MANAGING TRANSPORTATION SAFETY AND SECURITY RISKS

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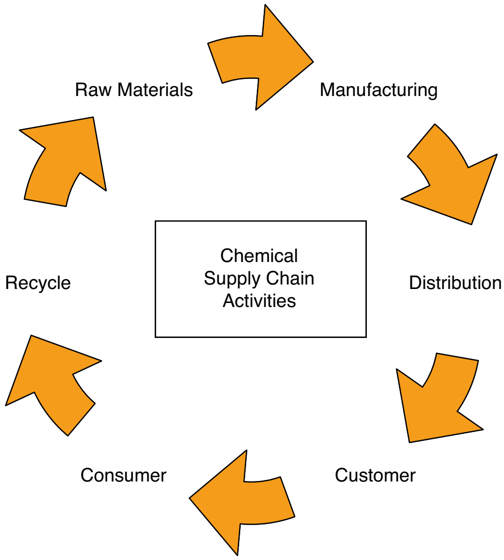
Effective transportation risk management (TRM) balances safety and security with operational efficiency. When developing a TRM program, use this comprehensive framework and these practical techniques to identify and screen risks.

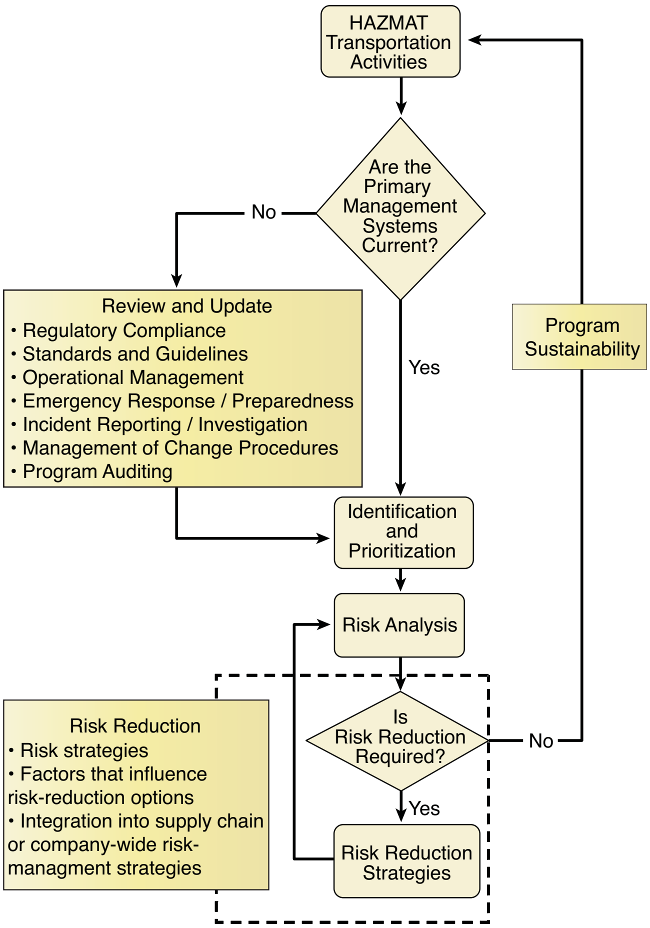
A major goal of the safe and secure transportation of hazardous materials is the elimination (or a reduction in number) of incidents that could lead to a release or to misuse.

Due to the complexity of a transportation supply chain, risk management is the shared responsibility of all stakeholders. Although their roles and responsibilities differ, everyone involved in the supply chain (Figure 1), from raw material supplier, through manufacturing and distribution, to the final end user, needs to understand how their activities and actions can impact the risk to the overall supply chain. Several factors contribute to the complexity of hazardous materials transportation:

- the large number of regulated hazardous materials (thousands are listed in regulations worldwide)
- regulations that vary by transportation mode, region, and country
- different hazard criteria, including toxicity, flammability, corrosivity, and reactivity
- various modes of transportation, including road, rail, marine (including bulk vessels), pipeline, and air



▲ **Figure 1.** Risk management is a shared responsibility of all parties — from the raw material supplier, through manufacturing and distribution, to the final end user — involved in the supply chain.



▲ **Figure 2.** A flexible framework consisting of a primary management system, identification and prioritization, risk analysis, risk reduction, and program sustainability, enables companies to design a TRM program for their specific application.

• multiple types of packaging, including bulk and smaller containers

• the use of more than one mode during a shipment (intermodal transport)

• the complexity of the supply chain, which includes multiple parties and involves changes of custody during transit

• overlapping and potentially unclear responsibilities of various parties

• transport routes whose risk profile can change depending on proximity to the public or other sensitive areas.

Even with current safety regulations and operating practices, these complexities contribute to accidents during the transportation of hazardous materials.

In addition to safety considerations, security has become an increasingly greater concern during hazardous materials transport. Certain hazardous materials could potentially be used as a weapon to spread fear, cause injuries or fatalities, and/or create negative economic impacts. To address the potential for deliberate misuse, additional security regulations and industry standards continue to be developed.

AIChE's Center for Chemical and Process Safety (CCPS) recently published a new book *(1)* to deal with transportation safety, security and risk management on a broad basis and provide information and tools for a wide range of transportation professionals and stakeholders. This article, which is based on the book, outlines a methodology for adapting and applying security vulnerability assessment (SVA) techniques designed for fixed chemical facilities to account for differences specific to transportation. It is meant to embrace and utilize a company's existing systems, but it must be adapted to meet regulatory requirements in the areas where shipping activities occur. Many companies transport materials across country borders and around the globe, and while local customs, regulations, and cultures may vary, the common principles of safety, security, and risk management should always be recognized.

Framework for managing transportation risk

A comprehensive, holistic risk-management program covering the entire supply chain and involving all stakeholders, such as the framework depicted in Figure 2, is needed to ensure the safety and security of chemicals in transit. This framework is designed to be flexible, enabling companies to tailor their transportation risk management (TRM) process to their individual circumstances and specific applications. The TRM framework is comprised of the following steps.

The primary management systems are the foundation of the TRM program. These programs are the baseline activities or management systems that need to be in place to address compliance with all applicable regulations and implementation of additional programs and practices to manage the safety and security of hazardous material transportation activities. With the potential for cross-border shipments and international operations, understanding and keeping up-to-date with changes in regulations is a critical part of this step.

Identification and prioritization involves cataloging the hazardous materials and modes of transportation, identifying sensitive areas and potential points of failure along the transit route, and understanding interactions with other stakeholders in the supply chain.

Risk analysis can range from simple, quick and general to detailed, time-consuming and quantitative assessments. It is recommended to start with simpler techniques and move to more-complex and resource-intensive activities on a risk-justified basis. Simple risk analysis techniques include qualitative analyses that can be based primarily on description and comparison using historical experience and judgment, with little quantification of the hazards, consequences, likelihood, or level of risk. For those issues requiring more detail and insight, semi-quantitative and full quantitative risk analysis techniques can be applied. (References 1–3 provide additional information on risk analysis.)

Risk reduction is the process of determining whether the assessed risk is being managed adequately, and evaluating and implementing options to further reduce risk as needed. If the risks merit additional reduction, methods can be developed for the individual hazardous material operation, coordinated with the company's risk management philosophy, and/or developed in concert with other supply chain partners.

Program sustainability, the final step in the TRM framework, is designed to ensure that the risk-management process remains current. It involves an ongoing commitment to managing risk, continuously improving, reacting to emerging trends, and keeping current on evolving transportation risk analysis practices.

Table 1. Transportation risk management involves synergies and tradeoffs between safety and security.

Issue	Safety	Security
Placards	Commodity information needed by emergency responders to react appropriately to an accident and to minimize any impact	Commodity information could be used by terrorists to target specific chemicals
Rerouting	May result in more accidents if there are longer transits or the infrastructure along an alternative route is less well maintained or contains undesirable features (*e.g.,* uncontrolled intersections, no shoulders, etc.)	Eliminating a shipment near a specific location (most likely a highly populated or critical area) may inadvertently transfer the risk from one community to another
Working with Supply Chain Partners (Implementing Security Countermeasures)	Technology can be used for both safety and security (*e.g.,* GPS to indicate location en route, emergency response to accident, and monitoring time-sensitive chemicals and materials)	Technologies focused on security should not interfere with the main function of the carriers (*i.e.,* the safe transport of chemicals from one location to another)
Risk Analysis Methods	Rational and structured results lead to recommendations Participation and engagement by individuals with different perspectives, roles, backgrounds, and skill sets for safety, security, and transportation Similar methodology Same decision metrics (guidelines)	

Transportation security and risk analysis

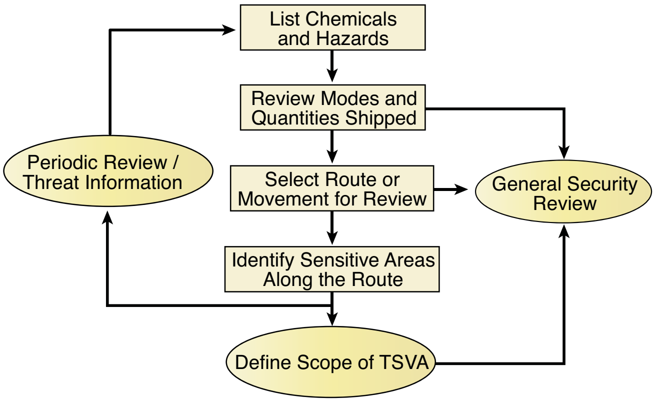
Transportation security involves many challenges as a result of a global economy and supply chain. These challenges include not only terrorism, but also piracy, organized crime, illegal drug manufacturing and trafficking, and smuggling. It is important to consider all potential threats when evaluating chemical transportation security, since a chemical shipment can fall victim to various types of attacks. Fortunately, many of the same security countermeasures can be effective in addressing these widely divergent security threats.

The terrorist bombings of the Madrid commuter railroad system and the London subway highlighted the inherent vulnerabilities of the transportation infrastructure. These types of attacks, combined with derailment accidents involving chemical releases, have raised awareness of the potential consequences should a shipment be compromised when in route. This is changing the perception, tolerance, and means of managing the risk of hazardous-material transportation operations, and has led to an increasing focus on not only transportation safety, but also hazardous material transportation security. This concern, in turn, has led to worldwide calls for legislation directed at increased security, rerouting of hazardous material shipments, and a push for the application of inherently safer technologies (ISTs).

The risks stem from the fact that hazardous materials could be attractive terrorist targets due to the potential consequences resulting from an intentional release, contamination of the material in transit, or theft for use as a weapon against another target. Since the chemical industry is critical to the global economy, any successful attack, damage, or disruption could cause negative local, regional, and/or national impacts or rippling economic disruptions across numerous industry sectors. Therefore, the chemical industry and its value chain have been identified as critical infrastructure requiring security measures that address today's threat environment.

Safety and security synergies and tradeoffs

When developing or applying baseline elements of a risk-management program and proposing recommended countermeasures as part of a security review, it is important to understand the compromises among safety, security, and convenience. The key difference between safety and security is that security incidents are the result of intentional acts. This is the basis for understanding



▲ **Figure 3.** A multistep prioritization process should be used to identify the specific chemicals, movements, and route segments that may require further evaluation.

the hazards, potential consequences, and likelihood of an intentional malevolent event.

An increase in security may result in changes and inconveniences that everyone in the supply chain will need to understand, accept, and adjust to. Therefore, security decisions should not be made blindly without considering transportation safety implications. Furthermore, it is recommended that security be integrated into the overall transportation risk-management process. Examples of safety and security synergies and tradeoffs are presented in Table 1.

Similar to safety risk analyses, a security screening process should be carried out to identify specific issues that require a full transportation security vulnerability analysis (TSVA) and screen out those scenarios that justify only a general security review. A security screening involves concerns different from those of a prioritization effort focused solely on safety, so the chemicals and movements of interest may be different. Some chemicals and movements that are ranked as a lower priority (or even screened out of further detailed analysis) based on safety issues may receive a higher ranking when security issues are considered, as the following examples demonstrate.

• During a safety review, a material is assigned a low ranking because it is transported in a container specially designed to minimize the likelihood of an accidental release and the potential for a large release is low. However, since the goal of an intentional act is to create the largest release possible, a more-significant security event may be possible, and needs to be considered and evaluated further.

• The transportation of a chemical in a limited number of small cylinders may be ranked low based on safety concerns. However, its ranking may be escalated for security reasons based on the potential for theft and the subsequent use of this material to produce a chemical weapon.

• A food additive may have screened out of a safety analysis since there are no hazards associated with the product, but the potential for tampering with a loaded tank truck or rail car may raise a concern about potential product contamination. A review of the measures in place to prevent and detect tampering at the origin, along the route, and at the destination may be warranted.

• A tank truck of flammable materials may be ranked low in a safety analysis because the consequence footprint of such a material can be much smaller than that of toxic materials. But if an attack along the truck's route could significantly damage a critical transportation route and result in an extended shutdown for cleanup and repair, or allow the shipment to be hijacked and diverted, then a segment of the route may warrant escalation in the security review.

Security prioritization

The following factors should be considered in developing a security prioritization process:

- chemical hazards
- quantity transported per container
- number of shipments or campaigns
- mode of transit
- interim (unsecured) storage
- proximity to people
- proximity to sensitive environmental areas
- proximity to other critical assets or infrastructure
- specific threat information.

No single prioritization factor is intended to trigger a full TSVA. Rather, a multistep process should be used to identify the specific chemicals, movements, and route segments that may require further evaluation. An example prioritization process, consisting of the following steps, is illustrated in Figure 3.

Step 1. List chemicals and hazards. The inherent physical properties (*e.g.*, toxicity, flammability, reactivity) of a hazardous material in transit should be used to develop a list of chemicals that will go through the prioritization process. This list of chemicals may be different from that developed for accidental releases and may need to consider the following security issues:

• loss of significant containment in transit due to intentional equipment damage or malicious release with the potential to impact people, property, or the environment

• theft or diversion and misuse with the intent to cause harm along the route or at an alternate location

• contamination with the intent to cause a reactive event while in transit, an event at the final destination, or other offsite impacts that could result from material tampering.

Step 2. Review mode(s) and quantities shipped. For each chemical, review the mode of transport and the quantities transported and refine the list of chemicals and modes to be further prioritized. This review should consider the following factors:

• for toxic, flammable or explosive materials, the minimum quantity (or threshold) that, if released in transit, could have an impact on people, property, or the environment

• whether transport is by a dedicated contract carrier or a common carrier

• features of the transport mode related to the difficulty of attack or cargo vulnerability during various stages of the operation or at specific segments along the route.

Step 3. Select the routes and movements to be evaluated. Depending on the complexity of the supply chain network, it may first be desirable to divide the transportation activities into more manageable groups. These may include specific chemicals or chemical classes, modes of transportation, movements, regions, in-transit storage (yard or warehouse), etc.

Step 4. Identify sensitive areas along each route. Except for chemicals that remain on the list because of potential theft and contamination issues, the chemicals and modes carried forward from Step 3 should be evaluated with respect to specific sensitive segments along the routes. Sensitivity may be determined by proximity to people, delicate environmental areas, or other critical assets or infrastructure, or by the degradation of critical infrastructure or other assets that could result from an attack along the route.

Step 5. Perform a security evaluation. Each of the chemical movements screened out through the prioritization process should be analyzed by a general security review before closing them as action items. All chemical/mode/route combinations that make it through the prioritization process should be reviewed using a TSVA methodology. A TSVA can be designed to analyze risk from a wide range of threats. In theory, risk is a function of consequence and likelihood, but in security analyses likelihood is evaluated as a function of vulnerability and threat. Therefore, security risk is defined as a measure of the consequences, vulnerabilities, and threats. The details of the TSVA methodology are presented in Chapter 6 of Ref. 1.

Step 6. Conduct periodic reviews. It is important to periodically review the security of the transportation network to ensure that the baseline program elements are still in place and the recommended countermeasures have been implemented, and to reassess vulnerabilities. This process should also be reinitiated if specific intelligence or threat information about the particular supply chain, mode of transport, or chemical movement is received.

By following this (or a similar) approach to prioritization, one can evaluate the transportation system to identify those issues that need to be escalated to a more-detailed TSVA and better understand the potential consequences, vulnerabilities, and level of risk, or to compare potential security countermeasures.

The CCPS book from which this article is excerpted is not intended to be the sole reference for transportation vulnerability assessment, but rather it provides the background for transportation professionals conducting such an analysis. It includes references to other security vulnerability methodologies and discusses adapting methodologies developed for fixed chemical facilities to transportation. It also offers the additional guidance on the key elements of a TRM program, including developing a security plan, shipping and receiving, and responding to security incidents. CEP

Literature Cited

1. **Center for Chemical Process Safety,** "Guidelines for Chemical Transportation Safety, Security and Risk Management," 2nd ed., AIChE and Wiley, Hoboken, NJ (2008).
2. **Center for Chemical Process Safety, "**Guidelines for Chemical Process Quantitative Risk Analysis," 2nd ed., American Institute of Chemical Engineers, New York, NY (2000).
3. **Center for Chemical Process Safety,** "Guidelines for Chemical Transportation Risk Analysis," American Institute of Chemical Engineers, New York, NY (1995).

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