU member states to all of Europe and elsewhere in the world. FEHRL recently developed SERRP IV, a plan that defines a strategic direction for research for 2006 to 2011. The road directorates in each country are FEHRL's most important customers. The challenge in working with road directorate partners is that they feel significant pressure to react to current situations and are afforded less time to plan for the future. To work effectively with these customers, FEHRL must simultaneously address immediate concerns while helping them plan and prepare for the future. FEHRL is also looking to increase partnerships with industry.

Research related to commercial motor vehicles makes up about 10 percent of FEHRL's research efforts. This proportion is expected to increase to 25 percent in the future. In SERPP IV, commercial motor vehicle research will focus on the development of network-level systems capable of supporting heavy vehicles (i.e., in excess of 60 metric tons), considering issues of restrictions for bridges, tunnels, steep grades, and congested or environmentally sensitive environmental areas. In a related effort, the recently initiated Heavy Route Project focuses on intelligent route guidance for heavy vehicles. FEHRL's role in the project, slated for completion in 2009, is to demonstrate the value of the research and product, while NAVTEQ will develop a route guidance/mapping product. Road directorates may remain skeptical until proof of concept is achieved.

European Traffic Police Network

Eight member countries and three observing countries are represented in the European Traffic Police Network (TISPOL, *www.tispol.org).* TISPOL's mission is to improve traffic safety in Europe by arranging continuous exchange of knowledge, experience, and best-practice information among European police departments. TISPOL coordinates several annual European traffic controls and vehicle spot checks. In 2006, for example, two heavy truck spot-check events and two bus spot-check events were conducted:

- Operation Mermaid *(www.tispol.org/news/articles/mermaid2006/)*
- Operation Bus *(www.tispol.org/news/articles/operationbus2006/)*

European Control Route

The European Control Route (ECR, *(webcomite.com/ecr/)* is an international review panel or working group dedicated to improving commercial motor vehicle size and weight enforcement. ECR is composed of representatives of the transport ministries or inspection bodies from the Benelux countries, France, and Germany. The United Kingdom, Spain, and Ireland are observing countries. ECR consists of a steering committee and a number of working groups focused on particular aspects of commercial vehicle operation (e.g., driving and resting periods, transport of hazardous substances, overloading). The ECR objectives are the following:

- Exchange information (e.g., the number and methods of surveillances or violations, potential for national legislation).
- Cooperate in enforecment activities (e.g., joint surveillances in the field of driving and resting periods of buses).
- Share information about national organizations, procedures, rules, and regulations in the various countries.

Comparison/Contrast with the United States

A common goal or priority in decisionmaking for the countries visited is consistency within the European Union while maintaining each country's economic interests. In the United States, States operate more independently and with less regard for harmonization with bordering States or countries.

Similar to the National Association of Chiefs of Police or other law enforcement organizations in the United States, the European Traffic Police Network (TIPSOL) provides a framework for multinational, coordinated highway enforcement actions.

In general, a greater focus on coordinated research efforts exists among EU member countries than among U.S. States. The European Union and FEHRL provide the framework for administration of large-scale, multiyear coordinated research efforts.

Recommendations

Team Recommendations

Based on its general findings and observations, the scan team ranked a preliminary list of European commercial motor vehicle size and weight enforcement technologies and procedures as having "high," "medium," or "low" interest levels for implementation consideration in the United States. These relative rankings did not recommend implementation of the various technologies or procedures, but instead provided an indication of the interest in further investigation.

After the scan, the scan tour implementation team (STIT) focused on implementation opportunities assigned a high interest level and worked further with scan team members to prioritize the 17 initial opportunities included in this category. Some opportunities were later combined because of perceived overlap. Through this process, the STIT identified seven specific implementation opportunities as having the greatest potential benefit to U.S. commercial motor vehicle size and weight enforcement procedures:

- Slovenia bridge weigh-in-motion (Slovenia, France)
- Swiss heavy goods vehicle control facility (Switzerland)
- Prescreening for mobile enforcement (Slovenia, Switzerland, the Netherlands, France)
- Applying WIM for direct enforcement: a template for implementation and certification (France)
- Behavior-based enforcement activities (the Netherlands, France)
- Synthesis of safety implications of oversize/overweight commercial vehicles (Belgium)
- Effective use of WIM data: the Dutch case study (the Netherlands)

Specific strategies for advancing these implementation opportunities were also identified, with various scan team members assigned supporting action items. These implementation opportunities and strategies are detailed below.

Slovenia Bridge Weigh-in-Motion (Slovenia, France)

B-WIM was initially identified in the late 1970s in the United States and developed in the WAVE Project. European researchers continued to advance field testing and applied research of the concept, leading to its widespread deployment in Slovenia. B-WIM is a vital component of Slovenia's commercial motor vehicle weight monitoring system and is used to prescreen commercial vehicles for weight enforcement purposes. SiWIM in Slovenia was developed and implemented through a partnership between staff at the National Building and Civil Engineering Institute's (ZAG) Research Department and a private engineering firm, CESTEL. Deployment of Slovenian SiWIM targets short-deck (5- to 10-meter) orthotropic bridges. Extensive research into the bridge deck's reaction to weights has led to the ability to estimate, within acceptable levels of accuracy for prescreening, a vehicle's static weight. Analysis and data collection leading to this capability centered on the behavior of the "influence line" when truck weights are applied to the bridge's deck. Weight-detection instrumentation is applied at the under-deck location of the structure, eliminating the need to disrupt traffic flow during installation. Multiple sensors are used to monitor travel lanes, and a sensor data hub or cabinet feature draws readings from the individual sensors and generates a composite of the deck loading readings. Axle weights, gross vehicle weights, axle spacing, vehicle speed, and vehicle class are captured through this data collection approach.

The Netherlands is analyzing its inventory of structures to determine the number and location of bridges where B-WIM could be deployed. Recently, one bridge WIM system was installed for testing under Dutch highway conditions. In France, significant applied research efforts are concentrated on advancing the use of B-WIM on multiple-span, multiple-lane structures and steel orthotropic deck bridges. The target of research is the filtering of sensor readings from several vehicles on the bridge deck simultaneously. The scan team visited the Autreville orthotropic steel bridge site on the A31 motorway outside of Nancy, France. French hosts provided a tour of the site layout and demonstrated the SiWIM under testing.

Because it eliminates the need to disrupt traffic flow and minimizes the worker risk involved in installing traditional roadway telemetry, B-WIM was seen to possess major benefits over U.S. practices. Also, as seen in Slovenia, the time required for installation is not significant and, once bridge deck superstructures are instrumented, B-WIM is highly portable. In Slovenia, five SiWIM devices are used to collect data for 1 week at 30 locations twice a year. Applications of B-WIM in the United States would enhance prescreening capabilities for commercial motor vehicle weight enforcement, as well as provide important information to bridge management systems. The choice of a suitable bridge and the development of an appropriate instrumentation plan and related calibration procedures may be challenging and require a high expertise level.

Implementation Strategy (George Conner, Pam Thurber, and Randy Woolley)

- Obtain detailed site layout specifications from Slovenian contacts.
- Synthesize the French experience and analyze the accuracy and performance results.
- Prepare and deploy a one-page information sheet presenting a compelling case for pursuing B-WIM implementation in the United States.
- Present findings at AASHTO's Bridge Conference.

Deliverables

- One-page information sheet detailing B-WIM requirements and benefits
- Summary of the French experience, including accuracy and performance results
- Transportation Pooled Fund Program study focusing on deployment opportunities in the United States
- Implementation of a pilot B-WIM system (i.e., potential bypass route adjacent to enforcement location)

Swiss Heavy Goods Vehicle Control Facility (Switzerland)

In an effort to protect highway tunnel facilities and roadway infrastructure from the impacts of heavy trucks, Switzerland has developed and implemented an efficient and effective approach to simultaneously measuring commercial vehicle size and weight at stationary enforcement locations. The system also includes a high-speed WIM (HS-WIM) and video (VID) technology component used to prescreen strategically selected trucks requiring additional measurements.

The scan team had the opportunity to observe enforcement procedures at the control facility outside of Bern, Switzerland. Mobile enforcement details escorted vehicles into the facility for additional measurements using the HS-WIM/VID prescreening capability. Vehicles were directed onto a weigh bridge (i.e., static scale pad instrumented with several load cell scales) that provided simultaneous axle and gross vehicle weight measurements. An overhead gantry fitted with laser scanners capable of capturing commercial vehicle length, height, and width measurements is used simultaneously.

An attractive element of the Swiss heavy goods control facility operation is the user-friendly presentation of data to enforcement officers operating the system. A horizontal line on the computer screen represents legal axle and gross vehicle weight allowances with violations clearly shown as exceeding this allowance line. Size dimensions exceeding legal allowances are highlighted in red on a three-dimensional model of the vehicle. Size- and weight-related citations are generated automatically for issuance to the vehicle operator and submission to the appropriate judiciary officials. Swiss enforcement personnel described the advantages of this system over the traditional portable scale and manual measurements efforts. More accurate measurements are achieved with less manpower, resulting in more effective enforcement in considerably less time. The Swiss operate three control centers, with additional centers in the planning and development stages. The scan team believes that U.S. deployment of such an enforcement station at key high-volume domestic or international land-crossing locations would be beneficial.

Implementation Strategy (Jeff Honefanger and Tom Kearney)

- Obtain control facility weigh bridge and laser scanner gantry specifications from Swiss contacts (i.e., number and type of load cell scales, number and type of laser scanners).
- Evaluate domestic or international land-crossing locations as possible candidates for a model deployment pilot site.

Deliverables

- List of locations viable for model deployment
- Implementation of a control facility in the United States
- Documentation of timesaving benefits realized through pilot deployment

Prescreening for Mobile Enforcement (Slovenia, Switzerland, the Netherlands, and France)

A significant level of interest exists in the United States in the use of automation tools and technology to improve the conduct of commercial motor vehicle size and weight enforcement. The scan team witnessed similar mobile enforcement activities in four of the six countries visited: Slovenia, Switzerland, the Netherlands, and France. Common features and elements were identified in each. High-speed WIM technology was used in each case for mainline prescreening of suspected overweight commercial motor vehicles. Video capture (i.e., digital photo images) of the vehicle was triggered by overweight detections. Both weight and image data were transmitted via short-range communications to enforcement personnel, allowing them to identify appropriate commercial vehicles in the traffic stream and escort them off of the mainline for further investigation. Such systems are referred to as WIM/VID in Europe. Such approaches were embraced by the COST 323 action and are used widely by EU member nations.

U.S. States use elements of this approach to varying degrees. The scan team identified the need for a comparative analysis to measure the differences between the state of the practice for mobile enforcement in the United States and that observed in European countries. The team believes that advancement of the most effective mobile enforcement practices could be supported and delivered most expeditiously once State-level variations are identified and compared to practices used in Europe.

Implementation Strategy (Ric Athey and John Nicholas)

- Survey U.S. States on mobile enforcement program components and aspects.
- Obtain specific detail on mobile enforcement tools and techniques in use from European contacts.
- Identify demonstration site(s) for a European mobile enforcement approach (may be combined with B-WIM deployment).

Deliverables

- One-page information sheet on U.S.-versus-European state of the practice
- Implementation of a pilot demonstration of the European mobile enforcement approach

Applying WIM for Direct Enforcement: A Template for Implementation and Certification (France and the Netherlands)

In many cases, the difficulty in deploying advanced technologies stems from institutional barriers. The widespread deployment and use of technologies for commercial motor vehicle size and weight enforcement require support from both the metrological bodies responsible for equipment certification and judicial bodies responsible for related legal actions. Low-speed WIM systems can be tested and certified using similar methods as static weighing equipment, making their use a logical first step toward direct enforcement. The testing and certification process for high-speed WIM systems is more complex and requires the development of new acceptance methods.

French officials are leading the effort to overcome institutional challenges to the use of low-speed WIM systems for direct enforcement (i.e., gaining acceptance from the national metrology and judiciary communities). While the French are focused on the initial acceptance of low-speed WIM systems for direct enforcement, the Dutch are focused on gaining acceptance of high-speed WIM for direct enforcement.

Because a similar development process would be required in the United States, the scan team recommended an indepth review of the French and Dutch evolutionary process for acceptance of WIM systems for direct enforcement, with a concurrent review of the U.S. direct enforcement climate and requirements.

Implementation Strategy (Jodi Carson)

- Characterize the U.S. climate toward the use of WIM for direct enforcement.
- Identify issues that must be addressed to gain metrological and judicial acceptance in the United States.
- Identify and review successful European practices on direct weight enforcement using WIM technology.
- Establish a legal basis and gain judicial support for citing overweight trucks directly from low-speed WIM initially and later from high-speed WIM.

Deliverable

- Modeled after the French and Dutch process, an outline of the required steps leading to legal acceptance of WIM technology for use in direct weight enforcement in the United States

Behavior-Based Enforcement Activities (the Netherlands and France)

Using the European WIM/VID (photo) approach of simultaneously capturing a digital image of the vehicle when an overweight condition is detected, officials in the Netherlands and France have gained additional knowledge of the trucking firms most frequently operating in an overweight condition. This information is captured continuously (i.e., 24 hours a day, 7 days a week), regardless of whether a mobile enforcement activity is taking place. Historical WIM information is reviewed, typically on a monthly basis, to determine trucking firms that most frequently engage in overloading practices. Enforcement officials contact the most frequently offending firms to encourage compliant loading behavior. Following this contact, the trucking firm then begins a probationary period. If no positive change is observed through continued monitoring by the WIM/VID systems, graduated enforcement actions are taken. France is just beginning a 3-year study to determine the effectiveness of this process.

The scan team observed that this general process is similar to the safety inspection steps routinely followed by the Federal Motor Carrier Safety Administration (FMCSA) in its oversight of trucking firms operating commercial vehicle fleets. The application of this process to commercial motor vehicle weight enforcement in the United States shows promise for firms that could have reasonably brought their loading practices into legal compliance with relevant laws.

Implementation Strategy
(Julie Strawhorn and Mike Onder)

- Obtain specific details on the behavior-based enforcement approach from Dutch and French contacts.
- Obtain estimates of approach effectiveness (i.e., percentage of reduction in the proportion of overweight trucks) from Dutch and French contacts.
- Coordinate with FMCSA officials to gain understanding of their behavior-based approach to commercial vehicle safety enforcement.

Deliverable

- One-page information sheet on the behavior-based approach to commercial motor vehicle weight enforcement in the Netherlands and France.

Synthesis of Safety Implications of Oversize/ Overweight Commercial Vehicles (Belgium)

In the United States, justification and authority for the conduct of commercial vehicle weight enforcement are vested in the public's interest in preserving highway infrastructure and promoting a climate of equity and fairness among trucking firms (e.g., not allowing violators to be rewarded at the expense of law-abiding firms). These same principles and interests were reported in each of the European countries the scan team visited. In addition, several countries visited identified safety as a primary motivator for commercial vehicle size and weight enforcement. In Belgium, officials have linked weight enforcement activities to the public's interest in safe operating conditions on the highways. After years of weight and speed data collection and analysis, Belgium officials noted direct relationships between excessive speed by overweight vehicles involved in highway accidents and the frequency of fatalities occurring in accidents including such vehicles. As such, they were able to build the case to their legislative leaders that weight and speed needed to be aggressively regulated. To control speed, governors, or speed-monitoring devices, are installed on trucks to control their maximum speed. Speed violations are treated as criminal offenses because excessive speeds can be achieved only as a result of tampering with the speed-control devices.

The scan team indicated a desire to better understand the relationship between commercial motor vehicle weight condition and safety in the United States. While public concerns about overweight vehicles impacting bridge and pavement conditions and undermining equitable trade practices are valid, the safety benefits tied to commercial vehicle weight enforcement activities need to be better defined. The scan team proposes that an assimilation of existing safety studies and research be undertaken to improve understanding.

Implementation Strategy
(George Conner and Mike Onder)

- Invite university research communities, via the University Transportation Research Consortium (UTRC) initiative, to conduct a synthesis effort on the linkages of overweight commercial motor vehicles and safety.
- Obtain detailed information on the use of safety as a compelling case for commercial motor vehicle weight enforcement from Belgium contacts.

Deliverables

- One-page information sheet describing the basis for Belgium's regulations
- Synthesis of existing research describing relationships between commercial motor vehicle weight condition and safety in the United States

Effective Use of WIM Data: The Dutch Case Study (the Netherlands)

In the Netherlands, every Wednesday morning at 7 a.m., an e-mail with an attachment detailing the frequency of truck weight violations by location, time of day, and day of the week is distributed to enforcement personnel responsible for scheduling enforcement actions and transportation personnel charged with infrastructure condition monitoring and multimodal freight planning and forecasting. The data report is a product of an extensive database management operation constructed by Dutch officials. Extensive quality control and quality assurance protocols have been built into the operation of this data management system.

In the United States, State-level officials operate data management systems to manage their highway and bridge programs and to monitor travel to support program and policy development. The scan team determined that documentation of the Dutch database management system could assist States in extracting greater value from the database systems in operation.

Implementation Strategy (David Jones and Tom Kearney)

- Obtain detailed information on the architecture and system specifications for the data model used in the Netherlands from Dutch contacts.
- Conduct a comparative scan of data management operations employed in the United States.
- Propose a National Cooperative Highway Research Program synthesis topic on WIM database management and potential enhancements.

Deliverables

- Case study report on WIM data processing, reporting, and distribution opportunities based on findings from the Netherlands
- Presentation of case study report findings at the next scheduled North American Travel Monitoring Exhibition and Conference (NATMEC)

Next Steps

Next steps include defining specific timeframes and funding requirements for implementation. Once defined, specific funding sources can be identified and secured.

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Scan Itinerary

SLOVENIA

EVENT SLO-1: Arrivals/Flights in Ljubljana; Saturday, June 17
EVENT SLO-2: Panel Meeting; Sunday, June 18/09:00-11:30; Place: Hotel Conference Room
EVENT SLO-3: Meetings/Site Visit; Monday, June 19/09:00-18:30; Place: Slovenian National Building and Civil Engineering Institute (ZAG) Offices, Dimiceva 12, SI-1000 Ljubljana, Slovenia; POC: Ales Znidaric, ZAG

Program:
9:00 to 10:30 ZAG (Dr. Andraž Legat, Director), SiWIM Technology/Applications (Ales Znidaric, Robert Brozovi), AASHTO, FHWA, and CMV Size/Weight Enforcement Panel
10:30 to 10:45 Coffee Break
10:45 to 12:15 Amplifying Question Discussion
12:15 to 13:30 Cestel/SiWIM Production Facilities Site Visit
13:30 to 15:00 Lunch
15:00 to 18:00 Postojna SiWIM Site Visit

EVENT SLO-4: Working Dinner; Monday, June 19/20:00-TBD; Place: Restaurant Stara Ljubljana
EVENT SLO-5: Meetings/Discussions; Tuesday, June 20/09:00-15:00; Place: Slovenian National Building and Civil Engineering Institute (ZAG) Offices, Dimiceva 12, SI-1000 Ljubljana, Slovenia; POC: Ales Znidaric, ZAG

Program:
9:00 to 12:30 Dean Herenda, State Undersecretary, Ministry of Transportation; Robert Sušanj, Head, Traffic Police, Ministry of Interior Affairs; Ljiljana Herga, Head, Sector for Road Maintenance, Directorate of the Republic of Slovenia for Roads
12:30 to 14:00 Lunch
14:00 to 15:00 Conclusions

EVENT SLO-6: Air Travel to Switzerland; Tuesday, June 20/18:05

SWITZERLAND

EVENT SWI-1: Meetings/Discussions; Wednesday, June 21/09:00-16:00; Place: Swiss Federal Road Administration Offices, Worblenstr 68, Ittigen, CH-3003 Bern, Switzerland; POC: Christoph Kaeser, Swiss Federal Road Administration

Program:
9:30 to 10:00 Welcome, Coffee
10:00 to 11:00 Information about FEDRO, Christoph Käser
11:00 to 12:00 Heavy Vehicle Control, Amplifying Questions, Christoph Käser
12:00 to 13:30 Lunch
13:30 to 14:30 Heavy Vehicle Control Enforcement, R. Aellen
14:30 to 15:00 Break
15:00 to 16:00 Amplifying Questions (continued), R. Aellen

EVENT SWI-2: Site Visits/Discussions; Thursday, June 22/08:30-16:00; Place: Schafisheim and Winterthur Areas; POC: Christoph Kaeser, Swiss Federal Road Administration

Program:
8:30 to 09:30 Transfer to Schafisheim (Canton of Aargau)
9:30 to 09:45 Welcome and Coffee in Schafisheim
9:45 to 11:15 R+D Project "Footprint" (L. Poulikakos), Footprint Monitoring Site Visit
11:15 to 12:00 Travel towards Winterthur
12:00 to 13:00 Lunch at Movenpick Restaurant
13:00 to 13:15 Travel to Winterthur
13:15 to 15:15 Winterthur Board of Control Site Visit

EVENT SWI-3: Air Travel to Berlin, Germany; Thursday, June 22/17:30

GERMANY

EVENT GE-1: Meetings/Discussion; Friday, June 23/09:00-12:00; Place: Offices of Toll-Collect, Linkstr 4, D-10875 Berlin, Germany; POC: Martin Rickmann, Director of Communications

Program:
9:00 to 10:00 Martin Rickmann, Status of New Toll System
10:00 to 11:00 Harald Lindlar, Satellic
11:00 to 12:30 Demonstration Tour
12:30 to 13:15 Lunch
13:15 to 14:00 Siegried Klar, Enforcement
14:00 to 15:00 Ralf Meschede, BASt—Federal Highway Research Institute
15:00 to 15:30 Q + As

EVENT GE-2: Mid-Tour Panel Meeting; Saturday, June 24/09:00-11:30; Place: Hotel Conference Room

EVENT GE-3: Train Travel to the Netherlands; Sunday, June 25/08:38

THE NETHERLANDS

EVENT NL-1: Meetings/Discussions; Monday, June 26/09:00–16:30; Place: Offices of the Dutch Ministry, Utrecht (Mobilion); POC: Hans van Loo, Road and Hydraulic Engineering Institute (DWW)

Program:
9:00 to 9:15 Hans van Saan (DWW), Welcome and Opening of the Visit
9:15 to 9:45 Jeff Honefanger (AASHTO), Julie Strawhorn (FHWA), U.S. Commercial Motor Vehicle Size and Weight Enforcement
9:45 to 10:30 Hans van Saan (DWW), Introduction to the Project Overloading and Dutch Weigh-in-Motion and Discussion
10:30 to 11:00 Coffee/Tea Break, MOBILION Exhibition Area
11:00 to 11:45 Danny van Grondelle (Dutch National Police Agency), Experience with Enforcement of Overloading using WIM as a Preselection Tool and Discussion
11:45 to 12:30 Kees Hersbach (Dutch Ministry of Transport, Freight Transport Inspectorate), Prevention of Overloading using WIM Data as a part of e-Government and Discussion
12:30 to 14:15 Lunch
14:15 to 15:15 Police Overloading Enforcement Operation Site Visit
15:15 to 16:00 Jan Kramer (National Traffic Management Centre), The Project Overloading: Cooperation among Partners to Fight Overloading and Methods for Monitoring the Results

EVENT NL-2: Working Dinner; Monday, June 26/19:00-21:00; Place: Café Diner Vlaanderen

EVENT NL-3: Meetings/Discussions; Tuesday, June 27/09:00-15:00; Place: Road and Hydraulic Engineering Institute (DWW) Offices, Van der Burghweg 1, 2628 CS Delft; POC: Hans van Loo, DWW

Program:
9:00 to 9:10 Pieter Stienstra (DWW), Welcome
9:10 to 9:45 Hans van Saan (DWW), The Use of WIM to data for Statistics and Planning, QC and Results and Discussion
9:45 to 10:30 Hans van Loo (DWW), Development of Weigh-in-Motion System for Direct Enforcement of Overloading including Calibration Vehicle and Discussion
10:30 to 11:30 Calibration Vehicle Demonstration, Coffee/Tea Break
11:30 to 12:15 Hans van Loo, Developments in the European Union; the REMOVE project and Discussion
12:15 to 13:15 Lunch
13:15 to 14:00 U.S. Cochairs, U.S. projects on WIM, Overload Enforcement and International Cooperation and Discussion
14:00 to 14:30 Govert Sweere (DWW), DWW to Experience with Participation in International (EU) Projects
14:30 to 15:00 Bert de Wit (DWW) and Mr. Jeff Honefanger (AASHTO), Julie Strawhorn (FHWA), Summary and Closing

EVENT NL-4: Ground Travel to Belgium; Tuesday, June 27/16:30-TBD

BELGIUM

EVENT BE-1: Meetings/Discussion; Wednesday, June 28/09:00-16:00; Place: Belgian Road Research Centre (BRRC), Blvd. de la Woluwe, 42, 1200 Bruxelles, Belgium; POC: Xavier Cocu, BRRC

Program:
9:30 Introduction and Tour de Table
9:35 Country, Road Network, Administrative Structure (Xavier Cocu, BRRC) Belgian Vehicles Size and Weight Rules
9:50 Goods Transportation Policies in Belgium and EU (Davy Decock, BRRC)
10:10 Weight/Size Enforcement by Federal Police: Procedure and Legislative Background (Eddy Greif, Federal Police)
10:30 Weight Enforcement by Road Inspectors in the Flemish Region: Procedure and Legislative Background (Jo Goossens, Flemish Road Administration)
10:50 Technologies in Use in Walloon Region (Xavier Cocu, BRRC); Static weighting systems; WIM System Statistical Analysis Applications
11:15 FEHRL Offices
12:00 Lunch
14:00 FEHRL Joint Research Programmes (Steve Phillips, FEHRL)
14:20 Open Discussion
16:00 Conclusion

EVENT BE-2: Ground Travel to Metz, France; Wednesday, June 28/TBD

FRANCE

EVENT FR-1: Meetings/Site Visit; Thursday, June 28/09:00–15:00; Place: Centre d'Etudes Techniques de l'Equipement de l'Est (CETE de l'Est), 1, Boulevard Solidarité BP 85230 57076 METZ Cedex; POC: Bernard Jacob, Technical Director for Road Operation and Safety, Laboratoire Central des Ponts et Chaussees (LCPC), Victor Dolcemascolo, Head of Road Operations and Equipment Section, Laboratoire Central des Ponts et Chaussees (LCPC)

Program:

10:00 to 10:15	Welcome—Presentation of the CETE Est
10:15 to 11:00	SIREDO Network—Discussions
11:00 to 11:15	Coffee Break
11:15 to 11:45	Preselection Results—Discussion
11:45 to 12:00	Multiple-sensor Weigh-in-Motion Planned Testing
12:00 to 13:30	Lunch
Afternoon:	A 31 Motorway Site Visits (Fays, Lesménil, Autreville)

EVENT FR-2: Meetings/Discussions; Friday, June 30/09:00–16:00; Place: Laboratoire Central des Ponts et Chaussées (LCPC), 58 boulevard Lefebvre 75732 PARIS Cedex 15; POC: Bernard Jacob and Victor Dolcemascolo, LCPC

Program:

9:30 to 9:45	Welcome—Tour de Table
9:45 to 10:00	LCPC
10:00 to 10:30	DGMT, Political Aspects of Overloading in France and Control Organization
10:30 to 10:50	Control Overloading in U.S.
10:50 to 11:00	Discussion and Possible Cooperation on Overloading Controls
11:00 to 11:45	European Specification COST 323, ASTM 1318
11:45 to 12:30	Low-speed WIM for Enforcement and Model Agreement
12:30 to 14:00	Lunch
14:00 to 15:00	Bridge WIM: Tools and Testing - Discussion
15:00 to 15:30	Multiple-sensor WIM: Algorithms and Grid Design - Discussion
15:30 to 16:00	Conclusions and Prospects

EVENT FR-3: Final Panel Meeting; Saturday, July 1/09:00-16:30; Place: Hotel Conference Room

EVENT FR-4: Departures/Flights to U.S.; Sunday, July 2

Amplifying Questions

Each Country

Enforcement Technologies

1. What technologies are currently used to enforce commercial motor vehicle size?
   a. Describe any problems encountered with these technologies.
   b. Describe the accuracy and reliability of these technologies.
   c. Describe any factors (e.g., inclement weather) affecting the performance of these technologies. How are these performance effects accounted for?
   d. Describe any associated maintenance requirements (including calibration) for these technologies. What guidance or standards exist for technology maintenance and calibration?
   e. Describe the manpower needed/saved by using these technologies.
2. What are some of the emerging technologies for enforcing commercial motor vehicle size?
   a. What benefits are anticipated from these emerging technologies?
   b. Have nonintrusive technologies (e.g., micro loop systems, roadside acoustic devices) been investigated or deployed? If yes, describe your experiences.
3. What technologies are currently used to enforce commercial motor vehicle weight?
   a. Describe any problems encountered with these technologies.
   b. Describe the accuracy and reliability of these technologies.
   c. Describe any factors (e.g., inclement weather) affecting the performance of these technologies. How are these performance effects accounted for?
   d. Describe any associated maintenance requirements (including calibration) for these technologies. What guidance or standards exist for technology maintenance and calibration?
   e. Describe the manpower needed/saved by using these technologies.
4. What are some of the emerging technologies for enforcing commercial motor vehicle weight?
   a. Is a favored weigh-in-motion (WIM) sensor type (e.g., quartz, fiber optic) emerging? Describe when each might be used.
   b. Is a favored WIM system type (e.g., multiple sensor, bridge, portable) emerging? Describe when each might be used.
   c. What benefits are anticipated from these emerging technologies?
5. In general, is technology playing a large or small role in commercial motor vehicle size and weight enforcement? Would you like to see the use of technology increase?

Enforcement Procedures

6. Describe how technology is currently being used in day-to-day operations to enforce commercial motor vehicle size and weight. Is technology used in place of or in unison with traditional procedures?
   a. What guidance or standards exist for integrating technology into enforcement procedures?
   b. Describe any positive or negative impacts resulting from the use of technology in day-to-day operations to enforce commercial motor vehicle size and weight.
   c. How does the use of technology and related commercial motor vehicle size and weight enforcement procedures differ for high (urban) and low (rural, intercity) traffic volume roads?
   d. Are technology-equipped, unmanned weigh stations being used to identify noncompliant commercial motor vehicles for downstream enforcement in (i) remote areas? (ii) urban areas?
7. Technology can be used to identify (i) noncompliant vehicles in real-time, (ii) consistently noncompliant vehicle types for targeted enforcement, or (iii) consistently noncompliant carriers for preventive measures. What is the more prevalent practice or combination of practices in your country? Describe your experiences.
   a. What concurrent measures (e.g., increased fines) are required for these practices to be successful?
8. Is technology currently being used for fully automated commercial motor vehicle size and

weight enforcement (to automatically identify noncompliant vehicles and issue citations)? If yes, describe your experiences.

a. If yes, who is the citation issued to and who is responsible for paying the fine (e.g., driver, carrier)?
b. If no, describe any impediments (e.g., technological limitations, legal or legislative constraints) to achieving fully automated enforcement and any plans to overcome these impediments.
c. Have any privacy issues been encountered regarding the use of photographs for enforcement?
d. Are technology performance standards to allow automated enforcement (e.g., minimum accuracy levels) well defined? If yes, please describe.

9. Describe how current commercial motor vehicle size and weight enforcement procedures and/or technologies are being used to prevent weigh station bypass.
   a. Has portable technology been used for enforcement along bypass routes? If yes, describe your experiences.

10. Describe how current commercial motor vehicle size and weight enforcement procedures and/or technologies accommodate legally permitted oversize/overweight (OS/OW) commercial motor vehicles.
    a. To what degree is technology used in the issuance and procurement of OS/OW permits (i.e., self-issuing permits)?

11. Describe any benefits (e.g., cost savings, increased productivity) resulting from the use of technology for commercial motor vehicle size and weight enforcement.
    a. How is commercial motor vehicle size and weight enforcement performance measured (e.g., number of citations issued, magnitude of size or weight exceedance in citations, aggregate reduction in average loads)?
    b. Do commercial motor vehicle size and weight enforcement personnel view technology as beneficial? Why or why not?

Unique Data Applications

12. What data related to commercial motor vehicle size and weight enforcement are currently collected?
    a. Who collects these data?
    b. Are these data routinely shared (i) within your country, (ii) with other nations, or (iii) with the European Union (EU)? If yes, who are the specific recipients?
    c. Is this data sharing optional or mandatory?
    d. Is national, county, or local funding dependent on the data results?

13. How are data related to commercial motor vehicle size and weight enforcement currently being used (e.g., to support enforcement, roadway design and construction, planning, safety, bridge analysis, permit approval, establishment of legal loads, distance-based tolling activities)?
    a. Is the data quality sufficient for these purposes?
    b. Is the data quantity (i.e., geographic coverage, sample sizes, etc.) sufficient for these purposes?
    c. Is the level of detail in the data sufficient for these purposes?
    d. What guidance or standards exist related to commercial motor vehicle size and weight enforcement data collection and quality?

Public-Private Funding

14. Are emerging technologies primarily developed in the public sector (by government), by the private sector, or though joint public-private partnerships? Describe your experiences and any notable developments.

15. Describe any ongoing roles for private sector involvement in commercial motor vehicle size and weight enforcement (e.g., collecting and processing data, calibrating and maintaining technology).
    a. What typically motivates ongoing private sector involvement in commercial motor vehicle size and weight enforcement? How is this involvement initiated and coordinated over time?
    b. Describe any positive or negative impacts resulting from ongoing private sector involvement.
    c. With respect to private sector data collection and processing, have you encountered any challenges related to data ownership or the quality of the data being collected and reported?
    d. Is ongoing private sector involvement in commercial motor vehicle size and weight enforcement cost effective?

16. In the United States, qualifying members of the commercial motor vehicle industry can pay a voluntary fee to participate in a weigh station bypass program. Does the commercial motor vehicle industry similarly invest or participate in commercial vehicle size and weight enforcement in your country? Describe your experiences.

Harmonization Approaches

17. Who determines the commercial motor vehicle size and weight limits for your country? Is commercial motor vehicle size and weight enforcement

considered a local-, national-, or international-level issue?

18. Are the commercial motor vehicle size and weight limits/regulations/laws harmonized (i) within your country or (ii) with other EU members?
    a. If no, describe the nature and source of the differences.
    b. Describe the primary challenges in achieving harmonization (e.g., physical limitations such as low-clearance bridges, narrow lane widths, narrow roadway widths; political differences focused on infrastructure preservation versus economic productivity).
    c. What notable measures has your country taken to move toward harmonization (e.g., increasing road taxes to compensate for higher weight limits)? Describe the implementation process for such measures.
    d. If yes, are associated permit processes, fine structures, electronic data transfer procedures, etc., also harmonized?

19. Describe the nature and frequency of coordination/communication among EU members and the European Union regarding commercial motor vehicle size and weight enforcement.
    a. What are recurring challenges with such coordination/communication?
    b. Are any international review panels or working groups dedicated to improving commercial motor vehicle size and weight enforcement? If yes, what legal authority is vested in such panels/groups?

20. What notable measures has the European Union taken to accommodate inconsistencies among member nations?
    a. Does the European Union set commercial vehicle size and weight standards that national governments must adopt or otherwise be in compliance? If yes, what actions does the European Union take when a sovereign state is not in compliance with a standard?
    b. Describe the market/supply chain pressures that the European Union and EU members are facing with regard to heavier and larger vehicles.

European Union

21. Is commercial motor vehicle size and weight enforcement considered a local-, national-, or international-level issue?

22. Are the commercial motor vehicle size and weight limits/regulations/laws harmonized among EU members?
    a. If no, describe the nature and source of the differences.
    b. Describe the primary challenges in achieving harmonization (e.g., physical limitations such as low-clearance bridges, narrow lane widths, narrow roadway widths; political differences focused on infrastructure preservation verses economic productivity).
    c. If yes, are associated permit processes, fine structures, electronic data transfer procedures, etc., also harmonized?

23. Describe the nature and frequency of coordination/communication among the European Union and EU members regarding commercial motor vehicle size and weight enforcement.
    a. What are recurring challenges with such coordination/communication?
    b. Are any international review panels or working groups dedicated to improving commercial motor vehicle size and weight enforcement? If yes, what legal authority is vested in such panels/groups?

24. What notable measures has the European Union taken to accommodate inconsistencies among member nations?
    a. Does the European Union set commercial vehicle size and weight standards that national governments must adopt or otherwise comply with?
    b. If yes, what actions does the European Union take when a sovereign state is not in compliance with a standard?

25. Describe the market/supply chain pressures that the European Union is facing with regard to heavier and larger vehicles.

26. How does the commercial motor vehicle industry manage differences in size and weight limitations and subsequent enforcement among nations?
    a. How are complaints from commercial vehicle operators received? Is there a formal process available to carrier industry officials to voice concerns?
    b. In cases where complaints are international by their nature, how is coordination across national boundaries conducted?

Commercial Motor Vehicle Industry

27. How does the commercial motor vehicle industry manage differences in size and weight limitations and subsequent enforcement among nations?

28. How are complaints from commercial vehicle operators expressed? Is there a formal process available to carrier industry officials to voice concerns?
29. In cases where complaints are international by their nature, how is coordination across national boundaries conducted?
30. In the United States, qualifying members of the commercial motor vehicle industry can pay a voluntary fee to participate in a weigh station bypass program. Does the commercial motor vehicle industry similarly invest or participate in commercial vehicle size and weight enforcement in your country? Describe your experiences.
31. Development is underway for fully automated commercial motor vehicle size and weight enforcement (to automatically identify noncompliant vehicles and issue citations). Is the commercial motor vehicle industry generally supportive of this strategy? Why or why not?

Scan Team Biographies and Contact Information

Biographies

Jeff G. Honefanger *(AASHTO cochair)* is the manager of the Ohio Department of Transportation (ODOT) Special Hauling Permits Section. This position has statewide responsibility for issuing permits for every oversize and overweight permit vehicle traveling in Ohio. This section is also involved in all commercial vehicle activities in which ODOT has interest and involvement, including coordination with other State agencies, local governments, and Federal agencies. Before his current assignment, Honefanger was the deputy director of ODOT's Division of Rail Transportation. Honefanger has a business degree and paramedic science degree from Clark Technical College and attended Wittenberg University. On a national level, Honefanger serves as vice chair of the American Association of State Highway and Transportation Officials' (AASHTO) Subcommittee on Highway Transport and is a member of AASHTO's Special Committee on International Activity Coordination, AASHTO's Special Task Force on Commercial Vehicle Highway/Rail Crossing Safety, the Multi-State Permit Group Board of Directors, and the Transportation Research Board's (TRB) Vehicle Size and Weight Committee. In Ohio, Honefanger is a member of the PrePass Steering Committee, Commercial Vehicle Information Systems and Networks (CVISN) Committee, and Governor's Motor Carrier Advisory Committee and instructs classes on oversize/overweight vehicles at the Ohio State Highway Patrol Academy and the Ohio Peace Officer Training Academy. Honefanger is a coauthor of *Freight Transportation: The European Market.*

Julie Strawhorn *(FHWA cochair)* is a transportation specialist for the Federal Highway Administration (FHWA) at the Washington, DC, headquarters. Strawhorn works in the FHWA Office of Freight Management and Operations as the commercial motor vehicle size and weight expert. She is in charge of reviewing and approving State enforcement plans and certifications on size and weight and leads several project initiatives on weigh-in-motion, virtual weigh stations, and other technologies to improve and enhance size and weight enforcement. Before joining FHWA, Strawhorn worked as a program analyst for the Maritime and Land, Highway Cargo Security, Division at the Transportation Security Administration. She also worked as liaison on the International, Legal, and Regulatory Affairs; Vehicle; and Size and Weight Committees at the Commercial Vehicle Safety Alliance. Strawhorn also has direct enforcement experience as a former patrol officer in Montgomery County, MD. Strawhorn has a bachelor's degree in criminology and criminal justice from the University of Maryland. She represents the Federal government on many panels and conducts training and makes presentations on size and weight rules, regulations, and enforcement in the United States.

Richard (Ric) Athey is the assistant division director of the Enforcement Services Program for the Arizona Department of Transportation's Motor Vehicle Division. His is responsible for the operations of 22 ports of entry, size and weights, registration compliance activities, statewide enhanced vehicle inspection provisions, and six international ports between the United States and Mexico. Athey is a representative to the AASHTO Highway Transportation group and Western Association of State Highway and Transportation Officials (WASHTO). He is the division liaison to FHWA, U.S. Customs and Border Protection, U.S. Citizenship and Immigration Services, Federal Bureau of Investigation, National Highway Traffic Safety Administration, Arizona Auto Theft Task Force, Governor's Office of Highway Safety, and the law enforcement community. Athey is chair of the Overdimensional Committee. He has a bachelor's degree in business from Western International University. He is a retired commander with 29 years in law enforcement and a graduate of the Federal Bureau of Investigation Academy.

Dr. Jodi L. Carson *(report facilitator)* is an associate research engineer for the Texas Transportation Institute at the Texas A&M University System. She has more than 15 years' experience investigating various aspects of commercial vehicle size and weight enforcement, including (1) the nature and effects of administrative and operational disparities between States and across international borders, (2) the performance of size and weight enforcement technologies (i.e., weigh-in-motion) compared to each other and to national WIM system standards (ASTM E1318-00) under different traffic loading and weather conditions, and (3) alternative performance-based commercial vehicle size and weight enforcement programs with a focus on changing commercial vehicle loading behavior and reducing infrastructure damage rather than issuing citations. Carson has provided expertise on proposal review panels related to commercial vehicle operations for the National Science Foundation and the U.S. Department of Transportation. She received a Ph.D. in civil engineering from the University of Washington and is a licensed professional engineer in Montana and Texas.

George Conner is the assistant state maintenance engineer for bridges for the Alabama Department of Transportation (ALDOT) in Montgomery, AL. Conner is responsible for the maintenance, inspection, and rating of bridges for ALDOT, including the analysis of numerous superload permit vehicles. He has worked with the Southern Association of State Highway and Transportation Officials (SASHTO) Multi-State Permit Working Group to promote more uniform rating and permitting practices between States. Conner has bachelor's and master's degrees from the University of Alabama. He is a licensed professional engineer in Alabama, a member of the AASHTO BRIDGEWare Task Force for Bridge Rating and Design Software, and a member of Technical Committee T-18, Bridge Management, Evaluation, and Rehabilitation, of the AASHTO Subcommittee on Bridges and Structures. He was a panel member for the National Cooperative Highway Research Program's Project 20-5, Topic 36-01, "Bridge Evaluation Practices and Permit Policies for Overweight Vehicles."

David Jones is a transportation specialist for the FHWA Office of Highway Policy and Governmental Affairs in Washington, DC. Jones has more than 16 years of experience with weigh-in-motion (WIM) systems and WIM data management. He manages the Truck Weight Study and Heavy Vehicle Travel Information System Program, which is part of FHWA's national database for travel monitoring. Before his current position, Jones was an electronic engineering technologist for FHWA's Office of Technology Application (OTA). He served as lead technologist for OTA's Demonstration Project 76, which was conducted in 43 States to provide State highway administrators, pavement designers, weight enforcement personnel, and planners with an understanding of the various types of WIM technologies, their accuracies and reliability, installation costs and procedures, maintenance requirements, appropriate applications, limitations to their use, and cost-effective methods of coordinating WIM data. He studied computer and electronic technology at Northern Virginia Community College and obtained an electronic technician certificate from the Northern Virginian Industrial System.

Tom Kearney is a statewide planner in FHWA's New York Division. Kearney coordinates the division's New York State Truck Size and Weight Program. His duties include working with enforcement agencies on equipment and resource issues, coordinating with State officials on preparing and submitting the annual certification of enforcement and annual enforcement plan, and providing technical assistance to trucking firms and local officials on commercial vehicle mobility issues. Kearney also oversees New York State highway data programs and coordinates the Statewide Transportation Improvement Program. Kearney is a National Highway Institute-certified instructor for FHWA's "Highway Program Financing" course. Before joining FHWA in February 2000, Kearney worked in the New York State Department of Transportation's (NYSDOT) Planning Division for 14 years, including serving as supervisor of NYSDOT's Highway Inventory Program. Kearney has an undergraduate degree from Albany State University and a master's degree in regional planning with specialties in urban and transportation planning from Albany State. Kearney is a trustee on the Village of Cambridge Board, a member of the Washington County Planning Board, and a member of the Community Advisory Board for Albany State University's Graduate Planning Program. Kearney has been a member of the American Planning Association since 1983.

John Nicholas is a Commercial Vehicle Program manager with the Washington State Patrol. He works as part of a management team in the Commercial Vehicle Division headquarters responsible for operation of four ports of entry, 52 interior scales, and 200 enforcement officers. Nicholas is responsible for developing Federal size and weight certification and enforcement plans, managing State CVISN and weigh-in-motion commercial vehicle weigh station bypass programs, and planning new commercial vehicle weigh station facilities in conjunction with the Washington State Department of Transportation. He is a representative to the Western Association of State Highway and Transportation Officials (WASHTO) and a voting member of the Commercial Vehicle Safety Alliance (CVSA) Vehicle Committee. Nicholas has a bachelor's degree in political science from the University of Washington. He has been with the Washington State Patrol Commercial Vehicle Division for 27 years.

Pam Thurber is the bridge management and inspection engineer for the Vermont Agency of Transportation (VTrans), headquartered in Montpelier, VT. Thurber manages Vermont's bridge inventory and management systems, develops the draft yearly bridge program, oversees the bridge inspection and fabrication programs, is project manager for several bridge projects under consultant design, and is responsible for statewide overweight and overheight permit reviews that support the Vermont Division of Motor Vehicles permitting process. After contributing to its development, Thurber presented Vermont's self-propelled crane self-issuance permit process to the AASHTO Subcommittee on Highway Transport in June 2004, and is now involved in the development of a VTrans position paper on the effects of possible increased interstate truck weight limits in Vermont. Thurber has a bachelor's degree in civil engineering from the University of Vermont. She is a licensed professional engineer in Vermont and has served on or contributed to various AASHTO user groups and technical committees.

Randy Woolley is the chief of the Systems Engineering Branch for the California Department of Transportation (Caltrans) Division of Research and Innovation. Woolley leads the division in integrating systems engineering into mainstream transportation research and is conducting a truck monitoring/safety project for the Federal Motor Carrier Safety Administration using the systems engineering "Vee" model. He led a team of transportation professionals developing a highly successful virtual weigh-in-motion display for the 2005 World Congress in San Francisco, CA. Woolley's team developed the *Systems Engineering Guidebook for ITS Projects* and is now converting the guidebook to a Web-based format that will be hosted on an FHWA Web site. He is active in developing and presenting training in systems engineering, system integration, and configuration management and is an instructor for the "Systems Engineering Fundamentals" course for both Caltrans and the University of California, Irvine. Woolley has 26 years of experience in the electronics industry, including systems engineering, design, manufacturing, project management, and research. He is a registered professional engineer in California and has been with Caltrans for 14 years.

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