RISK MANAGEMENT FRAMEWORK FOR HAZARDOUS MATERIALS TRANSPORTATION

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The U.S. Department of Transportation's (DOT) Research and Special Programs Administration (RSPA) administers a comprehensive safety program in hazardous materials transportation to protect the Nation from risks to life, health, property, and the environment. Although incidents resulting in hazardous materials releases occasionally occur, most observers believe the existing hazardous materials transportation safety program has performed well. Both government and private industry have undertaken extensive efforts through regulations, programs, and initiatives to reduce the risks of transporting hazardous materials. Society is generally intolerant, however, of risks from hazardous materials transportation, particularly when there is potential for multiple injuries and/or fatalities. To reduce the number and impact of serious incidents, RSPA has made it a priority to use structured risk management approaches in its own programs and to encourage hazardous materials shippers and carriers, as well as others involved in transporting hazardous materials, to *proactively* evaluate the risks of their operations and take appropriate steps to further reduce those risks.

This report presents and explains a RSPA risk management framework for transportation of hazardous materials. As part of its One Flagship Initiative, RSPA is developing this new framework, with significant stakeholder input, to serve as a resource for self-evaluation by all parties involved in transporting hazardous materials. Although the framework itself is new, many of its concepts and components are drawn from existing risk management systems and approaches used in hazardous materials transport and other venues. The framework is broad in scope, addressing the full range of hazardous materials, transport modes, and parties involved in transporting hazardous materials. It is intended to be comprehensive and thus to cover all the major aspects of risk management.

The new framework is not meant to create duplicative activities with risk management approaches already in place, but to complement such approaches where they exist and serve as a model where they don't. It is intended to help involved parties – shippers, carriers, packaging manufacturers, emergency responders, government regulators, and others – systematically think about and manage, in a cost-effective manner, the risks associated with transportation of hazardous materials. It is meant to be flexible so that it can be adapted and applied by various parties in a wide variety of situations.

Process for Developing the Framework

Development of the framework began in 1999 with preliminary research on the existing hazardous materials transportation system and the available risk management approaches (ICF 2000a). This initial research was followed by a two-day exploratory meeting of stakeholders and experts to introduce the idea of a risk management framework and obtain preliminary feedback, learn about existing risk management efforts, and help formulate ideas to guide initial framework development. Following the meeting, a draft report describing the framework was prepared, then reviewed by an expert panel and revised into this risk management framework (ICF 2000b). In addition, a series of three case studies (ICF 2000c) was performed in which the framework was evaluated across a range of hazardous materials transport applications. After taking into account stakeholder recommendations, DOT chose as case study participants a railroad industry trade association, RSPA itself, and a sampling of selected companies in the trucking industry. This risk management framework was revised to incorporate lessons learned from these case studies.

This report articulates the goals for the framework, gives definitions and a brief background discussion to provide context and a common starting point, and describes the three main elements of the framework: a basic philosophy, a set of fundamental risk management principles, and a stepwise general approach to hazardous materials transportation risk management. More detailed information supporting the framework is provided in the appendices.

1. GOALS

The overarching goal for this initiative is simple. RSPA wants to further reduce the human health and environmental risks associated with hazardous materials transportation without imposing significant new regulatory burdens and costs on the hazardous materials transport community. In short, RSPA wants to reduce the number of incidents and, where incidents occur, reduce their adverse impacts.

RSPA recognizes that parties involved in hazardous materials transportation are subject to extensive federal regulation and that many parties already implement some degree of voluntary risk management beyond the regulations. RSPA wants to encourage and build on these efforts and stimulate others where they do not exist. RSPA believes that promoting and expanding, in a constructive manner, the use of risk assessment techniques and risk management concepts throughout the hazardous materials transport community will help achieve more effective and efficient control of risks, now and into the future. An important goal for this RSPA initiative is to provide a means to help identify and address areas of hazardous materials transportation risk that may not be covered adequately by existing regulations or current voluntary approaches. Moreover, many of the more readily apparent and easier actions to reduce risk ("low hanging fruit") have already been taken, which has improved the safety record to its current state, and the framework provides a structured approach to identify and implement additional steps whose costs are justified by their risk reduction benefits.

The goal of the framework itself is to serve as a unifying structure and self-evaluation resource that will encourage and guide the voluntary use of risk assessment and risk management concepts and tools by the many disparate parties involved in transporting hazardous materials. This is a significant challenge because the hazardous materials transportation system is quite complex. The framework is intended to help those involved in risk management, but not be a mandatory tool or required way of thinking. RSPA believes that a systematic approach of some sort is needed, but also recognizes that parties who choose to use this framework will need to tailor it to their individual circumstances and specific applications.

2. BACKGROUND AND CONTEXT

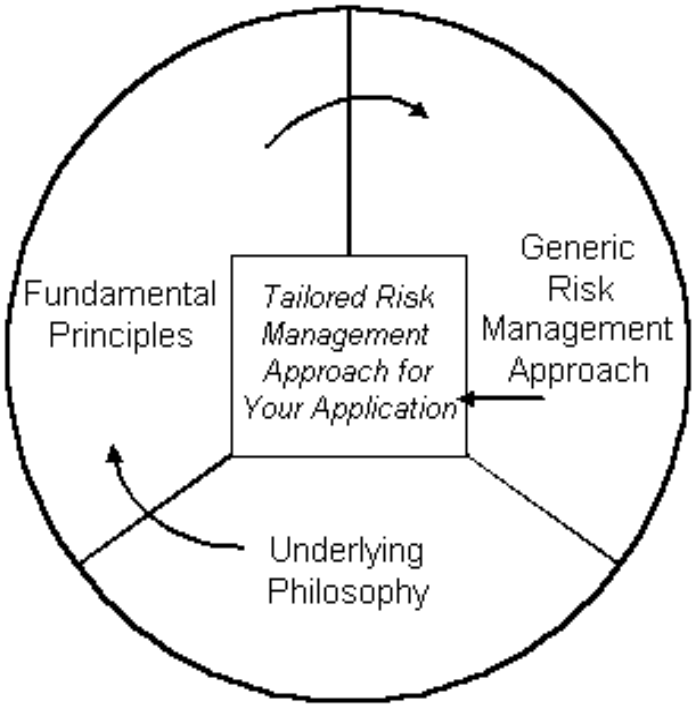
Definitions: A Common Starting Point

What is a *framework*? In the context of this report, a framework is an overall organizing structure that identifies and defines the main elements of a process – in this case, risk

management of hazardous materials transportation – and explains how they fit together. A framework is comprehensive and integrative in nature, but not necessarily detailed. A framework can be supplemented by many specific methods, tools, and detailed guidance documents.

The framework for hazardous materials transportation risk management has three basic elements (see Exhibit 1): (1) an underlying philosophy, which in short, is to proactively assess your risks, then act to reduce them; (2) a set of fundamental principles to guide, at the broadest level, risk management decisions and actions; and (3) a generic risk management approach that can serve as a model and be adapted to many specific purposes by various players in hazardous materials transport.

Exhibit 1
Risk Management Framework for Hazardous Materials Transportation



There are several important risk-related terms that are used throughout this report in presenting and explaining the framework. It is useful to start with a common definition for each of them. Therefore, definitions of the terms hazard, risk, risk assessment, risk management, and risk control point are provided in the text box on the next page. With the exception of risk control point, these definitions are derived primarily from DOT's published definitions. Note the key distinctions between hazard (inherent properties) and risk (likelihood and consequence) and between risk assessment (scientific analysis) and risk management (decision-making and action).

Hazardous Materials Transportation: A Complex System

Definitions of Risk-related Terms

Hazard – the inherent characteristic of a material, condition, or activity that has the potential to cause harm to people, property, or the environment.

Risk – the combination of the likelihood and the consequence of a specified hazard being realized.

Risk assessment – the systematic approach to organizing and analyzing scientific knowledge and information about potentially hazardous activities; simply stated, the analysis of risk; generally includes problem formulation, hazard assessment, exposure analysis, and risk characterization.

Risk management – the systematic application of policies, practices, and resources to the assessment and control of risk affecting human health and safety and the environment.

Risk control point – a place within a given process (e.g., a specific step in an unloading operation), or more broadly speaking within an overall management system (e.g., training), where actions can be taken to reduce risk.

Several basic truths about hazardous materials transportation provide useful context for the risk management framework. In a number of ways, the hazardous materials transport system is highly heterogeneous and complex. Hazardous materials transport is a chain of events involving *multiple players* (e.g., shippers, carriers, packaging manufacturers, container reconditioners, distributors, freight forwarders, consignees (receivers of shipment), emergency responders, government regulators, enforcement personnel) having different roles in the process of safely moving hazardous materials from their origin to their destination. There often are *multiple handoffs* of a material from one party to another during transport. The various parties, who range from individuals to small firms to the largest of multinational organizations, may have *overlapping and unclear responsibilities* for managing the risks.

In addition, there are *many different hazardous materials* (thousands are listed in DOT regulations) that pose a *variety of hazards*, such as flammability, corrosiveness, reactivity, and toxicity. Further adding to the system complexity is the fact that hazardous materials transportation encompasses several *different modes* of transport, principally highway, rail, waterway, and air. Moreover, some shipments are intermodal (i.e., switch from one mode to another during transit). In many hazardous materials transport situations, there are numerous choices regarding the mode to be used and the specific *route* to be followed in transporting the material.

Existing Risk Management Approaches

Overlying the inherent complexity of hazardous materials transport – multiple players, many different materials, multiple hazards, multiple modes and routes – is an extensive federal regulatory system administered by DOT. The regulations cover many aspects of hazardous materials transportation, from labeling and packaging the materials to employee training to loading and unloading operations. While the regulatory system has many requirements that result in risk reductions, it is not a holistic approach to risk management. RSPA believes a comprehensive, general risk management framework can help it better carry out its own programs and also can assist individual companies, who know their day-to-day operations best, in developing tailored approaches to achieve cost-effective risk reduction beyond the regulations.

In addition to the existing DOT regulatory system for hazardous materials transportation, there are a number of approaches to risk management – both formal published approaches and *ad hoc* methods used by individual parties – that are being followed to varying degrees within the hazardous materials transport community. There are other approaches that may have some applicability even though they are not currently in wide use in hazardous materials transportation.[1] Examples of widely used voluntary approaches include the:

- Responsible Care Distribution Code (CMA 1999), developed by the Chemical Manufacturers Association (CMA); and
- Responsible Distribution Process (NACD 1999), developed by the National Association of Chemical Distributors (NACD).

Both of these approaches were developed for the chemical industry, which is a major originator of hazardous material shipments. Although targeted to the chemical industry, these approaches, along with their associated guidelines and tools, could have wider applicability.

Another structured risk management approach that covers some aspects of hazardous materials transportation (primarily loading and unloading), but is aimed primarily at fixed facility risk management, is the process risk management regulations established by the U.S. Environmental Protection Agency (EPA) (EPA 1999) and the U.S. Occupational Safety and Health Administration (OSHA) (OSHA 1999). Aspects of this comprehensive regulatory approach, especially its breadth with regard to the components of risk management, also are potentially applicable to hazardous materials transportation risk management. One notable approach to risk management not being used within the hazardous materials transportation community, but with potential applicability, is the Hazard Analysis and Critical Control Point (HACCP) process, which was developed for and is widely used to manage microbial disease risks in the food processing industry (NACMCF 1998).

Approach to Developing a New Framework

The basic characteristics of the hazardous materials transportation system, the existing DOT regulatory structure, and the various approaches to risk management either in use or with potential applicability form the context within which the new framework was developed. Following background research on the current hazardous materials transportation system and available risk management approaches, and an initial exploratory meeting with key stakeholders, the following main options were considered in developing the framework:

- Adapt/build on the CMA Distribution Code and/or the NACD Responsible Distribution Process;
- Adapt/build on the EPA/OSHA process safety and risk management regulatory approach;
- Adapt/build on the Manual of Recommendations for Inter-industry Bulk Chemical Highway Safety Task Force;
- Adapt/build on the HACCP approach; or

[1] ICF 2000a, *Task 2 Report – Evaluate Current System,* contains more detailed discussion of various potentially relevant approaches to risk management, including those noted here and several others.

- Create something new, maintaining consistency with other systems used by the hazardous materials transportation community and incorporating concepts from those systems where appropriate.

It was determined that although the existing approaches have valuable concepts and relevant components, no single one was broad enough in scope, nor in some cases sufficiently applicable to transportation processes, to serve as the primary basis for the new framework. Thus, a new framework, consistent with and based in part on many of the approaches in place, was created.

Several design criteria guided development of the framework. For instance, it was designed to be voluntary in application. It had to be comprehensive in scope and widely applicable throughout the very diverse hazardous materials transportation community. It had to be flexible so it could be adapted for various uses by various government and industry users. It had to be understandable, and usable by small entities with very limited resources as well as large organizations already investing heavily in formalized risk management programs. Very importantly, it could not penalize those already practicing effective risk management.

3. PHILOSOPHY AND PRINCIPLES

The philosophy underlying the framework is ***action informed by analysis***. Analysis of risks, costs, benefits, technical feasibility, and other items is necessary for effective risk management, particularly within a system as complicated as hazardous materials transport, but analysis should not become an end unto itself. Analysis provides the information needed for decision-making and planning but does not by itself reduce risks. Risks are reduced by actions, and therefore action – informed by analysis – is the true cornerstone of effective risk management. Analysis should be driven by the need for information to feed into decision-making about what actions, if any, are appropriate. The value of information likely to be gained through analysis should be explicitly considered before any significant studies are undertaken.

The philosophy is action-oriented and emphasizes taking a proactive stance toward risk management, performing analyses and taking appropriate actions to prevent incidents and adverse effects from occurring rather than just reacting (and possibly overreacting) to individual incidents when they occur. A proactive risk management strategy centered on prevention will be more effective and more efficient than a reactive strategy that waits for incidents to occur.

Seven fundamental principles, constructed broadly enough to apply across all the disparate materials, modes, and parties involved in transporting hazardous materials, "flesh out" the philosophy. These principles are widely applicable, and they can be used to guide development of individual risk management approaches for various situations. The seven principles, described briefly in the adjacent text box, are: commitment, culture, partnership, prioritization, action, continuous improvement, and communication. The generic risk management approach described in Section 4 builds on and is consistent with these principles. The principles, however, stand on their own and can be applied to guide development of a specific risk management approach even when the generic approach described in Section 4 is not followed.

Fundamental Risk Management Principles for Hazardous Materials Transportation

Commitment – There must be a tangible, visible commitment – including resources – from management and the work force to reduce risks. Risk management should be everyone's job. Provide incentives to reinforce the commitment. *Be accountable.*

Culture – Promote a proactive "risk reduction culture" in day-to-day operations. Ask risk questions when making decisions and performing operations. Incorporate risk considerations into basic management systems, such as record keeping, quality control, performance evaluation, and training. *Think risk reduction.*

Partnership – The most effective risk management is built on interaction among all the parties involved in a hazardous materials transport chain (e.g., shipper, package manufacturer, carrier, consignee). Don't try to manage risks in a vacuum. *Team up to manage risk effectively.*

Prioritization – Because there typically are numerous risks to address and various ways to reduce them, and because resources – both private and public sector – for managing risks are limited, priorities must be set. Establish priorities, based on analysis, to address the worst risks first. *Articulate your risk reduction priorities.*

Action – Risk is reduced by concrete actions specific to your hazardous materials transport operations. Actions are selected based on risks, costs, and benefits, factoring in such realistic considerations as technical feasibility, budgets, competition, regulatory burden, and legal constraints. Action is the heart of effective risk management; planning and analysis, while necessary, do not reduce risk. Actions do. *Adopt a bias for action.*

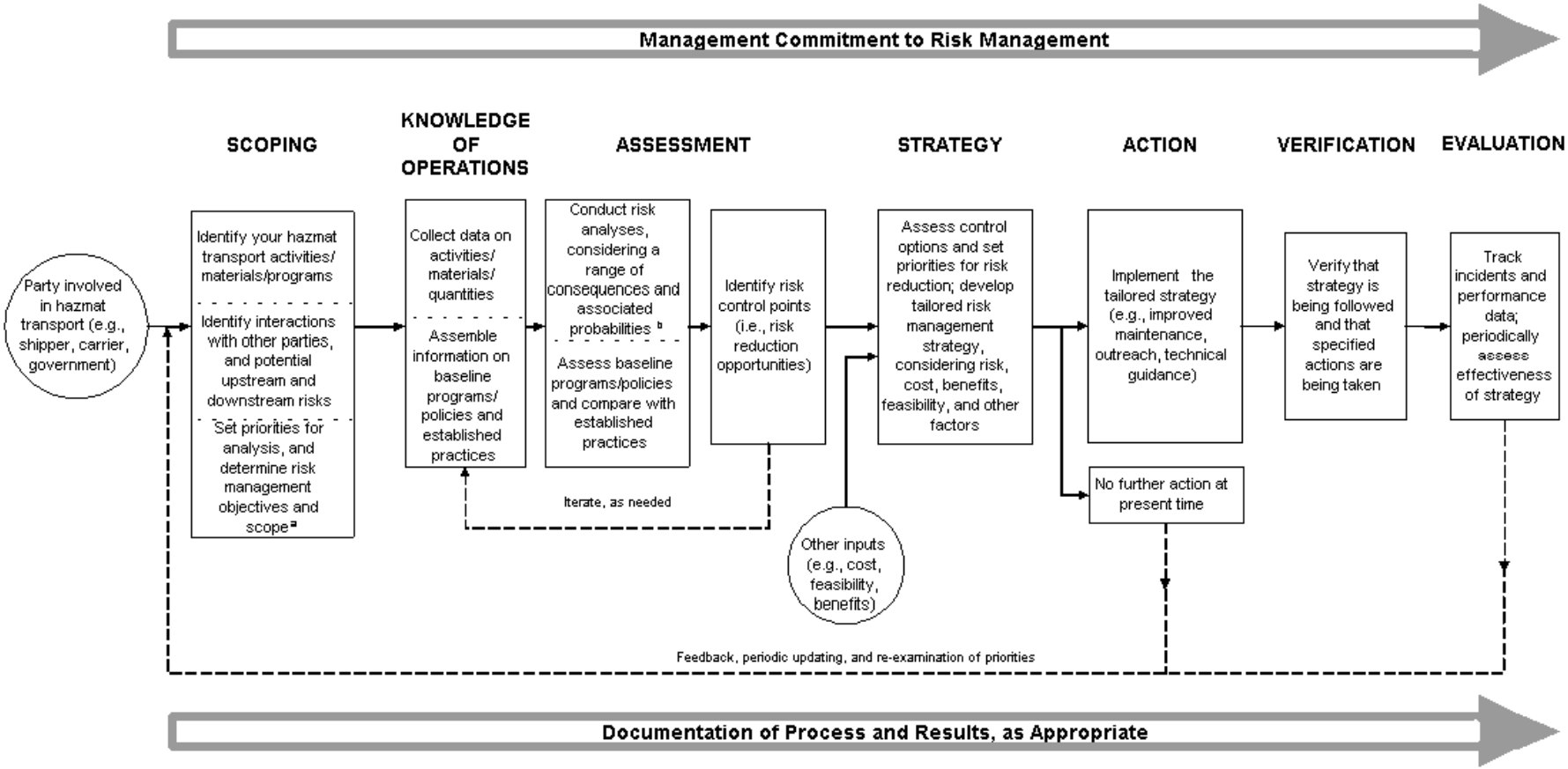
Continuous improvement – All risks associated with hazardous materials transportation cannot be totally eliminated. Through commitment, self-evaluation, and the flexibility to change, improvements in risk management results and efficiency should be sought continuously. *Adapt to get better.*

Communication – All parties who have a role in risk management – including company management, employees, consignees, suppliers, emergency responders – need to know their role and be aware of relevant risk information (e.g., nature and level of risk, risk control points). Appropriate documentation and dissemination of risk analyses and risk reduction strategies can facilitate communications. *Share risk knowledge.*

4. A GENERIC, STEPWISE APPROACH TO HAZARDOUS MATERIALS TRANSPORTATION RISK MANAGEMENT

Exhibit 2 is a flowchart portraying a generic, stepwise approach to risk management for hazardous materials transportation. Even though it has many boxes and arrows, the flowchart is a substantial simplification of reality, especially with respect to all the possible interconnections and feedback loops among the steps. This approach applies generally to a wide range of risk management situations in hazardous materials transportation. It can be adapted, in whole or in part, and used by a shipper, carrier, government regulator, or other involved party. This general

Exhibit 2
A Generic, Stepwise Approach to Risk Management for Hazardous Materials Transportation



[a] Scope can vary from extremely broad, such as addressing an organization's entire hazardous materials transport operations, to very specific, such as targeted to a single material or transport route.
[b] Analyses can be qualitative or quantitative, and usually are partly both.

approach can be applied broadly to serve as the foundation for an organization's overall risk management program. Alternatively, it can be applied in a more focused way to guide a risk management analysis and implementation targeted at a single high-risk material or process. It can be used by both large and small organizations, although there are likely to be differences in application of the approach by organizations of different size.

The generic approach is intended to serve as a model of a logical, sequential process for effectively addressing risk issues. The steps in the process are described below. While presented in the exhibit and discussed below as a sequence of discrete steps, feedback and iteration are critical throughout the process. Typically, analyses and strategies begin simply and through iteration grow into more complete, complex, and realistic forms *as needed*. The information gained in one iteration feeds into the successive iterations, which should enhance the quality of the products (e.g., analyses, decisions) and improve the efficiency of the process.

It is important to recognize that a systematic approach to hazardous materials transportation risk management can have at least two valuable products. As discussed throughout this report, it can identify critical areas demanding greater attention and control. Also of great value, it can identify those areas where additional controls may not be necessary. When used by DOT as a regulatory agency, a systematic approach to risk management can aid in reaching and substantiating decisions about new controls, alternative controls that may be less burdensome, or relaxation of existing regulatory controls that may be excessive.

Overlying the entire risk management approach, as indicated by the top arrow in Exhibit 2, is an absolute requirement for management commitment. There must be a tangible, visible commitment – including resources – from management to reduce risks. Various ways to establish management commitment include distributing written policies stating commitment, establishing direct accountability of risk management personnel (e.g., safety officer) to the chief executive officer, formation of an organizational structure to support risk management, establishing partnerships with other parties in risk management (e.g., shipper, package manufacturer, carrier, consignee), and dedication of resources to conduct risk assessment and reduction efforts. Visible management commitment should help to promote a proactive "risk reduction culture" where risk questions are asked in making day-to-day decisions and performing routine operations.

As illustrated by the bottom arrow in Exhibit 2, the need for appropriate documentation runs throughout the risk management approach. Analyses, data, results, decisions, and other key inputs to and outputs from your risk management activities should be documented *in a way that will benefit you in the future*. Documentation should have a clear purpose, and need not be burdensome or bureaucratic. Maintaining a clear record of what you do in a risk management initiative will improve communication and allow you and others to learn more from the experience, and it should be a valuable resource for future risk management efforts. You should decide early in a risk management initiative about the level and type of documentation that will best meet your future needs. Unlike many regulatory programs, which can have extensive documentation requirements, the documentation policies under this voluntary framework are totally up to you.

Exhibit 3, placed at the end of this section, presents a simple example of one kind of application of this generic approach. The objective of this example is to illustrate the approach with the purpose of enhancing the reader's understanding, not necessarily to provide a fully realistic application of the approach. Three case studies provide more detailed and realistic examples of how the generic approach could be adapted to specific organizations and applications (ICF 2000c).

Legal Considerations

Agencies and companies engaged in systematic risk assessment and management would be prudent to consider the legal implications of such processes. Generally speaking, those companies and associations that have engaged in such a process appear to have concluded that as a result (1) they are less likely to have the incidents that might give rise to civil liability for damages, and (2) if incidents do occur, at least the companies have a record upon which to have based their transportation decisions, documenting good faith against possible contentions of criminal liability or claims for punitive damages. In short, those companies indicate the general view that it is better from a liability perspective to have examined the risks and taken actions based upon that examination, than not to have examined the risks.[2]

Before taking actions to manage risks, it is imperative that you – the person or team charged with risk management – know and thoroughly understand your hazardous materials transport activities and the *baseline programs* (i.e., the basic business practices needed for the safe transport of hazardous materials; see text below under Knowledge of Operations for further discussion) already in place. While this may seem obvious, it is the starting point for risk management. Except in very small organizations, it often will be the case that no individual has all the needed information about operations, so a team of people will generally need to be involved, or at a minimum consulted. The information needed to perform the assessments and to support the risk management decision-making is assembled as part of the first two steps described below, Scoping and Knowledge of Operations.

Scoping

The first order of business is to identify, at a fairly general level at first, the hazardous materials being transported, the processes for handling the materials, and the baseline programs currently in place. More in-depth data collection is performed as part of the next step, Knowledge of Operations, after the Scoping step has focused and set explicit goals for the risk management activities to follow.

In addition to collecting and organizing basic information about your own operations and baseline programs, you need to identify your interactions with any other players involved in transporting the particular material or materials being assessed. Moreover, you should try to identify any important risk considerations upstream and/or downstream from your own operations. At this point, an in-depth characterization of interactions and upstream/downstream risks is not necessary; detailed analysis of these items, where warranted, is generally conducted after the Scoping step has focused the effort.

[2] A second legal issue, especially for companies in trade associations and similar groups, is the applicability of the anticompetitive laws of the United States. A company or group should seek adequate advice of counsel before engaging in what might be considered standard-setting or cooperative activity arguably affecting competition.

Why is information about interactions with other parties and upstream/downstream risks important to risk management? Transport of a hazardous material typically involves several different parties, and risk management can be considerably more effective overall when the parties work together and a holistic view is taken. Attempting to isolate and manage your risks in a vacuum, without regard to other parties in the whole transport chain, is not an efficient approach. Shippers, carriers, consignees, packaging manufacturers and reconditioners, and others in a transport chain need to communicate and work together to produce optimal results. Therefore, it is important to identify the critical players and investigate opportunities to form partnerships for risk management early in the process.

Armed with sufficient knowledge about your own operations, and those of other critical parties in the transport chain, it is absolutely necessary to clearly define the risk management problem to be addressed and to spell out the objectives of the risk management initiative. In every risk management process, explicitly identifying exactly what risks you are trying to manage is an essential up-front step. Without clear up-front definition, goal-setting, and bounding, the assessments and other subsequent steps can have a tendency to become unfocused and sometimes get totally off-track, producing considerable inefficiency at best and possibly even misleading results. The importance of this step has been highlighted in prominent recent studies of risk management, including the 1997 report of the Presidential/Congressional Commission on Risk Assessment and Risk Management (CRARM 1997).

What does scoping mean in the context of hazardous materials transport? It basically means deciding up front, with input from appropriate parties, the goals and limitations of the risk management strategy to be developed and implemented. You need to specify exactly what it is you are trying to do, and recognize what you are not trying to do. In essence, you need to *set priorities* for the risk management initiative, based on your prior knowledge and experience, preliminary review of the available data, and in some cases screening-level estimates of risk. If you are a large organization who is a shipper of many different materials from many different locations, are you attempting to assess and manage risks of your entire operation? Or for shipments from a single facility? Or do you wish to focus on a single hazardous material, or some subset of all the materials shipped? Or is the focus on one mode or route of transport? While the general approach to risk assessment and risk management is similar in all these cases, the analytical details (e.g., data needed, data sources, models) and resource requirements can vary substantially. For organizations handling a variety of hazardous materials and/or having complex distribution patterns, the methods used for priority-setting may be more detailed, and the Scoping step itself may involve a stepwise, iterative process.

Examples of Scoping Decisions

- Types of risks to be considered (e.g., fire and explosion, human health, ecological)
- Types of receptors to be considers (e.g., workers, general public, ecosystems)
- Number and type of risk measures (sometimes referred to as risk metrics) to be used
- Time period for the analysis (e.g., short-term, long-term, steady-state)
- Spatial boundaries of the analysis
- Extent to which life cycle considerations will be taken into account
- Extent to which variability and uncertainty will be quantified

Scoping decisions, in essence, define the complexity of the analyses to be done. There is always a tradeoff between complexity and the analytical resources needed. In general, more accurate, more

precise, more realistic, more defensible results will cost more. Making explicit scoping decisions helps make the risk management process more efficient, as well as more transparent. Some examples of scoping decisions, in addition to defining which materials and operations are the subject of the immediate risk management process, are shown in the accompanying text box.

Knowledge of Operations

As shown in Exhibit 2, there are several parts to knowing your operations. For one, this step involves quantifying the hazardous materials that are being or will be transported, and then characterizing the process(es) currently followed or that will be followed for handling the materials. What is the material(s) in question? What quantities are being transported? What exactly is done to transport the material? Who does it? When? Where? It can often be helpful to develop flowcharts and tables to describe the process or processes involved. This data collection should build on the information gathered under the Scoping step and should be done in enough detail to feed the analyses and decision-making to follow. For an initial screening-level analysis, less detail would be needed than for a more refined follow-up analysis.

Knowledge of operations also includes assembling data about your organization's baseline programs and policies that relate to hazardous materials transportation risk management. Risk management is not an independent activity that occurs in a vacuum, but rather is a systematic way to manage risks that builds on, and in fact depends on, a number of an organization's baseline programs. Baseline programs and policies are the basic business practices, such as training or emergency preparedness and response, that should be in place for the safe transport of hazardous materials. *Baseline programs are not specific to an individual hazardous materials distribution chain, but are cross-cutting programs that can affect many of an organization's materials and operations*. They represent good management and operating practices and can limit or prevent disruptions in operations, worker injuries, and releases of hazardous materials that are extremely costly to hazardous materials transportation operations. In essence, these programs form the base of an organization's risk management efforts. Although details may differ from organization to organization (e.g., some organizations may have different levels, or tiers, of baseline programs depending on the hazards of the material being transported), there is a generally acknowledged set of baseline programs and policies to manage risk and improve safety of operations involving hazardous materials.

Examples of Baseline Programs

Hazard and process communication/information
Training
Maintenance/inspection
Standard operating procedures
Management of change
Incident investigation
Emergency preparedness and response
Documentation, compliance reviews, and feedback

Baseline programs apply to all operations that are part of hazardous materials transportation including packaging, loading/unloading, transporting, and storing. A set of baseline programs similar to that for transportation risk management has been used by fixed facilities that manufacture, use, or distribute hazardous materials. In fact, EPA and OSHA have required that such programs be implemented for certain facility processes involving certain hazardous materials. Many of the practices related specifically to hazardous materials

transportation are outlined in federal, state, and local regulations and guidelines. In addition, industry or industry associations have provided guidelines, recommended practices, and procedures for parties involved in hazardous materials transportation. Examples of baseline programs along with a brief description of how they relate specifically to hazardous materials transportation are provided in Appendix A.

Knowledge of operations also involves finding out about established practices for hazardous materials transportation operations that are similar in nature and scope to yours. Trade associations, professional organizations, published literature, periodicals, and networking with colleagues can be the source of such information. Knowledge of established practices can allow you to compare your baseline programs and other risk management activities against the norm.

Assessment

In this step, hazards and risks associated with the operations being addressed are systematically analyzed, baseline programs are assessed, and risk control points (i.e., opportunities for risk reduction) are identified. Risk assessments can be qualitative or quantitative, and in most cases they are partly both. They can be simple, screening-level analyses intended to provide a rough idea of the kinds and levels of risk, or they can be comprehensive, detailed analyses of incident probabilities, hazardous materials release probabilities and quantities, fate and transport of released materials, and adverse effects resulting from exposure to the materials. Applying experience on safety, risk, and operations is valuable to the analysis. Whether qualitative or quantitative, simple or complex, some type of systematic analysis of the risks needs to be done in all cases to serve as the basis for developing an effective risk management strategy. Typically, an *iterative approach* to assessing risks, which starts with simple analyses and only progresses to more complexity as warranted, is most efficient.

There are many variants of risk assessment that go by many different names – in addition to risk assessment itself, for example, hazard analysis, consequence analysis, worst-case analysis, fault tree analysis, failure modes and effects analysis – and there are numerous models and tools that can be used in a systematic quantitative assessment. For example, supporting guidance for CMA's Distribution Code includes a semi-quantitative matrix-based approach for assessing and ranking risks at a screening level, and EPA and other government agencies have made available models and software for calculating air dispersion for hazardous material releases. In selecting a specific method to follow, it is important to always keep in mind the objective of the analysis, and how the information will be used in the subsequent strategy development and implementation steps. Otherwise, the analysis itself can have a tendency to expand and consume significant resources. Appendix C provides a starting point for identifying potentially useful guidance, methods, models, and other tools for assessing risks associated with hazardous materials transportation.

As part of the Assessment step, baseline programs should be evaluated so that analyses of risk properly reflect the current level of programmatic controls affecting risk, and so that strengths and weaknesses of the current baseline programs can be identified and factored into risk control point determinations and risk management strategy development. Generally, this

assessment will be qualitative and based on past performance of the programs within the organization and on comparison of the programs with established practices across similar organizations.

In addition to characterizing the nature and magnitude of risks and the adequacy of baseline programs, the points in the transport chain – or within various baseline programs – at which actions can be taken to control risks also need to be explicitly identified. These risk control points are an important input to the strategy development step, which comes next. As a starting point for consideration, examples of risk control points across the entire hazardous materials transportation system are listed in Appendix B. Note that while baseline programs can and often will be identified as risk control points (e.g., instituting or upgrading a company-wide training program or modifying a standard maintenance procedure may be identified as points where some action could be taken to affect risk), *not all risk control points are baseline programs*. Risk control points also can include specific places in an individual hazardous materials distribution chain where some action could be taken to affect risk (e.g., the packaging of a specific material being shipped by truck from facility X to consignee Y, or the carrier or route selection for that material, or the loading/unloading protocols for that material).

Strategy

Following risk assessment, in which risks are characterized and in many cases quantified to some extent, and risk control points are identified, you are ready to develop a risk management strategy tailored to your situation. The strategy should be designed to reduce any particularly high risks and to address lower risks where it is cost-effective to do so. It may focus on a single risk control point that offers significant potential for risk reduction, or may be more broadly targeted to a set of risk control points. The strategy is yours and should be based on your assessment of the benefits and costs of the various options for controlling risk. It should address the risks you identify as most important, and should spell out preventive and control actions consistent with your operations. The actions can be new and different, or they can be enhancements to current activities. They can address an organization's baseline programs, or they can target specific control points in specific distribution chains. Remember, the fundamental goal of the strategy is to reduce risks, and do so cost-effectively.

In nearly any risk management setting, *priority-setting* is a key part of the Strategy step. There usually are numerous risk reduction opportunities for which various kinds of interventions could reduce risks. Based on the risk assessment results, the most important risks associated with current operations should be ranked (or at least grouped) for possible attention, and the factors contributing to those risks identified. Criteria to be considered in ranking risks initially could include size of the risk, nature of the risk, severity of the possible adverse effects, and certainty about the risk. After ranking the risks, priorities should be set among the opportunities for risk reduction, factoring in risk information along with cost and technical feasibility of control actions and any other considerations important to decision-making for your situation.

Resources are always limited. Beyond the absolutely necessary actions needed to reduce any particularly high risks, a key determination is to identify where resources can be applied to achieve the most risk reduction. In other words, which risk control points can you target and

which controls can you apply to get the most "bang for the buck." Often, it is valuable to develop and then evaluate a set of different control options. The process of comparing and contrasting options, in terms of their risk reduction potential, their feasibility, their cost, and other considerations, can lead to more confidence that the selected risk management strategy is effective and efficient.

Usually, for comparison purposes, one of the control options analyzed is the "no additional action" alternative. Sometimes, at the conclusion of the various analyses and the assessment of control options, a decision may be made that no further action is needed at the present time to manage risks. In other words, current baseline programs and in-place risk control actions are sufficient. As shown in the Exhibit 2 flowchart, this decision should be revisited periodically to make sure that changes in conditions over time (e.g., changes in consignee base, in risk reduction technologies, in regulations) have not made some kind of action appropriate. Likewise, decisions to take action should be revisited periodically as well, generally following the Evaluation step.

A Written Plan

It is important to have a written plan describing the strategy. A written plan demonstrates management commitment, and it also minimizes confusion about the strategy. It does not need to be lengthy, but the strategy needs to be documented and communicated to all who will play a role in implementing it. Objectives should be spelled out, key actions should be identified, and key players and their roles and responsibilities clearly articulated. A timeline for action, with clear milestones for accomplishing key items, should be part of the written plan.

Action

This step is simply the implementation of the written plan developed in the previous step. In this step, any specified preventive or corrective measures are taken, any called-for changes are made to standard operating procedures, any prescribed material substitutions are made, and other actions are taken as appropriate. Furthermore, identified modifications to baseline programs, such as training or emergency preparedness and response, should be implemented.

Sometimes an action identified in the Strategy step that can result in significant risk reduction lies in the hands of an entity other than the one leading the risk management process (i.e., one of the "interaction parties" identified in the Scoping step and, ideally, involved throughout the process). If this other entity has been a contributing partner throughout the process, they will be more likely to implement the action than if the lead party attempts to persuade them based on its independent findings. Thus, partnership is critical to matching an identified risk management action with the entity that can best implement it.

While this step does not require much explanatory text here, it is, as emphasized before, a critical aspect of successful risk management. Without action and follow-through, the most refined analysis, the most elegant strategy, or the most well crafted plan will not successfully reduce risks.

Verification

As is good practice for managing any process, it is important that you monitor implementation of the risk management strategy to make certain that the prescribed actions are being taken and that everything is proceeding according to plan. Verification procedures should be built into the plan so that it is straightforward to monitor activities and to ascertain achievement of key milestones. Verification need not be a cumbersome, bureaucratic procedure, but it is essential that someone is charged with tracking the implementation of the strategy. Because the risk management strategy is your strategy, carrying it out will presumably be beneficial to you. Thus, there should be incentives to embrace the strategy and implement it fully, and verification serves primarily as a double-check to make sure nothing is falling through the cracks. In some cases, to ensure objectivity, add credibility, or possibly even to save resources, it may be useful to consider employing a third party to perform some or all of the verification activities.

Evaluation

While verification is necessary to ensure that the strategy is actually being implemented to the fullest extent possible, verification alone is not enough. To ensure that the strategy is actually accomplishing its goals, it is necessary to periodically make an effort to evaluate the effectiveness of the risk management strategy. RSPA recognizes that this is a challenge. An evaluation, however, even when imperfect can point toward useful improvements in the strategy and can be the basis for identifying changes to either enhance the risk reduction effectiveness or reduce the costs of implementation. No matter how well planned the strategy is, no matter how good the analysis underlying it is, there is no substitute for real-time assessments of performance. Is it working as well as it could be? If not, how can it be improved? Risk management demands *continuous improvement*, and evaluation leads to improvements.

A key element of the evaluation step is identifying appropriate performance indicators (sometimes referred to as measures or metrics) that can be tracked and that relate closely to the risk reduction objectives of the strategy. Often, the ideal indicators cannot be measured, at least not for a reasonable cost. Furthermore, for relatively rare events such as serious hazardous materials transport incidents, some potentially desirable indicators may occur too rarely to be especially useful in an ongoing evaluation program. In such cases, surrogate measures that relate to the likelihood of the rare event may be useful. The objective is to strike a balance between the relevance of an indicator to the goals of the strategy and the feasibility and cost of measuring it. For example, it may be extremely difficult to measure reliably the numbers of premature deaths and illnesses caused by releases of toxic chemicals from hazardous materials transport incidents, whereas measuring the number of incidents in which toxic chemicals are released, and/or "near misses" or failed inspections or some other surrogate indicator, may be feasible and beneficial.

In addition to evaluating your strategy relative to its objectives, it also is helpful to compare your risk management plan, and your results, with others in your field. Such comparison with established practices can provide valuable information on whether your strategy is in line with others in a similar situation. For instance, trade associations may be able to help facilitate cooperative efforts in comparing risk management practices across companies.

As is the case when "no additional action" is determined to be appropriate (see discussion under the Strategy step), it also is necessary to monitor changing conditions over time and to periodically revisit the decisions made in cases where risk management actions are determined to be appropriate. This periodic updating is shown by the feedback arrow exiting the Evaluation step box in the Exhibit 2 flowchart.

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Exhibit 3
Applying the Stepwise Approach to Risk Management of Hazardous Materials Transportation: An Example

Background: Company X is a 50-truck company that primarily transports gasoline around the northeastern U.S. Company X hauls loads for smaller gasoline distribution firms. The fleet includes M306 tank vehicles. Recently, the company was contracted to carry other flammable liquids. The company is planning to buy five more trucks to accommodate an expanding business. The CEO of Company X is attempting to manage growth as well as maintain quality service and safety. The CEO felt it was a good time to re-examine the company's operations and implement a more structured risk management process to reduce the risk of accidents and releases of flammable products. The CEO was looking to determine what actions or equipment will significantly reduce risk. For example, should Company X spend valuable dollars in training, improvements in loading equipment, or overflow equipment?

Management Commitment: The management of Company X has decided that risk reduction makes financial and safety sense for their company. Because Company X interacts with both the distribution terminals and the receiving consignees, the CEO recognized the importance of involving and working with these parties in the Company's process for risk management. The safety officer presented the senior management with risk management approaches described in materials from several organizations including CMA, NTTC, and API. The officer also included the risk management framework developed by RSPA. Most of the methods begin with management commitment. The management of Company X committed to risk management by regularly getting updates from the safety officer, announcing the new risk management policy to all staff, and setting up a risk team of safety staff, truckers, and management to examine cost-effective risk management options. The team met and determined the scope of the risk management effort, the resources needed, approaches to do the job, and various roles. The team decided to generally follow the RSPA framework, but also use other techniques. The safety officer would lead the effort to develop knowledge of operations, including the status of baseline programs.

Documentation: With the assistance of the safety officer, the senior management determined the appropriate level of documentation for the risk management process. The documentation would help keep the risk management process on schedule and outline responsibilities. It would also provide a history for new management or other personnel as to why certain decisions were made or actions adopted. A file cabinet keeps information from the team meetings, the steps in the process, and decisions that are made.

Step in Risk Management Process	Description of Efforts
Scoping	Management tasked the risk management team to assist in defining the scope of the risk management effort. The safety officer developed an initial flowchart of their operations and prepared notes on each activity. Each truck from company X receives gasoline from the distributor and delivers the gasoline to five or six retailers per day. It was the general impression that distribution terminal operators were mostly familiar with risk management efforts, but that

	retail consignees were not. Because of the anticipated new contract to transport other flammable liquids, the risk management team recommended that the scope focus on how the company handles management of change issues. Additionally, the team recommended risk management be applied to the interactions of partners in the transport (e.g., distribution and consignees), and to include a general risk review of the company's baseline programs such as training, maintenance, accident investigation, and standard operation procedures.
Knowledge of Operations	One of the first activities of the risk management team was to develop a knowledge base of their operations. No one person at the Company has a complete knowledge of operations. Therefore, the officer interviewed the personnel involved in the operations on programs such as training, maintenance, and standard operating procedures. In addition to interviews, the safety officer reviewed the risk control points listed in the RSPA risk management framework and then specifically pursued company information on route selection and condition of vehicle and equipment. Consistent with the scope, the safety officer paid special attention to obtaining information in areas such as transitional responsibilities during loading/unloading of gasoline. The safety officer also gathered a library of established practices from industry associations. He researched recent practices such as API's *Recommended Practice on Loading and Unloading of MC306/DOT 406 Tank Motor Vehicles*. The officer also contacted RSPA to find out about the latest in risk reduction efforts for the gasoline and flammable liquid delivery industry. After assembling the information, the safety officer presented the information to the risk management team and asked for input and ideas to improve the knowledge of operations.
Assessment	To assess the risks of the operations, the risk team decided to use a combination of techniques. From interviews during the knowledge of operations step, the risk management team learned that driver routing, emergency response, staff levels for maintenance, and unloading/loading operations had some important gaps or issues to address. In fact, in an accident investigation last year, one immediate finding was that the safety and loading procedures were unclear and should be replaced with the API Recommended Practice, which was not conveyed to the other drivers. In accordance with the RSPA risk management framework, the team assessed the adequacy of the company's baseline programs or use of established practices for each hazardous materials activity/operation. The review of baseline programs provided a good check to see if the company was implementing accepted risk management practices. The safety officer found that the company adequately implemented most of the baseline programs, but that several standard operating procedures for loading were unclear and that incident investigations were minimally conducted. In addition to baseline programs, the team looked at past accidents and possible tank truck releases from a traffic accident and during a loading/unloading operation. The team requested from the distributors any accidental release modeling of gasoline spills and fires. In addition to the above techniques, the team used the FHWA *Hazardous Materials Incident Prevention Manual: A Guide to Countermeasures* to guide the risk assessment effort. A short report of the assessment was prepared by the team, given to senior management, and then made available to all employees. The report indicated that unloading/loading accidents are quite possible and are caused most often from poor standard operating procedures and training on such procedures. On unloading/loading procedures, only informal training among drivers was being conducted. This has the potential to lead to transmission of unsafe practices. In addition, the risk team discovered the lack of coordination with consignees was a source of confusion at deliveries and added significant risk of release during unloading.
Strategy	There are many ways to address the identified risks. The key in the assessment step was to properly identify the major risk control points. Although several risk control points were identified, not all were highest priority or needed to be resolved immediately (e.g., driver training was adequate). The strategy to reduce risk was developed by the risk management team. For example, as a result of the assessment of significant risk related to other parties in the distribution chain (e.g., distributors, consignees), it was determined that it would be cost-effective to share information with distributors and have more active outreach and coordination with consignees regarding unloading and storage procedures. This was particularly important for new consignees under the new contract to deliver flammable liquids. Also, a formal effort was made to adopt and train on the API Recommended Practice for Unloading and Loading. Because generally turnover is low at the Company, it was accepted that training for risk management can have long-term beneficial impacts. The strategic plan for risk management was

	documented in the form of a spreadsheet with listing of problem, action, responsible party, timeframe, and existence of management of change analysis. A draft strategy including the potential costs to make or not make such changes was delivered to the CEO and senior management. After finalization, the strategy will be shared with distributors to encourage further support of other parties in risk reduction.
Action	Priority actions for Company X included replacement of standard operating procedures for unloading/loading with API's guidelines, formal training on the API guidelines, introductory and follow-up risk management meetings with other parties in the distribution chain, and a re-examination of hazardous intersections for routing.
Verification	The safety officer is charged with day-to-day verification that risk reduction measures are implemented. To periodically check, the officer uses the strategy spreadsheet. The senior manager on the risk management team is given the ultimate responsibility for verification. It was decided that third parties were not needed.
Evaluation	The risk management team recommended that the risk management process and results be evaluated formally every year.

Appendix A
Baseline Programs

This appendix describes a number of common baseline programs to support risk management for hazardous materials transportation. Baseline programs and policies are the basic business practices, such as training, that should be in place for the safe transport of hazardous materials. *Baseline programs are not specific to an individual hazardous materials distribution chain, but are cross-cutting programs that can affect many of an organization's materials and operations*. Some organizations may have different levels, or tiers, of baseline programs depending on the hazards of the material being transported (i.e., more stringent programs for more hazardous materials).

Management Commitment to Risk Management. Senior management needs to commit to ongoing improvements in hazardous materials transportation safety through policy, communications, and resources. Management needs to identify and implement risk reduction strategies. Management should support efforts to coordinate efforts by all players in hazardous materials transportation including the packaging manufacturers, packagers, shippers, and carriers. Coordination efforts could take the form of industry partnerships or cooperatives. Management can create the environment that stresses the importance of safety and risk management within the organization in everyday operations. An example is making safety records of an employee one qualification for hiring and promotion.

Employee Participation. Employees are the front-line players in implementing efforts to manage the risks associated with hazardous materials transportation. Employee input in risk and safety management programs can improve the effectiveness of the programs.

Hazard and Process Communication/Information. To handle hazardous materials safely, employees and consignees must have the information necessary to understand the chemical hazards and process hazards (e.g., those posed by cryogenics) of transporting hazardous materials. DOT regulations provide extensive requirements regarding packaging, labeling, and placarding for hazardous materials so that employees can make informed decisions regarding handling of the containers and materials.

Training. Employees, contractors, and other appropriate support staff in the hazardous materials transportation operations should be trained, tested, and retrained in their knowledge of hazardous materials transportation regulations and procedures. Training can address safety and health hazards, safe work practices applicable to the job, and emergency operations. In hazardous materials transportation, given the variety of equipment types, loading/unloading locations, and commodities transported, shippers, carriers, and consignees may need coordinated training. All training should be documented and refresher training should be provided to assure training knowledge is kept up. As appropriate, training could cover:

- Applicable U.S. DOT regulations
- Hazard classification and communication
- Material Safety Data Sheets
- Loading/unloading procedures

- Special equipment and/or handling requirements
- Locations/marking of loading/unloading facilities
- Load compatibility
- Types and uses of personnel protective equipment
- Use of mechanical equipment
- Emergency response procedures

Hazard identification, classification, and analysis. As a screening for hazards, DOT has developed a regulatory classification of hazardous materials. Classifications include explosives, gases (flammable/nonflammable), flammable liquids, oxidizers, radioactive material, corrosives, poisons, infectious substance, and miscellaneous materials. The classification system should be used to drive the need for mitigation measures including packaging, operating procedures, and emergency response. Selecting packaging that is consistent with regulations and according to established procedures for choosing the package and equipment can prevent unanticipated safety problems and hazardous materials releases. The route, carrier, and packaging selected can influence the risk of incident, release, and/or impacts. Not all routes present the same risks. Cost considerations must not be paramount. Periodically, shippers and carriers should discuss and review the routing of hazardous materials shipments. Considerations in the routing including human safety and environmental damage. The shipper can have the major responsibility for initiating route evaluations. Carriers have responsibility to make sure appropriate routes are followed. Federal regulations provide a list of factors for state governments to consider in designating hazardous materials routing. State and local regulations may also apply to hazardous materials routing. Carriers are responsible for the safe transportation and handling of hazardous materials. When selecting a transport mode or a specific carrier, shippers should consider safety factors including insurance/liability coverage, federal safety ratings, compliance with regulations, training and safety plans, and access to adequate emergency response capability.

Maintenance/Inspection. A key to safe hazardous materials transportation is the proper functioning of equipment such as car/truck brakes, tank valves, pumps, and hoses. Preventive maintenance and inspection can reduce the risk of equipment failure. A maintenance program should provide guidelines for periodic scheduled maintenance of both operating equipment and emergency response equipment. Training on maintenance procedures needs to accompany efforts to improve such procedures. Equipment deficiencies discovered during maintenance must be addressed. DOT regulations and industry guidance provide some requirements for inspection and testing of hazardous materials transportation equipment.

Standard Operating Procedures. Companies should develop and implement operating procedures to provide clear instructions for safely conducting activities related to hazardous materials transportation. Procedures should be developed and documented for normal operations, maintenance operations, and emergency operations. Emergency procedures may include procedures for monitoring the air for toxic or flammable chemicals, notification procedures, steps to organize a response, and procedures for donning personnel protective equipment. All procedures should be periodically reviewed to ensure that they reflect current processes and reflect safe operating practices. The procedures should be readily available to employees that work in the operation including contractors.

Management of Change. Companies should establish and implement written procedures to manage changes to equipment, employee roles, and process operations in hazardous materials transportation. The risk implications of changes to a process (e.g., using new type of hose for gasoline unloading) should be examined. Employees who work in the operation or maintenance operations should be informed of and trained in the change.

Contractor/Other Players Coordination. All players in hazardous materials transportation including packagers, shippers, and carriers need to safely steward the hazardous material among themselves and to the ultimate consignees to ensure safe use and handling. Communication among all players should ensure that procedures, training, and information is shared. Contractors that work for any of the players in hazardous materials transportation should be integrated into the baseline programs of the packager, shipper, and carrier.

Incident Investigation. Learning from past accidents, incidents, and discrepancies can help prevent future incidents. Formal investigations of incidents that result in hazardous materials releases and even "near misses" (events that could have lead to an incident) are necessary for effective risk reduction. Investigations can bring to light additional information that can improve future operations. Prompt investigations, usually within 48 hours, can better get at the root cause or causes of the incident. Teams of investigators usually provide a comprehensive examination. An incident report should at minimum cover the date of the incident, description of incident, factors that contributed to the incident, and recommendations for change.

Emergency Preparedness and Response. Emergencies can occur anywhere along miles of track, highway, waterways, or in the air. Companies should have a program for preparing for and responding to emergencies involving hazardous materials transport. Such a program should comply with federal and state regulations and could include procedures, response equipment, training and maintenance on equipment, response capability assessment to the hazards posed by the hazardous materials, emergency contingency response plans, and coordination and communication with local and state emergency agencies and the public.

Documentation, Compliance Reviews, and Feedback. Baseline programs should be documented and regularly audited. Periodically, companies should review their risk management baseline programs to make sure they were properly conceived and are being implemented appropriately. Such reviews should provide feedback to determine if the risks are being managed. Effective reviews will include reexamination of safety and operations and comparison with best industry practices. The review should identify what works and what does not and provide recommendations to handle deficiencies. As part of management commitment to risk management, management should support the company reviewers and seriously address feedback from the reviews. Reviews may cross both shipper and carrier responsibilities and could be conducted internally or by a third party.

Appendix B
Possible Risk Control Points in Hazardous Materials Transportation

The concept of risk control points is useful for identifying, evaluating, and mitigating risk in hazardous materials transportation. Such control points are places where action can be taken to prevent, eliminate, or reduce risks. Personnel familiar with an organization's hazardous materials transportation operations can identify points in the operation where there may be higher risk than other points in the operation. Risk control points that involve the coordination of one party with others along the entire distribution chain are especially important to identify. For example, a high-risk point could be during joint shipper/carrier unloading operations if the shipper and carrier do not fully coordinate responsibilities and procedures. Although an organization-specific analysis of its risk control points should be conducted, the following is a general list of examples of possible control points that can serve as a starting point for consideration. Many of these risk control points have historically been identified as potential problem areas. A brief description of the risk control points is followed by a sample listing of applicable tools, resources, and regulations that pertain to the risk control points. The tools, resources, and regulations are summarized in more detail in Appendix C.

It is important to understand the relationship (overlap and differences) between risk control points and baseline programs as described in Appendix A. Baseline programs are general program areas such as training, hazard analysis, and incident investigation that should be in place for the safe transport of hazardous materials. Typically, these programs work together to reduce the risk of release. In risk management, baseline programs can and often will be characterized as risk control points because the baseline programs have specific points to control risk. Examples include instituting or upgrading a specific training program or modifying a standard maintenance procedure to address a specific fail scenario of concern. Risk control points are not limited to baseline programs, however. Risk control points also can include specific places in an individual hazardous materials distribution chain where some action could be taken to affect risk (e.g., choice of packaging of a specific material, or the carrier or route selection for that material, or the loading/unloading protocols for that material). In practical terms, a broader set of risk control points for hazardous materials transportation might be viewed as a union of the elements listed in Appendix A and Appendix B.

Possible Risk Control Point	Brief Description	Applicable Tools, Resources, Regulations
Senior Management Commitment	Management commitment sets the policy, programs, and resources for identifying, evaluating, and mitigating critical control points for risk.	CMA Distribution Code NACD Responsible Distribution Process CMA/NTTC Manual Recommendation
Inherent Hazard of Materials	Hazardous materials have different chemical hazards (e.g., toxic, corrosive, flammable) as well as process hazards (e.g., high pressure, cryogenic). Choice of which materials to transport and perhaps additional controls (e.g., inhibitors to reduce sudden polymerization) to reduce the hazard of the material can reduce the risk.	DOT Regs 49CFR Part 172 CMA Distribution Code NACD Responsible Distribution Process CMA/NTTC Manual Recommendation
Packaging, Labeling, Placarding	Appropriate packaging, labeling, and placarding can reduce risk for loading and transporting by shippers and carriers and can promote effective and safe emergency response by responders. Different containers have different risk levels.	DOT Regs 49CFR Parts 172, 173, 178

Mode Selection	Different modes may have different risks. Judicious selection can reduce the risk.	CMA Distribution Code NACD Responsible Distribution Process
Carrier Selection	Different carriers may have different risks. Judicious selection can reduce the risk.	CMA Distribution Code NACD Responsible Distribution Process CMA/NTTC Manual Recommendation
Route Selection	Different routes may have different risks. Judicious selection can reduce the risk.	DOT Regs 49CFR Part 356 DOT Designating Routes FHWA HAZMAT Incident Prevention CMA/NTTC Manual Recommendation
Securement of Tank Car Fittings and Proper Venting	Lack of securing valves and manways on tank cars result in many non-accidental releases. Lack of proper venting devices is also a problem. These issues cut across the distribution chain (e.g., shippers, carriers, receivers).	Sample checklists and technology upgrades
Incident Command Coordination Between Parties	Emergency response often involves multiple players (e.g., local hazmat teams, carriers, shippers, other). Coordination and role definition under the incident command system has sometimes been difficult and may not have led to the best emergency response decisions.	TRANSCAER, drills, sharing emergency response plans
Chemical-specific Risk and Safety Concerns	Certain chemicals vary in properties and handling. Considering the specific chemicals is critical to appropriate risk reduction. Concerns include, for example, stable tank pressure after loading for ammonia and time sensitive shipments that could polymerize.	
Damage Assessment	Assessing damage to tank cars and tank trucks is critical to determining next steps in emergency response and consequence management (e.g., which tank cars can be moved)	Damage assessment documents and training
Commingling of Hazardous Materials	Some hazardous materials are incompatible, and commingling can significantly exacerbate a release situation.	EPA Study of Joint Use DOT regulations CMA/NTTC Manual Recommendation
Operator/Driver Training, Procedures, and Decision-making	Procedures that are not written down and lack of effective training can contribute significantly to accident risk factors.	FHWA HAZMAT Incident Prevention CMA/NTTC Manual Recommendation
Operator/Driver Fatigue and Substance Abuse	Fatigue is known to play a large role in accident rates.	DOT regulations FHWA Guide to Countermeasures
Operations During Handoff or Involving Two Parties	Handoff operations (e.g., loading/unloading) can involve shipper to carrier, carrier to carrier (intermodal), and carrier to consignee. The potential for poor coordination or gaps in responsibility is greater when several parties are involved.	FHWA Incident Prevention CMA/NTTC Manual Recommendation
Loading/Unloading Operations (Procedures, Training, and Equipment Maintenance)	Loading/unloading operations may involve critical points including temporary connections, labeling issues, several hazards (e.g., pressure, toxicity), little monitoring, and multiple parties and procedures. Past events include overfilling, erroneous hookups, hose failure, and vehicles that pull away while still in a loading position.	DOT regulations CMA Distribution Code NACD Responsible Distribution Process API Recommended Practice CMA/NTTC Manual Recommendation FHWA HAZMAT Incident Prevention
Vehicle/Equipment Condition and Maintenance	Good condition of vehicle and equipment such as brakes, lights, and emergency equipment is essential to prevent accidents that could result in hazardous materials releases.	DOT HAZMAT and mode-specific regs FHWA Guide to Countermeasures

Appendix C
Other Tools/Resources/Approaches for Risk Management

This appendix provides examples of tools, resources, and approaches for identifying and managing risk of hazardous materials transportation.

Tools, Resources, and Approaches	Sponsoring Organization	Descriptions
Hazardous Materials Transportation Regulations	Department of Transportation Research and Special Programs Administration (RSPA)	Generally, regulations geared to managing risk and focused on identifying and communicating hazards 49 CFR Part 107 HAZMAT program procedures 49 CFR Part 110 HAZMAT public sector training and planning grants 49 CFR Part 130 Oil spill prevention and response plans 49 CFR Part 171 HAZMAT regulations general information 49 CFR Part 172 HAZMAT table 49 CFR Part 173 Shipper –general requirements for shipments and packagings 49 CFR Part 178 Specifications for packaging 49 CFR Part 179 Specifications for tank cars 49 CFR Part 180 Continuing qualification and maintenance of packagings
Rail HAZMAT Regulations	Department of Transportation	49 CFR Part 174 Carriage by Rail
Aircraft HAZMAT Regulations	Department of Transportation	49 CFR Part 175 Carriage by Aircraft
Vessel HAZMAT Regulations	Department of Transportation	49 CFR Part 176 Carriage by Vessel Proposed regulations bulk transport of HAZMAT by vessel
Motor Vehicle HAZMAT Regulations	Department of Transportation	49 CFR Part 177 Carriage by Public Highway 49 CFR Part 356 Motor carrier routing regulations 49 CFR Part 397 Transportation of HAZMAT, driving and parking rules
Federal Railroad Admin Safety Regulations	Department of Transportation	49 CFR Parts 200-266
Federal Highway Administration Regulations	Department of Transportation	49 CFR Parts 301-399
Hazardous Materials Incident Reporting System	Department of Transportation RSPA	DOT collects data from carriers on unintentional releases of hazardous materials during transportation. The data is available to highlight problem areas, to pinpoint needs for corrective action, and to provide a statistical compilation of transportation incidents involving hazardous materials.
Risk-Based Decision Making (RBDM) Guidelines	Department of Transportation Coast Guard	The RBDM process aids in identifying/evaluating hazards and determining how to cost-effectively respond to those hazards. The RBDM process is used as a management tool that is generally applicable to most problems and decisions involving environmental pollution, the loss of vessels, personal injuries, and loss of life. The RBDM process is composed of the following five interrelated phases: • Goal identification; • Risk assessment; • Risk management; • Impact assessment; and • Risk communication. The risk assessment phase, a prominent feature in most risk management and risk-based regulatory systems, provides a vehicle for developing a list of hazards ranked by risk. The U.S. Coast Guard has developed several tools to calculate vessel risk, facility risk, port activity risk, and qualitative

		risk. After an assessment has been completed, a risk management plan is developed in a third phase to address the identified potential hazards. In this integrated plan, various counter measures that can be implemented to reduce the risk of the hazards are identified, evaluated, and ranked by overall effectiveness.
Hazardous Materials Incident Prevention Manual: A Guide to Countermeasures	Department of Transportation Federal Highway Administration	This manual presents countermeasures that may be used to reduce the number of hazardous materials incidents. It includes guides and tips to help HAZMAT employees and safety managers formulate strategies appropriate to their company circumstances. Topics include loading/unloading operations, incident mitigation by shipper, routing and scheduling policy, and employee training.
A Guide to Countermeasures	Department of Transportation Federal Highway Administration	This manual presents countermeasures that may be used to reduce the number of vehicle accidents on the highway. It includes guides and tips to help safety managers formulate strategies appropriate to their company circumstances. Topics include defensive driving, preventive maintenance and inspection, accident preventability evaluations.
Compliance and Benefit/Cost Assessments	Department of Transportation RSPA	DOT's Research and Special Programs Administration (RSPA) uses risk management concepts and tools to prioritize compliance activities and address the risks associated with non-compliance. RSPA places greater compliance emphasis on materials and packaging that present high hazard to the public such as poisons and flammable gases, and explosives. When packagings are found in non-compliance, risk and benefit/cost assessments are used to determine if actions such as recalls, down-rating, or use restrictions are necessary to protect public safety. RSPA is increasingly using quantitative analyses of risk to support cost/benefit assessments. RSPA has developed a "Procedure for Removal on Non-conforming Hazardous Materials Packaging from Service" that delineates a process and provides assessment guidelines for non-conforming packaging.
Alternatives to Regulations	Department of Transportation RSPA	Exemptions provide alternative technologies/operations to the HMR when a safety analysis reveals that the exemption sought will provide at least the same level of safety as that provided under the regulations. Exemptions are granted on a case-by-case basis. The safety analysis required to support exemptions varies greatly, from complex risk analyses for complex packaging systems involving new technologies to simple comparative analyses for minor variations in packaging or operational controls for relatively low hazard materials.
Mitigation Strategies	Department of Transportation RSPA	RSPA has developed various aids that can be used to mitigate the consequences of a release. RSPA publishes and distributes to first responders the *2000 Emergency Response Guidebook* to provide guidance on hazards, emergency actions, protective action decision factors, and distances. To support emergency preparedness and response planners at the State and local levels, DOT, FEMA, and EPA jointly developed the *Handbook of Chemical Hazards Analysis Procedures* and a personal computer program called "Automated Resource for Chemical Hazard Incident Evaluation (ARCHIE)." RSPA, through Planning and Training Grants, provides funds to State and local emergency preparedness and emergency response organizations for planning and training directed toward mitigation of the consequences associated with hazardous material incidents
Distribution Code of Management Practices (part of CMA's Responsible Care)	Chemical Manufacturers Association (CMA)	The Distribution Code is meant to reduce the risk of harm posed by the distribution of chemicals to the general public, carrier, distributor, contractor, environment, and chemical industry employees. The Distribution Code applies to: (1) all modes of transportation; (2) the shipment of all chemicals and wastes; and (3) distribution activities while chemicals are in transit between companies and suppliers or consignees. The Distribution Code relies on the following elements to reduce the risk

		of harm posed by the distribution of chemicals: • Risk Management; • Compliance Review and Training; • Carrier Safety; • Handling and Storage; and • Emergency Response and Public Preparedness The CMA Distribution Code includes an Implementation Aid to assist in conducting a risk assessment for hazardous materials transportation.
TRANSCAER	Chemical Manufacturers Association (CMA)	TRANSCAER is a community outreach program that addresses community concerns about the transportation of hazardous materials through planning and cooperation. The program provides assistance for communities to develop and evaluate their emergency response plan for hazardous material transportation incidents.
Responsible Distribution Process	National Association of Chemical Distributors (NACD)	NACD members are companies that are typically involved in buying chemicals (e.g., raw materials) or chemical products (e.g., laboratory products) from chemical manufacturers and then reselling those chemical products to other purchasers; often they work as "middle men." These companies usually own large warehouses or other facilities where chemicals are stored. Carriers and transporters (e.g., railroad companies) are not members of NACD, but can participate in their affiliate program. In an effort to promote improvements in health, safety, and environmental performance in its member companies and to improve the use and handling of chemicals, NACD developed a set of principles called the Responsible Distribution Process (RDP) (NACD,1999). In developing these principles, NACD adopted the majority of its guidance from CMA's Distribution Code of Management Practice and from the Canadian Chemical Producers Association Responsible Care Program. This guidance was then combined with some of NACD's own guidance and adapted specifically to the needs of the U.S. chemical distribution industry. Member companies have up to one year after they submit a membership application to take part in the third-party verification process.
Recommended Practice on Loading and Unloading of MC306/DOT 406 Tank Motor Vehicles	American Petroleum Institute	The recommended practice covers loading and unloading practices for the most common tank vehicles carrying gasoline.
Manual of Recommendations for Inter-Industry Bulk Chemical Highway Safety Task Force	Chemical Manufacturers Association and the National Tank Truck Carriers	The National Tank Truck Carriers, Inc. and members of CMA form the Inter-Industry Bulk Highway Safety Task Force to look into and solve safety issues. The outcome of this effort is a Manual of Recommendations that provides guidance to both shippers and carriers on day-to-day operational concerns relative to tank truck transportation of chemicals. The manual also customizes the CMA Distribution Code Implementation Aid for tank truck transportation. Additionally, the National Tank Truck Carriers examines issues and disseminates information to safety directors of trucking companies in newsletters and periodic seminars.
Manual of Standards and Recommended Practices Section CIII Specifications for Tank Cars M-1002	Association of American Railroads	The specifications list regulatory requirements as well as non-regulatory requirements that are necessary for rail consistency and safety.
Selected Chapters, Specifically Hazardous Materials Users Flow Charts and Recommended Methods for Safe Loading and Unloading of Non-Pressure Tank Cars	Bureau of Explosives Tariff BOE-6000	The series of charts assists the user in preparing shipments of hazardous materials. Charts cover shipping name, packaging, marking, labeling, placarding, and shipping papers. The recommended methods include general guidelines applicable for the transportation of loaded tank cars as well as for the return of tank cars containing residue.

Emergency Handling of Hazardous Materials in Surface Transportation	Bureau of Explosives	This guidance provides information on the properties of hazardous materials, shipping containers, and recommendations for initial response, personnel protection, and first aid.
Intermodal Loading Guide for Products in Closed Trailers and Containers; Recommended Practices for Hazardous Materials	Bureau of Explosives	These practices address the specific issues of intermodal transfers and loading of hazardous materials.
Emergency Response Guidance for Aircraft Incidents Involving Dangerous Goods	International Civil Aviation Organisation	This manual provides guidance to states and operators for developing procedures and policies for dealing with dangerous goods incidents on board aircraft. Checklists and general information on dealing with any dangerous goods incident are provided. Lists of dangerous goods and appropriate emergency response drills are also provided.
Dangerous Goods Regulations	International Air Transport Association	The regulations provide procedures for the shipper and operator to safely transport dangerous goods by air. The regulations are based on the International Civil Aviation Organisation Technical Instructions.
Study of Joint Use of Vehicles for Transportation of Hazardous and Nonhazardous Materials	Environmental Protection Agency	This study examines the regulatory and safety issues of joint use of transportation of hazardous and nonhazardous materials. The study addresses both rail and truck transport.
Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials	Department of Transportation Federal Highway Administration	This document provides techniques for evaluating alternative highway routes for hazardous materials movements.
Computer-Aided Management of Emergency Operations (CAMEO)	National Oceanic and Atmospheric Administration; Environmental Protection Agency	CAMEO is a software program that includes chemical properties and response database, a chemical release disperse model, and a mapping program.