Multi-Modal Integrated Safety, Security & Environmental Program Strategy

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Abstract

This paper describes an approach to assessing and protecting the surface transportation infrastructure from a network science viewpoint. We address transportation security from a human behavior-dynamics perspective under both normal and emergency conditions for the purpose of measuring, managing and mitigating risks. The key factor for the planning and design of a robust transportation network solution is to ensure accountability for safety, security and environmental risks.

The Oak Ridge National Laboratory (ORNL) Multi-Modal Integrated Safety, Security and Environmental Program (M²IS²EP) evolved from a joint US Department of Energy (DOE) Oak Ridge Office (ORO) Assets Utilization Program and ORNL SensorNet Program initiative named the Identification and Monitoring of Radiation (in commerce) Shipments (IMRicS). In November of 2002 the first of six pilot demonstrations was constructed at the Tennessee I-40/75 Knox County Weigh Stations outside of Knoxville. Over the life of the project four more installations were deployed with various levels of ORNL oversight.

In October of 2004 the ORNL SensorNet Program commissioned a research team to develop a project plan and to identify/develop a strategic vision in support of the SensorNet Program, keeping in mind the needs of the various governmental constituencies (i.e., DOT/DHS/EPA) for improving the safety/security/environment of the highway transportation system. Ultimately a more comprehensive ORNL SensorNet Program entitled Trusted Corridors was established and presented to ORNL, DOE, DOT, DHS, EPA and State leaders. Several of these entities adopted their own versions of these programs and are at various stages of deployment. All of these initiatives and pilots make up the foundation of the concepts and ideas of M²IS²EP and will be discussed further on in this paper.

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1. Introduction

The US economy depends heavily on the domestic surface transportation system. The sensitivity of Just-in-Time and Lean Manufacturing business strategies makes safe, secure, and reliable operation of the system a critical economic determinate. Even minor sustained interruptions can lead to cascading economic consequences. International developments are stressing the system in ways that exacerbate all of the elemental risks (i.e., safety, security, environmental as well as economic).

Commerce with Canada and Mexico, which increased dramatically after approval of the NAFTA treaty, has also increased international traffic within the United States. International containers traffic move about in a multimodal fashion from ships, to ports, to freight rail lines, and finally onto the highway system. These trends are increasingly responsible for overloaded border crossing systems and ultimately over burden domestic public traffic safety and highway systems. The resulting congestion presents a public safety and environmental hazard that negatively impacts economic performance. Accordingly, federal legislation is making new investments in the highway infrastructure (1)

1.1 Impact

Since 1980 there have been significant strains placed on our supply chain as a result of political, economic and environmental events. See Figure 1 for an overview and chronology of the “ad hoc” evolution of the surface transport supply chain from US transportation history. Every day, hundreds of millions of people use the highway system safely and legitimately. However, a small percentage of drivers, operators, and shippers attempt to violate federal safety and environmental regulations when they use the highways. Criminals move on the highway, hoping to evade detection and apprehension. Furthermore, terrorists may attack the highway infrastructure, or use it to carry out attacks. Other challenges of these significant strains are discussed in this section.

First, the current situation of world events, from a political perspective, resulting from the 9/11 terrorist attacks has pressured supply chain stakeholders, regulators and law enforcers to augment and amplify security awareness and solutions. Recent past actions have focused on a combination of deploying existing Chemical Biological, Radiological, Nuclear and Explosive (CBRNE) detection technologies at national and international transportation chokepoints. The promulgation of programs and requirements was designed to increase stakeholder vigilance. From a policy perspective the DHS has focused on improving these detection technologies at chokepoints such as the nation’s borders or international loading points. The DOT has mandated security awareness programs such as Security Plans for commercial carriers, stricter qualification
requirements for commercial vehicle operators, and additional physical security and communication requirements of certain types and quantities of Hazardous Materials. Furthermore, political pressure in the form of the terrorism threat has been the most recent strain to be placed on an already burdened supply chain. The influx of Central American and Mexican workers and Mexican assembled goods has been of even more political significance. The 1994 North American Free Trade Agreement (NAFTA) legislation provided the catalyst for the southern border influx from a safety and security standpoint.

Secondly, the country has become, from an economic perspective, more service job oriented and less production job oriented. This has served to increase the amount of imports to the country. This has flooded our ports, from a supply chain standpoint, with low cost Asian goods. US West Coast ports are approaching overcapacity and subject our economy to disruption whenever any type of “delay occurrence” affects the 24/7 operations at the ports (i.e. the 1990s Longshoreman strike, Natural disasters such as Hurricane Katrina, our potential of a debilitating terrorist attack on a port). This unprecedented trade (i.e., volume) driven port congestion is further exacerbated by the recent business practices of Lean Manufacturing and Just-in-Time Delivery creating plant shutdowns or shortages based on the inability to get one critical part or service to a assembly line. The fact that “America is the most mobile nation in history” coupled with the aforementioned increase in freight traffic on the nation’s highways has been paramount to an unprecedented increase in traffic congestion which contributes to injury, death and property loss on the roadways.

Thirdly, the phenomena known as global warming dominates much of the political and media attention on our environment today. Not lost in this debate, is the fact that auto emissions have taken over as the number one air pollution contributor. Places where there is heavy traffic congestion are realizing unprecedented increases in air pollution. The Environmental Protection Agency (EPA) now states that the Mexican-American border crossings are a number one priority for targeting reductions. Additionally, cross-border hazardous waste transport has taken on a new priority as Mexican manufacturers’ ship their hazardous waste for processing to the US and Border States must ensure that this same waste is shipped back to Mexico after processing.

These three challenges are handled by a myriad of Federal and State agencies armed with individual laws and policies that address their specific issues. In most cases enforcement is focused on data collection and subsequent site visits however much of this data collection is on the honor system and is performed using 1960s technologies. Integration of the data and the abilities for the agencies to “cross-talk” or “peer” into each other’s databases simply doesn’t exist. Many private systems integrators are working these issues however the software is generally proprietary and focused on the sponsoring agencies specific needs. Therefore, state and local law enforcement
personnel are focused on a multitude of requirements (and responsibilities) that have been imposed in an ad hoc manner (Figure 2).

1.2 Response

Federal, state, and local governments are responding to these security, safety, and capacity challenges. The Transportation Security Agency (TSA), part of DHS, has the lead federal role to prevent acts of terrorism; the Department of Transportation (DOT) has a supporting role in preventing terrorism in the transportation system. The agencies have codified the agreement in a Memorandum of Understanding (MOU) (2, 3). Even before 9/11 there existed the IMRicS’s (Identification and Monitoring of Radiation in-commerce Shipments) Program who’s original charter was as a commercial vehicle compliance monitoring system for the enforcement of State/Federal regulations. It has become apparent that this program is effective toward solving security and environmental problems as well.2

The DOT oversees the development the nation’s highway through federal grants to the states. Federal regulatory requirements are integral to the federal grant process (4). When states accept federal transportation funds, they accept responsibility for the inspection and enforcement of highway safety and environmental regulations. To assist the state inspectors, and improve traffic flow at inspection stations, DOT has built an information-sharing infrastructure to provide system-wide safety information to state inspectors.3

1.3 Sensitivities

The nation faces multiple challenges to ensuring the integrity of our critical highway systems infrastructure. Economic sensitivities combined with increasing foreign traffic and dwindling capacity, mandate that improved measures be developed. In doing so, safety and security solutions must comprehend and account for all dimensions of the problem to ensure that environmental impacts and capacity are not soon overwhelmed.

The investment process has begun with new transportation planning strategies to improve the capacity of the system. Opportunities arise from every challenge. Studies (5, 6, and 7) have recommended an integrated security strategy for the surface transportation system. The studies acknowledge the immediacy and deterrent value of such measures in the transportation infrastructure. Therefore, now is the time to integrate safety and security measures. The M2IS2EP

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3 An example is Commercial Vehicle Information Systems and Networks (CVISN), a program for states to share commercial vehicle safety information. CVISN is actually a set of protocols set at the federal level, and implemented in the states through the DOT grant programs.
Program provides the management strategy that the SensorNet Program envisions including leveraging existing infrastructure and capabilities as well as new technology requirements (i.e., hardware/software, data architecture and risk management).

2. Goals and Objectives

The M^2IS^2EP effort proposes a unique approach to surface transportation safety and security, which relies on integrating DOT, EPA and DHS approaches to execute an integrated safety, security, environmental inspection system. The Program’s organizational objectives are:

1. Inspection programs integrate security into the existing safety and environmental inspections. DHS and DOT set the programmatic goals, objectives, and standards through a joint program office. The DOT and DHS grant systems jointly fund the enhanced state inspection program.

2. Integrate new technology at the highway inspection stations, intermodal switching points, and major inland ports to implement newly required capabilities using existing infrastructures where possible.

3. Develop a new generation of information sharing standards for transportation-system inspection-stations, including the new technology. The federal agencies exercise oversight to protect individual privacy rights throughout the process.

4. Apply adaptable anomaly detection and vehicle screening analysis methods that: a) use an all-risk approach that includes safety, security, law enforcement, and environmental protection considerations, b) are adaptable to national, regional, local, and sector-specific threat conditions, and c) are implemented to create uncertainty for terrorists.

5. Real-time notification when BOLO (Be On the Look Out) vehicles pass inspection stations.4

6. Apply all-risk screening criteria to all vehicles without disrupting normal traffic flow.

All of these objectives support the overarching goals of having an integrated safety and security policy, fused information technology enablers and analysis (e.g., knowledge discovery and management) capabilities for actionable intelligence to state and local law enforcement agencies.

2.1 Strengths Weaknesses Opportunities and Threats

To fully comprehend the complicated and daunting enforcement issues facing state governments and ultimately state law enforcement, consider the conjoined issues and define them as traditional business cases. The following list describes the current state of affairs and defines this national problem and its impact on our nation’s supply chain from a highway perspective. It is important to consider that the other four modes of transportation (i.e., rail, air, waterway and pipeline) are dependent on highway transport to either make final delivery of their freight or to pickup their freight; thus when addressing the supply chain inter-operability problem the common denominator is highway transport.

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4 A warning to “be on the lookout” for a particular person or vehicle is known as a BOLO.
Strengths

- Multiple cutting edge technologies are being purchased by state/locals governments for security, safety and environmental protection.
- Inspection infrastructure and real estate already exists along the nation’s highways.
- Industry is supportive of technologies that provide productivity and leverage their technology costs.
- States are actively seeking integrated solutions for homeland security, environmental protection and mitigation strategies for natural disasters.
- The US is the most mobile nation in the world and has an interstate commerce system model that is highly valued, high technological and highly emulated.

Weakness

- Ad hoc evolution of laws and regulations has complicated enforcement personnel priorities.
- Just-in-Time, Lean Manufacturing business practices and increasing dependence on foreign goods have led to unprecedented growth in commercial vehicle traffic.
- Construction and maintenance of highway infrastructure does not keep up with demand.
- Deployed technologies and multiple disparate databases have no enforced standards to ensure interoperability.
- Inspection infrastructure is aging and overburdened.
- No national tracking or situational awareness system exists.

Opportunities

- Mature Sensor Technology exists to allow for (semi-) automatic enforcement of multi-mission low-risk regulations.
- Knowledge Discovery technologies exist to allow for state/local and federal real-time situational awareness through machine learning.
- Data Architecture technologies exist to allow for non-proprietary interoperability between enforcement agencies and deployed sensors.
- State/Local law enforcement willingly and historically serve as multi-mission front line enforcement and embrace sorting and targeting as a value-added enforcement tool.
- New investment is pouring into modernized multi-modal switching facilities and public/private “freight-only” highways.

Threats

- Congestion is the number one cause of death and injury on the nation’s highways.
- Terrorists view our transportation system and the vehicles that traverse it not only as weapons but also as weapons delivery system(s).
- Resiliency of the nation’s supply chain has just recently become a part of the national debate.
- Vehicle emissions are becoming the number one contributor of air pollution.
- States are developing systems to combat their threats and protect their citizens in an ad hoc
• Our economy is more dependent than ever on the rapid movement of legitimate commerce through our nation’s land borders and seaports while human and drug trafficking has become our number one enemy using this same venue.

3. Program Structure

The current highway inspection protocols vary from state to state, however, the focus is on ensuring safety of commerce within the transportation system. Aside from a limited set of individual trials, security has not been a major component of the design and operation of the inspection stations.

Now is the time to integrate security considerations into the transportation system. Information sharing is a crucial factor in the efficient operation of the inspection stations. Commercial vehicles participate in voluntary programs (e.g. NORPASS®, PrePass®, and RadSTraM) to expedite inspections at these weigh stations, operators with excellent safety records have a lower frequency of inspections. The CVISN Program, administered by DOT, allows states to share operator safety records. CVISN provides integrated safety information to inspectors on the highways. The Federal government establishes CVISN standards in coordination with the states and the transportation sector. DOT grants provide funding to states to execute CVISN (see Paragraph 4.6). DOT is preparing to plan and execute the next generation of information sharing systems. This juncture will provide a natural opportunity to strengthen existing security measures and take advantage of emerging security technologies.

The existing safety inspection system is a prime opportunity to build, extend, and improve the security of the transportation infrastructure. The new transportation developments should include security in their design. Otherwise, the new transportation pathways could become the expressroutes for terrorists. Integrating security checks into the existing safety inspection system provides the following advantages:

1. Lower cost for security enhancements than a stand-alone approach,
2. Minimum disruption of legitimate traffic,
3. Utilize the experience expertise of current highway safety-inspection personnel to improve the effectiveness of the security inspections,
4. Extend uncertainty to terrorist use of highways,

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5 An example of integrated safety and security assessment is the weigh-station portals operated under the SensorNet Program coordinated by ORNL in conjunction with the states of Tennessee, Kentucky, and South Carolina.
6 http://www.norpass.net (NorPass): The North American Pre-clearance and Safety System, or NORPASS, is a partnership of state agencies and trucking industry representatives who are committed to promoting safe and efficient trucking throughout North America. The NORPASS partners work together to deploy mainline screening systems at weigh stations, thus allowing safe and legal trucks to proceed unimpeded while enforcement resources are focused on high-risk motor carriers; http://www.prepass.com (PrePass): PrePass is an automatic vehicle identification (AVI) system that allows participating transponder equipped commercial vehicles to bypass designated weigh stations, port-of-entry facilities and agricultural interdiction facilities. Cleared vehicles may proceed at highway speed, eliminating the need to stop; and http://www.ioc.ornl.gov/projects/radstram.shtml (RadSTraM): Radiological Source Tracking and Monitoring.
7 DOT inspection programs are integrated under the Commercial Vehicle Information Systems and Networks (CVISN) Program, with funding provided to states through DOT grant programs (http://cvisn.fmcsa.dot.gov/).
5. Encourages a prioritization of overall risks in a manner consistent with the Homeland Security Act,⁸
6. Uses screening analysis and decision tools that adapt to the federal, state, local, and sector-specific threat conditions,
7. Leverage and coordinate DOT and DHS policy, planning, and grant funding for the safety, security, and efficiency of the highway system,
8. Enhances public safety, and the effectiveness of law enforcement, through detection of vehicles that are subject to BOLOs and Amber Alerts,
9. Extends the layered security approach to highway safety inspections, ensuring that foreign vehicles and operators are subject to appropriate safety inspections following clearance at the borders, and
10. Maintain transportation system efficiency consistent with security requirements during heightened states of alert.

If security is not integrated into the safety inspection systems now, significant costs will be required to retrofit such systems for security when the risks are finally recognized. Moreover, the next generation of CVISN will provide an opportune time to include security.

### 3.1 Transportation Security Strategy

The dispersed and open nature of the transportation system makes it difficult to protect using defensive strategies. The TSA strategy to secure the surface transportation sector involves key components, which have been endorsed by several studies from advisory group (5, 6, 7, and 9).

- Security is in layers, because no single measure can be completely effective;
- TSA leverages the work of other agencies,
- Systems create “visible unpredictable deterrence environments to disrupt terrorists’ planning capabilities and operational launching of their missions”.

The proposed integration of security into the safety inspection process is entirely consistent with these security objectives. It was in line with the transportation security strategy that the Oak Ridge National Laboratory has been investigating the possibility of using multiple wide-area sensors at weigh station test-beds for effectively detecting commercial trucks that may be of safety and/or security concerns. In this section, we present a summary of some of our research efforts in detecting anomalies in commercial trucks using weigh station test-beds data.

#### 3.1.1 Anomaly Detection from Multiple Heterogeneous Sensor Data

The transportation of illicit radioactive materials that have evaded security checks at ports or border crossings poses a security risk to highly sensitive and secure locations. As a result, we have developed a suite of knowledge discovery approaches for detecting commercial trucks that may be transporting illicit radioactive materials and/or that are of security concerns such as truck over-weight. Some of the heterogeneous data collected at one of the four weigh station test-beds

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⁸ The DHS Principal Mission, as defined in Section 101 Homeland Security Act of 2002, includes “ensure that the overall economic security of the United States is not diminished by efforts, activities, and programs aimed at securing the homeland”
include weigh-in-motion data, static scales data, spectroscopy radiation signal, gross counting radiation data, truck images, license plate images, USDOT Number, and Driver License images.

Therefore, the objectives of this research are guarantee that trucks transporting unlawful radioactive materials along the nation's highway are detected, to ensure the safety of road users without compromising security, and minimize truck inspection time at weigh stations without disrupting commerce and supply chain networks. To achieve these objectives, we have developed a suite of knowledge discovery approaches to facilitate the decision making process. The approaches include linear and non-linear correlation estimation from short and noisy data (10), offline pattern detection and anomaly analysis based on linear and nonlinear dimensionality reduction (10), probabilistic dimensionality reduction for online anomaly detection (11), and a three-stage anomaly detection approach (12) with effective distance measures for profile matching and discrimination. Each of these approaches is briefly described in the following subsections.

### 3.1.1.1 Anomaly Detection in Static Scales Data
In this case, we developed both offline and online methodologies. The offline analysis is based on linear and nonlinear dimensionality reduction approaches such as multi-dimensional scaling (MDS), locally linear embedding (LLE), and isometric feature mapping (ISOMAP). Agovic et al. (10) presents an application of these approaches for transportation security. The offline methodology uses manifold learning approaches to classify trucks using seven truck features: truck length, number of axles, weights at three truck locations, speed near sensors, and distance from sensors. Based on this approaches, three distinct types of trucks are consistently observed using monthly data from September 2006 to January 2007 (10). The major insight from this work is that three features (of the seven truck features) and their mutual relationships contain most information about the trucks. These features are number of axles, truck length, and distance from sensors. Unexpectedly, truck weight is found to be irrelevant and distance of the truck from sensor is found to be relevant. Additional research is underway to explore the domain significance of these insights.

The offline analysis usually takes time and may not be useful for real-time decision. The issue of scalability has become a serious issue in the data mining community especially for online knowledge discovery applications in which decisions are expected in real time or near real time. As a result, the three extracted features obtained are used in an online approach to classify new incoming trucks. Therefore, the offline analysis can be implemented in the background and the results feed into the online component, which is then used for real-time decision making. The online parameters and variables are updated regularly based on the results of the offline analysis. A mixture of probabilistic principal component analysis (PPCA) approach with Expectation-Minimization (EM) algorithm is used for the online methodology to determine the chi-square statistic of incoming trucks and compared to the chi-square statistic of training datasets in order to determine if the incoming truck is an anomaly or not (11). Using 95% chi-square threshold value, trucks with anomalous features are consistently identified.

### 3.1.1.2 Anomaly Detection in Radiation Data
The transportation of illicit radioactive materials that have evaded security checks at ports or border crossings poses a security risk to highly sensitive and secure locations. Therefore, we
also developed a three-stage approach for detecting illicit radioactive materials using both spectroscopy and gross counting data. The assumption of this approach is that most of the given datasets represent "normal" radiation profiles and are, in a certain sense, similar and only a few datasets are "anomalies". The three-stage approach consists of data preprocessing based on Haar wavelet transformation, data representation as a binary form of the wavelet coefficients, and anomaly detection method by a distance-based metric (12). The approach is extensively tested using simulated radiation data and found to have the potential of reducing the number of false alarms and misses compared to the six-sigma based approach used with radiation portal monitors (RPM).

3.1.2 Decision User Interface and Sensor Output Fusion

We have also developed a proof of concept decision user interface (UI). The interface, designed for decision-makers, showcases capabilities for real-time analysis in the context of decision-making (13). Specifically, analyses based on static scale data, gross radiation counts, radiation spectroscopy data, truck images, and truck license plate image are demonstrated. Each set of analysis has a corresponding offline knowledge discovery component, which in turn can influence the online analysis and real-time decision aspects.

As stated above, each sensor data is processed separately as shown in Figure 3. Please note that for privacy reasons, we have blurred the descriptive information about the truck in this figure. Based on the different knowledge discovery analyses, the UI in Figure 3 shows that the license plate number is valid and the spectroscopy profile is an example of normal (GO) profile but static scales data and gross counting profile give abnormal (STOP) metrics.

These results could mean many things but from the static scales data perspective, it could be that the truck is over weight for the number of its axles or the truck is improperly loaded. From the radiation data perspective, the truck is transporting a legitimate or illegitimate source of radioactive material that is not detected using spectroscopy data but detected using the gross counting data possibly because the radiation source is shielded or mixed with other legitimate cargoes in commerce. Another example of a UI is shown in Figure 4. In this case, the three metrics is normal (GO) and the license plate is valid.

In both examples shown, the individual metrics need to be combined to achieve an overall
metric for user decision. As a result of the heterogeneous nature of the multiple sensor data used, it is a challenge to combine these metrics because the definition of anomaly (STOP) metric is different in each case.

Therefore, we proposed a framework, Figure 5, in which each of the sensors is processed separately and the knowledge is fused for a joint knowledge metric. We are developing methodology for fusing sensor outputs from heterogeneous sensor data outputs.

3.1.3 Future Research in Transportation Security

The focus and approaches described so far have been limited to individual weigh station test-beds. However, there is a need to take this to this next layer by developing a network of inspection stations for standards, information sharing, analyses, and dissemination purposes. The call at the federal level for standards and information sharing may go unheeded unless the user community sees the critical need and the benefit. Our study on weigh stations and extensions of such studies in the future can provide proof of concept rationale for the user community to move forward with standards and information sharing. Furthermore, this research has been focused on safety and security strategies but there is also a need for incorporating environmental strategies for the multi layer decision systems. Therefore, future research in this area includes developing a methodology for multiple heterogeneous sensor output fusion, developing a network of inspection stations that include weigh stations, border crossing, rail stations, and ports for a comprehensive approach for enhancing transportation safety, security, and environmental concerns without disrupting the global supply chain networks.

3.2 Integrated Risk and Mitigation Strategy

Risks on the highway system come in many forms. Safety is a broad term used to describe the steps taken to minimize the risks from vehicle operators, vehicles, and the cargo they carry. Statistical and anecdotal evidence abounds to support the reality that some operators are not safe, that some vehicles are not properly equipped or maintained, and that some cargos are hazardous. The DOT has worked with state officials for decades to address this risk through a regulatory inspection process.

The DHS utilizes a risk-based approach to terrorism prevention (14). TSA uses a risk-based approach to establish priorities for transportation security. Currently, TSA’s highest priority for highway transportation risk reduction is the transport of hazardous materials (HAZMAT). A change in terrorist tactics could alter the priorities, which enhances the value of adaptable security measures.
Law enforcement agencies address public safety risks, including criminal use of the transportation system to evade detection and apprehension. When law enforcement officials need to catch dangerous criminals, they broadcast warnings to “be on the lookout” (BOLO). “Amber Alerts” can also generate BOLOs. When a BOLO Alert identifies one or more license plates, vehicles can be matched at inspection station(s). Appropriate law enforcement agencies are immediately notified of the location and time of the BOLO detection. At elevated alert levels, and when the checkpoints are appropriately staffed, the BOLO subject vehicle(s) could be stopped immediately, depending on the requesting law enforcement agency jurisdiction. This law enforcement risk is not a high priority in existing inspection systems.

Both the Homeland Security Act and SAFETEA-LU require economic impacts to guide the inspection and security processes. Risks from traffic congestion affect highway safety. Minimizing the risks associated with congestion has beneficial impacts on safety as well as the economy and the environment. An inspection system that does not consider all of these risks, presents the real danger of enabling terrorist’s objectives. If an inspection system focuses on a relatively minor terrorism risk, and in the process causes an economic or public safety disaster, what ends have been accomplished? The design of the inspection systems must include all of the risk tradeoffs and adapt to highly changeable threat conditions.

Using the traditional risk management approach, each responsible agency – at either the federal or the state level – addresses a single risk-type in isolation (resulting in ad hoc risk mitigation). This may allow high priority terrorists to pass. An integrated risk management approach improves the overall efficiency of the transportation system. Consequently, the application of proven technologies and enhanced information sharing and real-time risk assessment are crucial enabling capabilities.

### 3.3 Federal Law & Policy

The integration of safety and security at transportation inspection stations is consistent with applicable public law, policies promulgated by the executive branch, and statements made by DHS and DOT officials before Congress. This strategy is consistent with, and furthers the goals of, the Homeland Security Act of 2002. This concept implements the specific requirements in SAFETEA-LU (Public Law 109-59) (1, 4) which modifies chapters of the CFR, including chapters 23 and 49. The grant guidance in SAFETEA-LU permits spending on highway security. Further, SAFETEA-LU requires states to include security in their highway planning.

#### 3.3.1 Policy

Homeland Security Presidential Directive 7 (HSPD-7) governs the Federal government’s approach to infrastructure security (8). The DHS Transportation Security Administration (TSA) has the lead federal role in security of the transportation infrastructure. HSPD-7 also requires transportation sector security be coordinated with the DOT. HSPD-7 requires the development of integrated security protection planning through the development of a sector-specific plan as part of the National Infrastructure Protection Plan (NIPP) (9). DHS’s Domestic Nuclear Detection Office (DNDO) coordinates the design and implementation of National Nuclear Detection architecture. DNDO is investigating the technology for nuclear detection architecture. However, such equipment could be implemented as a part of the checkpoints described here when the
systems are finalized. The DNDO operations could be integrated into the proposed transportation inspection system.

3.4 Leveraging Existing Capabilities

Intelligent Transportation Systems (ITS) are transportation systems, which utilize information, communication, sensor, and control technologies to achieve improved levels of performance. The DOT has developed a National ITS Program Plan, which provides a new vision for surface transportation in America. The ITS Program includes seven major elements:

- Travel & Transportation Management
- Travel Demand Management
- Public Transportation Management
- Electronic Payment
- Commercial Vehicle Operations (ITS/CVO)
- Emergency Management
- Advanced Vehicle Control & Safety Systems

Ground carrier safety inspections are a critical process in attaining the FMCSA (Federal Motor Carrier Safety Administration) strategic target of reducing the number of deaths and injuries in truck and bus related accidents 50 percent by 2010. This target is directly linked with enhancements to the flow of commerce. In the context of safety inspections, a performance based commercial vehicle inspection process was established including an advisory group, including government, industry and academic entities, to guide this transformation. The achievement of this target required a change from specification-based regulations to performance-based regulations creating an integrated sensor-based information infrastructure using performance based inspection technologies to: 1) improve screening for safety and security of non-compliant drivers, vehicles and cargos, 2) improve the actual inspection process, and thus 3) improve the productivity of inspection personnel. An Evaluation User Facility was also initiated to ascertain the “best of breed” performance based inspection processes for “real-world” testing, fielded at partnering state inspection weigh locations and in “smart” enforcement vehicles employing commercial vehicle inspection personnel. This process (in preliminary deployment phase) will significantly increase the number of roadside inspections, suspected and pre-selected as non-compliant by the screening process. The combination of “best-of-breed” performance based inspection technologies, utilizing a sensor-based information infrastructure and tested at an evaluation user facility and at the real-world weigh/inspection stations, is creating a safer and more secure environment for all users of today’s highways.

The DHS’s DNDO also initiated a demonstration project entitled Southeastern Transportation Corridor Project (SETCP) in 2006. The goal of this two-year Pilot is to leverage State deployed radiation bulk monitoring systems at weigh stations for radiation/nuclear (Rad/Nuc) threat prevention. The objectives for SETCP are:

- Develop a regional threat detection and interdiction architecture,
- Implement a limited operational detection and reporting capability,
- Develop and demonstrate a regional concept of operation, including alarm resolution
protocols,

- Enhance regional communication infrastructure and collaboration for information exchange,
- Implement technical reachback to support detector deployments, and
- Evaluate detection, data sharing, training, and connectivity components, individually and as part of an integrated system.

This Pilot is one of the first attempts by one government agency to leverage investments from another government agency with cooperation from the same state agency. Many issues will be addressed in this Pilot especially the problem of interoperability. Unless State’s demand interoperability as a pre-requisite development strategy the end result will simply perpetuate the current ad hoc patchwork of safety, security and environmental measures.

One of the main components of the EPA Clean Materials Program is to prevent the loss of radioactive materials through the use of tracking technologies. If a source is inadvertently lost or purposely abandoned or stolen, it is critical that the source be recovered before harm to the public or the environment occurs. Radio frequency identification (RFID) tagging on radioactive sources is a technology that can be operated in the active or passive mode, has a variety of frequencies available allowing for flexibility in use, is able to transmit detailed data and is discreet. The purpose of the joint DOE and EPA RadSTraM project is to evaluate the viability, effectiveness and scalability of RFID technology under a variety of transportation scenarios (15).

3.5 State & Local Role

While there have been considerable federal efforts in the protection of the nation’s highway infrastructure, the principal responsibility for execution falls on state and local officials. The DOT has promulgated safety regulations, but specific enforcement approaches vary from state to state.

The M$^2$I$^2$S$^2$EP Program includes a federal coordination and oversight role, but state and local officials carry out actual execution of inspections. The utilization of state and local transportation enforcement officials is a considerable advantage, because these officials have field experience in the inspection environment. They understand traffic patterns, operator habits, and the normal flow of people and commerce. This human experience and understanding is crucial in ferreting out the unusual behavior that is an indicator of malicious use of the transportation network.

3.6 M$^2$I$^2$S$^2$EP Prevention Concept

Consistent with the TSA layered security strategy, the M$^2$I$^2$S$^2$EP prevention concept adds a layer of protection and prevention. The DOT-funded, state-staffed safety inspection infrastructure gains a security role, so security is achieved at relatively low additional cost. Integrated safety/security screening will be included in ongoing development and improvement of highway systems and have the potential to significantly reduce costs. Based on relative risk/benefit analysis, some highway inspection stations could be retrofitted to meet the new standards. Future inspection system design will use these guiding principles:

1. Screening of vehicles will enhance the safety, security and environmental objectives.
2. Screening criteria selects vehicles for a progressive series of inspections and analysis. The criteria shall include national, state, local or sector-specific threat condition(s), detection of anomalies and variations in normal traffic patterns, responses of detection systems and historical patterns. Some screening is completely random. Screening criteria are changed to decrease deterrence predictability and increase obfuscation.

3. Minimize disruption of traffic and commerce in all threat situations. During high threat conditions, where scrutiny may be required to reduce risk of attack, some disruption will occur.

4. Each highway station will have the capability for real-time recognition of license plates and HAZMAT placards at highway speeds. Detection of BOLO or “Amber Alert” vehicles will be communicated to appropriate law enforcement.

3.6.1 Operations

Highways:
Figure 6 illustrates the integrated safety and security inspection station M²IS²EP prevention concept.

Sorting into Lanes – Approximately one mile prior to the station, vehicles are directed (using illuminated signs and Advisory Radio) into one of two groups of lanes. Vehicles that are not selected for screening will be directed to the left lanes. (Most private vehicles will be in this category.) Vehicles directed into the right lane(s) may be inspected. Note: the criteria for vehicle selection are flexible, and changeable. For instance, commercial trucks, HAZMAT trucks, and rental trucks could be required to move to the screening lane.

Vehicle Identification –
Automatic license plate recognition, HAZMAT placard category and division, and DOT number are examined to identify vehicles in both lanes. Vehicles in the right-hand lane are measured and identified with highway inspection tools (weight in motion, NORPASS®, PrePass®, RadSTraM, vehicle length). The appropriate law enforcement agency is notified if any vehicle appears on a BOLO or Amber Alert. No further action is taken with vehicles in the left lanes; they pass through the inspection station. The proper authorities will
apprehend vehicles that are objects of a BOLO.

**Vehicle Screening Selection** – As shown in Figure 6, selected vehicles are screened for detailed inspection. Vehicles are directed enter the inspection lane or return to the highway. The Vehicle screening selection criteria accommodate changes in the threat condition. Today the safety pre-screening criteria are based on information in the CVISN system, which shares the safety records of commercial carriers. Other security-based criteria are added, including: historical traffic patterns, cargo types, destinations, and prior security inspection records. Some vehicles are selected at random for screening.

Consider three examples: First, a line haul trucker with a good safety record and no particular security concerns for the cargo or destination. This truck is subject to random selection for screening, just as it is today. If it is not selected for screening, it returns to the highway after slowing to 35 mph. Legitimate, safe traffic is not interrupted.

Example 2 takes place during a period of heightened alert for large rental trucks. All rental trucks could be directed to the right-screening lanes for further identification, and go through Vehicle Screening Selection. When the concern is sufficient, all rental trucks could be subject to inspection. The specific threat condition can determine the selection and inspection criteria.

Example 3 is a HAZMAT vehicle carrying Division 2.3 Material (Gasses toxic by inhalation). All HAZMAT vehicles could be directed to the right lane for identification, and some, or all, Division 2.3 vehicles could be subject to inspection. The inspection would check for safety, and security (proper operator permits) and subject the driver to screening. Because all vehicles are screened, a HAZMAT vehicle that simply bypassed the inspection would be identified and law enforcement would be alerted.

**Vehicle Screening** – Vehicles selected for screening are segregated into a lane that approaches the inspection station. Identification equipment, measurement technology, and detection systems inspect the vehicle as it travels to the inspection station. Radiation, chemical, and biological detection systems could be included at this point. Accurate scales will determine the weight on each axle. Inspectors have safety, security and historical information to examine the vehicles. Inspectors use by automated systems to identify anomalous characteristics of the vehicle, operator, or cargo. Ultimately, if the inspector has further questions, the subject vehicle will be diverted to a parking lot for further inspection, citation or to await further law enforcement assistance.

**Detailed Vehicle Inspection** – When an inspector identifies a violation, or a screened vehicle that is subject to a BOLO, or has security concerns, the subject vehicle can be diverted out of the flow of traffic to a parking lot. Here, the inspector can take more time either to check the vehicle and occupants, to become satisfied, cite the operator, or to hold the vehicle pending assistance from appropriate law enforcement officials.

**Freight Rail:**

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9 ORNL has worked jointly with the Tennessee DOT to instrument I40/75 Knox County Weigh and Inspection Station.
International freight rail within the pilot corridor enter the country under the C-TPAT\textsuperscript{10} Program, which ensures that the cargo is sealed at the origin location, and that the supply chain is trusted. During transport between the borders and the intermodal stations, the cargo remains under seal. When this cargo is transferred to alternate modes of transportation, it is subjected to screening appropriate to that mode.

Of more concern in the rail case are the risks associated with the transport of HAZMAT. Concerns vary by category, but Toxic Inhalation Hazards (TIH) has received considerable attention as a mode of attack against large population centers. One of the features of the new transportation planning and investment is the routing of HAZMAT around large population centers. Some consideration could be given to automating some inspections of TIH rail cars (while underway) to detect externally applied explosives, or on-going leakage of TIH material. This concept is being piloted in the Washington, D.C. area. Based on those experiences, those inspections could be extended to some high-risk areas prior to the implementation of safe alternate routes.

\textit{Information Sharing:}

The information-sharing network extends the capabilities of CVISN. A set of standards and protocols must be developed to facilitate the exchange of information concerning safety records, safety history, and inspection history of particular operators, equipment, cargo, and companies. This information exchange must be enhanced to include the relevant security information that is necessary to conduct the security inspections described previously.

Information sharing is a crucial enabling technology for the vehicle screening and risk analysis decisions. It will facilitate the understanding of patterns in traffic, changes in those patterns, a history and pattern of inspections from other stations visited by the vehicle or the company. The standards and protocols must be developed in a collaborative process with the states and the transportation industry, much like the CVISN process. Federal partners (TSA and DOT) will establish the safety and security priorities for this information sharing system. Federal oversight ensures that individual privacy rights are recognized and properly handled throughout the design, implementation, and operation of the system.

\textit{Vehicle Screening and Analysis:}

The Vehicle Screening Analysis System (VSAS) is at the heart of the integrated inspection system. In Figure 3, the VSAS screening steps are labeled A-D. Although it is an automated information management tool, it supports the inspector and assists in decision-making. VSAS utilizes information from throughout the inspection system as well as specific information from an inspection station, and individual vehicle information to make recommendations for a series of inspection station screening decisions. In this sense, VSAS is an integrated risk management tool. Its selection criteria include safety, security, and law enforcement risk mitigation strategies.

At the system level, all of the safety information on companies, vehicles and operators is utilized in screening selection recommendations. Security considerations add additional information concerning cargo type, source, destination, shipper, and associated historical patterns. For security purposes, VSAS includes anomaly detection.

\textsuperscript{10} C-TPAT is an acronym for DHS’s Customs Trade Partnership Against Terrorism.
At the vehicle level, all available information concerning the vehicle, cargo, manifest, insurance, source, destination, axle weights, gross vehicle shape, and operator behavior are utilized to make screening decisions. Automated tools assist inspectors in identifying anomalies and questioning the operator until the anomalies are understood and explained.

Information could be exchanged with other federal agencies as well. For instance, on occasion Customs and Border Protection will have a concern about an international container, after it has crossed the border. By adding the container number to the screening criteria, the container would be stopped at the inspection station.

The VSAS criteria are adjusted based on the current threat conditions and informed by imbedded anomaly detection criteria. Anomalies can arise in comparison to historical information for a shipper, cargo types, seasonal variations, or other criteria that will only be determined after information is assembled and analyzed. Consequently, VSAS will provide an integrated methodology for recommending all of the sorting criteria used in the system (including, recommendations for lane sorting criteria, pre-screening analysis on a vehicle-by-vehicle basis, and final screening criteria).

As an example, a case can be made for increased attention to rental vehicles with gross vehicle weight less than 26,000 lbs. Such vehicles do not require operators to have a commercial drivers license, but are capable of transporting significant quantities of material for illicit purposes. Rental vehicles have been used by terrorists for transportation of materials, and as large vehicle improvised explosive devices. At some alert levels, and at some randomly chosen times, such vehicles could be subjected to additional screening at inspection stations. These criteria are easily selected in VSAS and integrated into the inspection station operations, at a single station, or across the country.

The use of an integrated risk assessment tool, VSAS, is essential in establishing a level of uncertainty for terrorists. Because any vehicle could be inspected, it makes planning and execution problematic for terrorists.

4. Future Research Directions

The DHS and DOT has vast amounts of data available, but its ultimate value cannot be realized without technologies for knowledge discovery to enable better decision-making by inspectors. Past evidence has shown that terrorist activities leave detectable footprints, but these footprints generally have not been discovered until the opportunity for maximum benefit has passed. The challenge faced by the DHS and DOT is to discover these activities (e.g., at border crossings), and other activities in advance of an attack and use that information to identify potential threats and vulnerabilities. Consequently, there is a massive projection of data (i.e., conveyance and ancillary data) that must be always available and reliable (i.e., correct and precise) (16).

Our ability to exploit the vast amount of disparate data for high-priority application solutions will depend critically on how the data is processed and utilized. Therefore, the four major steps for the data exploitation process are:
1. **Data to Information**: Raw data need to be converted to information for the data to be useful. This is achieved through systematic collection, integration, organization, presentation and summarization. This process is also referred to as data fusion.

2. **Information to Knowledge Discovery**: The process of converting information to actionable and meaningful insights through predictive analysis has been defined as knowledge discovery.

3. **Knowledge Discovery to Decisions**: Information obtained from data fusion and the knowledge gained from offline discovery need to be utilized in conjunction with real-time analysis for decision-making.

4. **Decisions to Knowledge Management**: The decisions obtained over time are useful for developing standards and sharing information.

This four-step iterative process typically needs to be tied in the context of the domain or the application where the information, knowledge, decisions, or knowledge management and information sharing is sought. However, commonalities do emerge in the requirements as well as the tools that need to be developed for each of the steps.

### 4.1.1 Key Features of Knowledge Discovery and Management Paradigm

In the context of M²IS²EP, the result of a shipper planning process is unknown data to VSAS, yet it is the input into the beginning of the VSAS process. The planning process dictates the origin and destination of the shipment, equipment to be shipped, when and by what means of conveyance for each commodity. At each trans-shipment point all cargo (i.e., equipment and vehicles) must be weighed and measured (i.e., for volume) to ensure that cargo meets critical volumetric storage criteria associated with the identified mode of surface transportation (e.g., ship, truck, train, barge in this paradigm). The execution process is the actual shipment and trans-shipment of commodities. This activity is constantly being monitored by individual states as these commodities transit the transportation network.

In an earlier project, the authors developed and provided a secured, web-enabled, and central data and service repository for configuration and data management processing (via a Reach Back Capability - RBC) that was used to continuously analyze and improve the weighing process system (17). Once constructed, both developers and users realized that the knowledge discovery features across multiple disparate data sources, sensors and spatial and temporal data were more important. The RBC stores and retrieves disparate types of system, logistics, and technical information in the form of text, data, images, and video using relational SQL-based data sources, flat files, and external Web Services as required. Moreover, all of these resources are readily accessible through a simple Web browser User Interface (UI) and as a result information storage and access is executed immediately over the Internet.

### 4.1.2 VSAS Data and Processing Produces Knowledge

The RBC information is modeled using two complementary forms: the Unified Modeling Language (UML) and the RBC XML Schema. UML is the standard object-oriented notation that facilitates modeling the structure, architecture and behavior of systems, software, and data. An XML Schema describes the structure or format for an XML document for such things including the contained elements, the order of the elements it contains, and the quantity and relationship of
each element. The VSAS data processing demonstrates how knowledge discovery can be used to provide a composite picture of activity on our nation’s transportation network. The input data as presented to the system was incomplete with respect to situational awareness of the entire multi-modal transportation network. By analyzing the process, both developers and users can recognize knowledge discovery features across multiple disparate data sources, sensors and spatial and temporal data.

5. Conclusion

The trend toward increasing globalization of the economy has resulted in increasing international shipments to US destinations and across the continent. The North American Free Trade Act (NAFTA) has removed barriers between North American Trading partners. The past decade has seen significant increases in containerized cargo. Trade with Asia increasingly depends on containerized cargo shipments that enter through crowded US ports. Rail lines are required to move containers from ports, but limited East-West rail capacity leads to congestion and increases overall shipment times. Increasing trade is stressing the capacity of US Ports, rail infrastructure and highways. US industry relies on Just-in-Time and Lean Manufacturing concepts; making a safe, secure, environmentally friendly and efficient transportation system more important. Accordingly, this paper has described M²IS²EP

The M²IS²EP Program provides a management strategy that includes leveraging existing infrastructure and capabilities as well as integration of new technology requirements (i.e., hardware/software, data architecture and risk management). Furthermore, the investment process has begun with new transportation planning strategies to improve capacity. Now is the time to integrate safety, security, and environmental measures. Opportunities arise from every challenge in realizing an integrated safety, security and environmental strategy for the surface transportation system.
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