THE HAZARDOUS MATERIALS HIGHWAY ROUTING ROUTE PLAN GUIDANCE REPORT TO CONGRESS

A Report Pursuant to Section 1553(a) of the
Implementing Recommendations of the 9/11 Commission Act of 2007
Public Law 110-53
March 2009

Section 1553(a) of the Implementing Recommendations of the 9/11 Commission Act of 2007 (the Act) directs the Secretary of the U.S. Department of Transportation, in consultation with the Secretary of the U.S. Department of Homeland Security (DHS), to complete the following actions:

1. Document existing and proposed routes for the transportation of radioactive and non-radioactive hazardous materials (HM) by motor carriers, and develop a framework for using a geographic information system (GIS) based approach to characterize routes in the national HM route registry.
2. Assess and characterize existing and proposed routes for the transportation of radioactive and non-radioactive HM by motor carrier for the purpose of identifying measurable criteria for selecting routes based on safety and security concerns.
3. Analyze current route-related HM regulations in the United States, Canada, and Mexico to identify cross-border differences and conflicting regulations.
4. Document the safety and security concerns of the public, motor carriers, and State, local, territorial, and tribal governments about the highway routing of HM.
5. Prepare guidance materials for State officials to assist them in identifying and reducing both safety concerns and security risks when designating highway routes for HM consistent with the 13 safety-based non-radioactive materials routing criteria and radioactive materials routing criteria in subpart C part 397 of title 49, Code of Federal Regulations.
6. Develop a tool that will enable State officials to examine potential routes for the highway transportation of HM, assess specific security risks associated with each route, and explore alternative mitigation measures.

The Secretary was also directed to transmit a report to Congress on the programs and activities carried out under the section and any recommended change to the routing requirements for the highway transportation of HM.

The Department's HM initiatives promote safe and secure operations and the best highway practices for commercial motor vehicles (CMV) transporting HM in commerce. The goal of the Federal Motor Carrier Safety Administration's (FMCSA) HM safety program is to reduce HM incidents by 20 percent by December 31, 2010, from the 2000 baseline of 574 incidents. To accomplish this goal, FMCSA broadened the safety activities under its authority to more effectively align safety and security initiatives.

The FMCSA supports the Federal Government's protection of the public and works closely with DHS. The FMCSA's access to the HM industry, through its safety programs, allows it to leverage relationships and experience to identify and address CMV security issues to protect against the risks to life and property that are inherent in the transportation of HM in commerce.

Section 1553(a)(1) – Document existing and proposed routes for the transportation of radioactive and non-radioactive HM by motor carriers, and develop a framework for using a GIS-based approach to characterize routes in the national HM route registry.

Documenting Existing and Proposed Routes

In advance of the Act, FMCSA initiated an update to the existing National HM Route Registry. The routing registry contains HM routes for all 50 States and the District of Columbia. The FMCSA's contractor, Battelle, requested current route information from State contacts through the Commercial Vehicle Safety Alliance. Knowledgeable State officials provided information about the location of existing, proposed, and planned HM routes. Simultaneously, FMCSA Division Administrators completed outreach to the States to elaborate on the purpose of the project and requested the State's cooperation in this effort. This information was captured in a report to FMCSA (Appendix A).

The report showed that approximately two-thirds of the States have designated HM routes. Seventeen States did not have registered assigned HM routes. In addition, the majority of designated HM routes in the United States have been designated for through-shipments. Through-shipments, which are those shipments on HM routes in States other than the point of origin and destination, are easier to regulate since the local area is not dependent on the shipments for their economic viability. For most States, the through HM routes are established to avoid urban populations.

Framework for Using GIS-Based Approach to Characterize Routes

A framework for using a GIS-based approach to characterize routes in the national HM route registry was developed by Battelle under their contract with FMCSA. Battelle conducted a literature review, which examined prior studies that focused on the designation of CMV routes for HM shipments. This information provided lessons learned that might benefit future routing.

Most State and local governments are primarily focused on through routing of HM between entry and exit points in the region. Consequently, the HM routes are largely controlled-access highways and other major arteries. Restraints are used to refine the list of candidate routes. Such restraints are defined as additional requirements for the transport of certain HM (e.g. Class 1 Explosive Material) through bridges and tunnels requiring an escort.

The primary analysis criteria used to evaluate candidate routes are measures of risk and trip efficiency. Risk is typically defined as the likelihood of an accident multiplied by the expected consequence, where population is used as the proxy measure for expected consequence. Trip efficiency is measured as the deviation in trip distance or travel time relative to the minimum

distance or travel time path. A variety of other criteria, including proximity to emergency response, type of HM, and certain roadway and traffic conditions are considered to be of moderate importance. Subjective criteria are also used to further characterize candidate routes, but do not appear to have the same level of importance in the decisionmaking process. Some subjective criteria include HM spill damage potential, number of potential evacuees, and exposure to environmentally sensitive areas.

Different analytical tools and subjective judgments are used in making routing decisions. One approach relies on local knowledge to identify a set of candidate routes from which quantitative analysis is performed to identify preferred routes. In contrast, another approach uses quantitative analysis initially to identify candidate routes, and then relies on local knowledge to select a preferred route from among these candidates. In either case, it is apparent that the routing agency believes that subjective judgment based on local knowledge plays an important role in the decision process. Varying the routing criteria or importance ratings often leads to the identification of different preferred routes. Consequently, routing agencies are usually faced with understanding and accepting tradeoffs in selecting a final route.

Comprehensive off-the-shelf route risk assessment software is already available to support analyses based on multiple criteria in determining a preferred route. These tools can be applied anywhere in the continental United States and produce results in both tabular and map form. Their applicability and ease of use is due to the advent of GIS technology and the proliferation of relevant route data being collected in a GIS format. The Battelle report (Appendix B) provides more detailed information regarding available software and its recommended application.

The incorporation of the route registry into a GIS allows route restrictions to be passed to the routing tool for analysis at any geographic level (i.e., local, regional, or national). This GIS format includes routes prescribed for specific types of HM as well as those with specific restrictions on a certain type of HM. Other restrictions, such as time-of-day restrictions for selected types of HM, permitting, and escort requirements for specified types of HM are placed on the GIS format to ease use for the user to obtain the necessary information to route HM. The GIS format provides the flexibility to select the designated HM routes and obtain information listing the specific restrictions for that route, such as type of HM or time of day. Furthermore, the GIS format allows for easier capabilities to include maps of border areas along the Canadian and Mexican borders with restrictions on the movement of HM.

In summary, routing agencies have shown familiarity with the Federal routing guidelines and demonstrated the ability to apply routing criteria both quantitatively and subjectively in making routing decisions. From these experiences, a hierarchy of important routing criteria has emerged along with recognition that the preferred route may differ depending on what routing criteria are utilized and the importance ratings associated with them. The decision process has been inclusive of other stakeholders and comprehensive tools are available to support identification and evaluation of candidate routes.

Section 1553(a)(2) – Assess and characterize existing and proposed routes for the transportation of radioactive and non-radioactive HM by motor carriers for the purpose of identifying measurable criteria for selecting routes based on safety and security concerns.

The Battelle report to FMCSA (Appendix A) presents a characterization of a selection of routes to test whether the methodology using security criteria to select HM routes functions for a variety of areas. The first step in the route characterization is to evaluate the route based on the route security criteria. The outcome of this step is one or more candidate routes. A single candidate route is carried into the second part of the analysis, considering the routes proximity to iconic structures, only if the route meets the security criteria.

A series of screening criteria have been proposed to prescribe or restrict HM routes and establish HM-free zones. The first step is to identify candidate routes based on the total distance traveled and the portion of each route that passes through areas having urban densities (defined as a population density of 3,000 people per square mile within a half-mile of the roadway).

Two criteria compare the most direct route, *y*, with the proposed alternative route *x*. The first criterion considers the ratio of the distance traveled through urban zones for the most direct route, *A*, divided by the distance through urban zones for the proposed alternative route, *B*. The proposed alternative route is selected if:

$$\frac{A}{B} > 1.5$$

The second criterion is considered only if the ratio is between 1 and 1.5. The second criterion considers the total distance traveled on the most direct route, *D*, compared with the total distance traveled on the proposed alternative route, *C*.

The proposed alternative route is considered a candidate route if:

$$\frac{A}{B} < 1.5 \text{ but } \frac{A}{B} > 1.0 \text{ and } \frac{C}{D} < 1.25 \text{ or 25 miles, whichever is less.}$$

Specifically, if the ratio obtained from dividing the distance traveled through urban areas for the through (or most direct) route by the distance traveled on an alternative route is greater than 1.5, or if the ratio is between 1.0 and 1.5 and the ratio of the total distance traveled on the alternative divided by the distance traveled on the through (or most direct route) is less than 1.25 or the difference in mileage is less than 25 miles, whichever is less, then the alternative route meets the criteria for being selected as a candidate route. For regional route selections, the 1.5 ratio is reduced to 1.25, the 1.25 ratio is reduced to 1.10 and the absolute mileage criterion is not used. If neither criterion is met, then the recommendation is that both routes be selected as candidate routes. When this occurs, subsequent steps in the analysis process are used to identify prescribed or restricted routes or HM-free zones.

In summary, a comprehensive and workable security assessment methodology has been developed. The methodology is flexible enough to handle a wide variety of route characteristics and is able to identify situations where prescribing a route for security has significant benefits. All the information used in these evaluations can be obtained from GIS databases depending on the individuals trained in their use. Most State routing officials would have access to the data and staff trained in the use of GIS databases. A Web-based application that implements the logic described in this section has been developed. While not intended to replace the decision maker, the methodology provides the decisionmaker with information that can be used to justify prescribing or restricting HM routes based on safety and security.

Section 1553(a)(3) – Analyze current route-related HM regulations in the United States, Canada, and Mexico to identify cross-border differences and conflicting regulations.

Routing regulations for HM in the United States, Canada, and Mexico were researched to determine if trans-border conflicts exist. The results of this investigation were submitted to FMCSA in a report entitled, "HM Routing Regulations and Truck Transport Border Conflicts" (Appendix C). This portion of the report was designed to accomplish the following two major objectives related to HM routing regulatory analysis:

1) To describe the most important aspects of the Federal routing regulations; and
2) To describe the major routing conflicts that exist for truck shipments of HM between the United States, Canada, and Mexico.

The major routing conflicts that exist for truck shipments of HM occur mainly between the United States and Canada and, more specifically, between the province of Ontario and the States of Michigan, Minnesota, and New York. There are restrictions at bridge and tunnel crossings that exist between the Canada and the United States. Certain types of HM are prohibited from crossing bridges and all HM is prohibited from tunnel crossings. This leaves motor carriers that transport HM between the two countries with fewer options to transport HM across the United States and Canada border. There are also some routing conflicts at border crossings between the United States and Mexico. The only border restrictions for HM truck shipments along the Mexican border are in California. These restrictions apply to explosives, inhalation hazards, and Highway Route Controlled Quantity (HRCQ) of radioactive materials. All other HM may be shipped across any of the three border crossings between California and Mexico that allow commercial trucks to cross. The following list shows each border crossing and the HM that are restricted from crossing either from or into California at that point:

- San Ysidro Border Crossing (I-5) — No commercial truck traffic at this port
- Otay Mesa Border Crossing — Explosives, Inhalation Hazards, and HRCQ
- Tecate Border Crossing (Route 188) — Explosives, Inhalation Hazards, and HRCQ
- Calexico Border Crossing — Inhalation Hazards and HRCQ

Section 1553(a)(4) – Document the safety and security concerns of the public, motor carriers, and State, local, territorial, and tribal governments about the highway routing of HM.

A cross-section of stakeholders including carriers, shippers, associations, and State officials, using questionnaires tailored for each major stakeholder group, was used to solicit information concerning their views on HM routing.

Results obtained from the surveys administered to carriers and shippers, State agencies, and several transportation associations provided diverse feedback regarding the designation of HM routing (Appendix D). In general, the shippers and carriers believe that although the use of HM routes are beneficial for safety, any diversion from the most direct route adds additional operating costs based on added mileage. Furthermore, the shippers and carriers had mixed opinions as to whether criteria are needed to ensure security. Among those carriers that thought security criteria could be beneficial, they commented that criteria could be applied only to those materials that could be used as a weapon and, specifically, to any materials that would require an evacuation of at least 1,000 feet.

The associations that responded to the questionnaire believe that interstates are much safer than other roads with respect to security because any potential terrorists would have less access to vehicles on limited access highways. The associations were also concerned about the process whereby routes are designated, believe that routes cannot be selected in a vacuum, and that any routing entity must consult with adjacent entities to ensure that routing conflicts do not arise. The associations were skeptical about the benefits that would be derived from adding security criteria. This was, in part, because they were unaware of any terrorist incidents in the United States that stemmed from the hijacking of a HM cargo on the highway.

Results obtained from the State representatives in response to the questionnaire were, for the most part, in favor of using safety and security analyses to derive routes. The State officials believe that, wherever possible, HM should be routed on limited access highways to improve both safety and security. The States were more positive about the impact of HM routing on both safety and security than the shippers and carriers. The States judged both the safety and security benefits to be rated 3.5 on a scale of 1 to 5 where 5 is extremely beneficial. When asked if they believe that the designation of HM routes improves public safety and security, five of the six States replied positively.

Shippers and carriers gave safety benefits a rating of 3.0, but the security benefits a score of only 2.6 out of 7.0 where 7.0 is extremely beneficial. All of the carriers responded that designating HM routes increased their operational costs. The carriers referenced costs associated with additional mileage resulting from traveling along HM designated routes. Other costs described included training costs, additional labor costs, costs associated with changing travel routes, and higher insurance costs due to negative (unintended) safety consequences. Carriers seem to disagree on ways to enhance HM security. Many carriers responded that there needs to be more flexibility in determining HM routes and that the regulations need to account for route exceptions

that will actually work to improve the safety and security for the cargo. On the other hand, one carrier responded that safety and security could be improved by stricter enforcement of the current regulations. Another carrier responded that instead of basing regulations on routing, HM safety and security regulations should focus on utilizing technology to track HM shipments and respond in emergency situations.

Section 1553(a)(5) – Prepare guidance materials for State officials to assist them in identifying and reducing both safety concerns and security risks when designating highway routes for HM consistent with the 13 safety-based non-radioactive materials routing criteria and radioactive materials routing criteria in subpart C part 397 of title 49, Code of Federal Regulations.

The purpose of the guidance document (Appendix E) is to develop an approach for incorporating security considerations into the existing process routing officials must follow to designate HM truck routes using the safety regulations contained in 49 Code of Federal Regulations Part 397. When designating highway routes for transporting non-radioactive HM, the regulations list 13 standards a routing official must follow. The guidance document will not change or abolish any of the safety standards. Rather, the guidance document proposes to add steps to the route evaluation process so that security concerns are addressed in sync with the safety requirements. While the guidance document attempts to anticipate many of the situations a routing official will face when trying to designate a route that meets both safety and security criteria, there will be cases where the selection of a route will have to rely on current standards in the regulations.

The guidance document was designed to be flexible enough to take advantage of the varying circumstances without being too complex. The guidance was designed to use route selection criteria that will enhance the safety and security of HM transport without overly restricting commerce.

In order to assist officials in making security-based routing decisions, the methodology described in the guidance document uses road type, distance traveled, and the proximity of both attractive targets and law enforcement personnel. The guidance provides an easy-to-use process for routing officials to prescribe or restrict HM routing using such factors applied to specific security conditions. Routing officials also receive guidance on reducing risk where targets remain vulnerable even after HM traffic has been diverted onto more secure routes.

Section 1553(a)(6) – Develop a tool that will enable State officials to examine potential routes for the highway transportation of HM, assess specific security risks associated with each route, and explore alternative mitigation measures.

The guidance document is accompanied by a Web-based routing tool that will guide the routing official through a logical sequence of data collection and evaluation steps. The routing tool is intended as a decision aid and is not intended to replace the judgment of the routing official who must balance the overall need of the region with the need to provide safe and secure HM transport. This tool is Web-based and provides routing officials with an interactive approach to assist in determining the safest and most secure routes in their area.

The approach focuses on identifying road type, distance traveled, and the proximity of both attractive targets and law enforcement personnel. The prototype allows:

- For assessments where there are multiple routes between a given origin and destination.
- For selection of a prescribed route (as appropriate) to help minimize security risks.
- For the application of routing restrictions (as appropriate) to reduce the risk in those situations where targets still remain vulnerable even after HM traffic is diverted onto more secure routes.

The prototype Web-based system facilitates the application of the guidance document through enabling officials to compare routes using data that is available in a GIS format. The guidance document is automated through the Web-based application and additional enhancements will be implemented before the Web-based application is suitable for State use for safety and security routing selections. The Web-based application is currently only available to FMCSA. However, after the enhancements are made in 2009, it will be made available for full implementation for States through FMCSA's Web site.

The prototype allows the user the ability to interact with the system by using a point and click operation to select routes. In addition, the system allows information to be gained from the GIS format and brought the analysis segment of the tool. The system is flexible enough to allow manual input and obtain the information from the GIS format.

The FMCSA plans to provide outreach initiatives that include training for State personnel responsible for routing HM within the State. The FMCSA will announce the release of the Web-based routing tool and present it at various State meetings. The Web-based tool will be presented in various forums to ensure State personnel will obtain the knowledge and functions of the Web-based routing tool.

Final Report:
Hazardous Materials Routing Safety & Security Risk Analysis

Prepared for:

Federal Motor Carrier Safety Administration
U.S. Department of Transportation

March 31, 2008

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1.0 Background

1.1 Introduction

This Final Report provides an overview of the work conducted during a yearlong project conducted for the Federal Motor Carrier Safety Administration (FMCSA). The project had several purposes. Battelle is conducting the Hazmat Routing Safety & Security Risk Analysis Project for the U.S. DOT Federal Motor Carrier Safety Administration (FMCSA) that emphasizes hazardous material routes in the United States. The project has focused on the following items:

1) Determine the location of existing and proposed hazardous material routes in the United States, Canada, and Mexico.
2) Investigate if additional criteria are needed to include security considerations when selecting routes in addition to the current safety criteria.
3) Determine if there are any conflicts between hazardous materials routes in the United States and those in Canada or Mexico.
4) Develop a potential requirement that could be used to apply the security routing methodology.
5) Conduct of preliminary benefit/cost analysis of the routing methodology to determine if benefits would exceed costs if the requirement was implemented.
6) Characterize a sample of hazmat routes to determine if the application of the security routing methodology is effective.

This Final Report briefly summarizes those documents that have already been delivered to FMCSA and includes three new products that are being presented to FMCSA for the first time in this report. These are a Potential Routing Requirement, A Preliminary Benefit/Cost Analysis of the requirement and characterization of a sample of routes to determine if the security routing methodology is effective.

1.2 Documents Submitted to FMCSA for the Hazmat Routing Project

1.2.1 Documenting Hazardous Materials (Hazmat) Routes in the United States

This portion of the project resulted in the preparation of an Updated National Hazardous Materials Route Registry. This electronic spread sheet was submitted under FMCSA's Hazardous Materials Routing Safety and Security Risk Analysis Project in January 2007.

The Battelle Team began this project by utilizing the existing National Hazardous Materials Route Registry list that was converted into an Excel file by Volpe. This listing contained information on all 50 States and District of Columbia. State contacts were primarily collected through the Commercial Vehicle Safety Alliance (CVSA), a project team member, who contacted members via email to explain the purpose of the project and then to request that the member identify the State official knowledgeable about the location of exiting, proposed and planned hazardous materials (hazmat) routes. FMCSA played a key role in this process by

sending a letter to the FMCSA Division Administrators that described the purpose of the project and sought their cooperation in this effort.

State contacts were first sorted by State, and then assigned to team members. Each team member began investigating their assigned State's routes by searching the internet and calling State contacts. Additional calls were often needed because in some cases the incorrect contacts were identified or in others, personnel changes mandated that the replacement be contacted. Changes and updates were made to the spread sheets based on the information collected. All 50 states and the District of Columbia were contacted in order to confirm and/or update the hazmat routes.

The documentation process showed that currently, approximately two thirds of the States have designated hazmat routes. Seventeen States or about 33 percent do not have registered assigned hazmat routes. There are about 760 hazmat routes designated in the United States. Of these, about 30 percent or 226 were created after the November 1994 routing regulations were in place. This means that the majority of hazmat routes were established without the use of the regulations.

The great majority of designated hazmat routes in the United States have been designated for through shipments. Through shipments, those with no origin or destination in an area, are easier to regulate since the local area is not dependent on theses shipments for their economic viability. For most states, the through hazmat routes are established to avoid urban populations. Exceptions to this occur especially in California, Colorado and Alaska where a number of rural routes have been designated for hazmat shipments.

1.2.2 Hazardous Materials Routing Survey Analysis

This task surveyed a cross section of stakeholders including carriers, shippers, associations and state officials and solicited information concerning their views on hazmat routing and specifically on routing following security criteria. A report entitled Hazardous Materials Routing Survey Analysis, summarized the findings and was submitted to FMCSA in December 2006.

Results obtained from surveys administered to carriers and shippers, state agencies, and several transportation associations tended to provide diverse feedback regarding the designation of hazardous material routing. In general, the shippers and carriers believe that although the use of hazmat routes are beneficial for safety, any diversion from the most direct route adds additional operating costs based on traveling added mileage along designated hazmat routes. Furthermore, they had mixed opinions as to whether criteria are needed to ensure security. Among those carriers that thought security criteria could be beneficial, they commented that criteria could be applied only to those materials that could be used as a weapon and specifically to any materials that would require an evacuation of at least 1,000 feet.

The associations that responded to the questionnaire believe that interstates are much safer than other roads with respect to security because any potential terrorists would have less access to vehicles on limited access highways. The associations were also concerned about the process whereby routes are designated and believe that routes can not be selected in a vacuum and that any routing entity must consult with adjacent entities to ensure that routing conflicts do not arise.

The associations were skeptical about the benefits that would be derived from adding security criteria. This was in part because they were unaware of any terrorist incidents in the United States that stemmed from the hijacking of a hazmat cargo on the highway.

Results obtained from the state representatives in response to the questions in the questionnaire were, for the most part, far more favorable towards the concept of enhanced safety and security being derived from routing regulations. The state officials believe that, wherever possible, hazmat should be routed on limited access highways to improve both safety and security. The states were more positive about the impact of hazmat routing on both safety and security than the shippers and carriers. The states judged both the safety and security benefits to be rated 3.5 out of a scale of 1 to 5 where 5.0 is extremely beneficial. When asked if they believe that the designation of hazmat routes improves public safety and security, five of the six states replied positively. On the other hand, the shippers and carriers gave safety benefits a rating of 3.0 but the security benefits a score of only 2.6 out of 7.0. All of the carriers responded that designating hazmat routes increased their operational costs. These carriers referenced costs associated with additional mileage resulting from traveling along hazmat designated routes. Other costs described included training costs, additional labor costs, costs associated with changing travel routes, and higher insurance costs due to negative (unintended) safety consequences. Carriers seem to disagree on ways to enhance hazmat security. Many carriers responded that there needs to be more flexibility in determining hazmat routes and that the regulations need to account for route exceptions that will actually work to improve the safety and security for the cargo. On the other hand, one carrier responded that safety and security could be improved by stricter enforcement of the current regulations. Another carrier responded that instead of basing regulations on routing, hazmat safety and security regulations should focus on utilizing technology to track hazardous material shipments and respond in emergency situations.

1.2.3 Guidance Document

The Guidance Document was developed to provide routing officials with guidance for applying a methodology to apply security criteria to a safety driven routing selection system for selecting hazmat routes. The Guidance Document was submitted to FMCSA in March 2008.

The purpose of this Guidance Document is to provide routing officials with the insights and methodology for selecting hazmat routes that consider security as a major selection factor. The material presented in this Guidance Document provides routing officials with background information, specific guidance, and a method for selecting hazmat routes that includes security as a major selection factor. The method is designed primarily to use information and data sources such as GIS databases that are compiled and maintained by U.S. Government organizations and, to a limited extent, using data identified through Internet searches. While it is impossible to anticipate every circumstance a routing official might encounter, the design is flexible enough to take advantage of the varying circumstances without being overly complex. The method has also been designed to use route selection criteria that will enhance the safety and security of hazmat transport without overly restricting commerce.

This Guidance Document is supplemented by the **Safety and Security Routing Tool** which guides the routing official through a logical sequence of data collection and evaluation steps. The routing tool is intended as a decision aid and is not intended to replace the judgment of the routing official who must balance the overall need of the region with the needs to provide secure hazardous material transport. This tool is Web-based and provides routing officials with an interactive approach for applying the security method to route selection in their area. The Routing Tool can be accessed through FMCSA Website.

In order to assist officials in making security-based routing decisions, the methodology described in this Guidance Document uses road type, distance traveled, and the proximity of both attractive targets and law enforcement personnel. The method provides an easy to use a stepwise process for routing officials to prescribe or restrict hazmat routing using these factors applied to specific security conditions.

Routing officials also receive guidance on reducing risk where targets remain vulnerable even after hazmat traffic has been diverted onto more secure routes.

1.2.4 Regulatory Summary Focusing on Cross Border Conflicts

Routing regulations for hazmat in the United States, Canada and Mexico were investigated to determine if trans border conflicts existed. The results of this investigation were submitted to FMCSA in May 2007 as: Hazardous Materials Routing Regulations and Truck Transport Border Conflicts.

This white paper was designed to accomplish two major objectives related to hazardous materials (hazmat) routing regulatory analysis:

1) To describe the most important aspects of the Federal routing regulations; and
2) To describe the major routing conflicts that exist for truck shipments of hazmat between the United States and both Canada and Mexico.

The Federal Motor Carrier Safety Administration's (FMCSA) regulations for transporting hazardous materials by motor vehicle documented in 49 CFR Part 397 (49 CFR, 2006) Subparts C and D, address the regulations for routing non-radioactive hazardous materials (NRHM) and radioactive hazardous materials (RAM), respectively. Subpart E specifies the preemption procedures to be followed if an individual including state or local government or Indian tribal official desires preemption from a route prescribed under either Subpart C or D. Following a brief summary in Section 2.0, these sections are summarized in detail.

The major routing conflicts that exist for truck shipments of hazmat occur mainly between the United States and Canada and more specifically between the province of Ontario and the states of Michigan, Minnesota, and New York. Specific routing conflicts are summarized in table of the white paper. However, there are also some "routing conflicts" at border crossings between the United States and Mexico. The only border restrictions for HM truck shipments along the Mexican border are in California. These restrictions apply to explosives, inhalation hazards and highway route controlled quantities of radioactive materials (HRCQ). All other HM may be shipped across any of the three border crossings between California and Mexico that allow

commercial trucks to cross. The bulleted list below lists each border crossing and those hazardous materials that are restricted from crossing either from or into California at that point.

- San Ysidro Border Crossing (I-5) — None*
- Otay Mesa Border Crossing — Explosives, Inhalation Hazards and HRCQ
- Tecate Border Crossing (Route 188) — Explosives, Inhalation Hazards and HRCQ
- Calexico Border Crossing — Inhalation Hazards and HRCQ

* None of the HM classes are restricted from traveling to or from the Mexican border. However, this crossing is closed to all commercial truck traffic. Therefore, no HM truck shipments can cross the border at San Ysidro.

2.0 Potential Security Routing Requirement

2.1 Introduction

Until recently, the approach to routing hazardous materials (hazmat) by highway assumed that when man-made disasters occurred, they were accidental in nature and not due to malicious intent. Terrorist activities, leading to the tragic events in Oklahoma City and on September 11, 2001, as well as those that have occurred in other countries have changed this assumption. We now know that terrorists consider vehicles carrying hazardous materials to be one of the instruments that could be used to further their cause. As a result, terrorism scenarios which previously would have been considered too unlikely to warrant the attention of routing officials must now be considered when designating or restricting routes on which hazardous materials can be transported. Specifically, we must consider hazmat incidents that are or maybe the direct result of terrorist acts; incidents in which hazmat are used as the weapon.

If a routing authority decides to take action and implement security-based routing restrictions, there are currently **no requirements** that enable the authority to implement such routing restrictions. The potential security requirements described below could provide them with the requirements to establish security based routing of hazmat within their jurisdictions.

The following paragraph provides a potential security requirement that FMCSA may consider as a framework for developing a draft regulation. Such a regulation would specify the steps and the types of evaluations routing officials would use to identify security vulnerabilities and actions these officials should take to reduce the risk of terrorists exploiting these possible vulnerabilities. While the language of the potential security requirement does not dictate the exact methodology a routing official must use to assess route security and designate (or restrict) hazmat transport routes, the language does dictate the types of information that should be considered when developing and implementing a hazardous materials route security assessment methodology. Such standardization would provide uniformity in how security vulnerabilities are addressed, in itself a security benefit, and help ensure that routing officials will not specify overly cumbersome hazardous material transport routes. **The proposed security requirements are designed to work in concert with and not replace the current safety routing regulations**.

The proposed requirement includes the following major sections:

- An approach for determining if hazmat routes should be designated for security
- The desirable characteristics of through hazmat shipment routes
- The desirable characteristics of local hazmat routes.
- The approach for designating hazmat routes for security.
- Discussions of state and tribal routing officials with local officials
- Public information and reporting requirements

2.2 Determining if Hazmat Routes Should be Designated for Security

The focus of a security assessment is to protect areas that are highly populated or contain iconic structures or critical infrastructure. Areas with important cultural, economic and symbolic resources such as historic sites and monuments, government offices, stadiums, convention centers, schools, bridges and tunnels might be designated as having iconic structures/critical infrastructure by the Federal government, State routing authorities or Indian tribes. Note that for the purposes of this proposed requirement, iconic structures and critical infrastructure are referred to as iconic structures.

A determination of adequate hazmat route security should address the following questions:

1) Does an existing or potential credible terrorist threat exist that could result in hazmat cargo being used as a weapon to damage or destroy nationally, regionally or locally recognized iconic structures or critical infrastructure?
2) Do current designated hazmat routes sufficiently protect these iconic structures/critical infrastructure by ensuring that hazmat shipments travel at sufficient distance from the potential targets?
3) Would imposing restrictions on through and/or local hazardous material routes significantly augment the security measures already in place to protect potential targets (i.e., physical barriers and stationing police close to the structure)?

Where hazmat routes have previously been designated based on safety criteria, these routes should be examined to determine if they also provide adequate security protection. Such an evaluation should be performed before reaching a decision that the previously performed safety assessment is adequate for security. If the routing officials deem this protection to be adequate, a report documenting the decision and its basis would be issued. The report would summarize the routes evaluated, there relative characteristics, and how the routes compare against the safety and security routing criteria. If the routing official chose to discount some of these analysis findings, the rationale for discounting the criteria would also become part of the documentation. This report would be provided to potentially affected parties (e.g., individuals, businesses and governmental entities).

Should the routing official make a determination that the security protection provided by the hazardous material routes prescribed for public safety may be inadequate when considering security concerns, the routing official should perform a more in depth evaluation to determine if additional route designations or restrictions would improve the security of hazmat transport.

A different evaluation approach should be used depending on whether the route serves *through* or *local* shipments. For through shipments, routing authorities may establish designated or restricted routes for all hazardous material shipments by truck or for selected classes/divisions of hazardous materials (e.g., toxic by inhalation (TIH), explosive) based on the proximity of the routes to icons and the presence of critical infrastructure on the routes. For local shipments, restricted zones may also be considered, which would include prohibiting hazmat shipments on all streets in the zone; this could be designated by listing just the streets forming the boundary. Based on the nature of the sensitive zone, the routing authorities can restrict travel of all

placarded vehicles or selected types of hazardous materials, and may also restrict travel during specific time periods.

2.3 Characteristics of Through Hazmat Shipment Routes

For security purposes, within urban areas, where they exist, *divided, limited access highway* bypasses or beltway*s* are the preferred hazardous material routes for through shipments. Divided, limited access highways are considered to be attractive routes for security purposes because they generally provide poorer access for potential terrorists to reach cargo and critical infrastructure of interest. Beltways or bypasses are desirable routes because they tend to be more remote from densely populated areas and are less exposed to icons/critical infrastructure than highways passing through the central core of an urban area.

2.4 Characteristics of Local Hazmat Shipment Routes

Preferred routes for local hazardous material shipments are divided, limited access highways traversing the urban area. Unless specifically restricted, major thoroughfares designated as truck routes are considered to be designated hazardous material truck routes. For pickup and delivery to locations not on designated routes, the route must be the shortest-distance from pickup and delivery location to the nearest access/egress point on the designated hazardous material route. Routes which do not meet this criterion should be considered only if the shortest route would result in the transport of hazardous material through highly populated areas or through zones established to protect icons/critical infrastructure. Pickup and delivery routes need not be specifically listed. In accordance with 49 CFR 397.67(b), a motor vehicle that requires to be placarded shall operate the vehicle over routes that do not go through or near populated areas or near heavily populated places where crowds are assembled, tunnels, narrow streets or alleys unless no practical alternatives exist. For explosives and shipments of Highway Route Controlled Quantities of Radioactive Material, additional route requirements are imposed. These requirements are intended to reduce the risk to the public posed by shipping these materials.

Where explosives, TIH shipments (and any other designated hazmat) must be made to/from customers located on restricted routes or in restricted zones, the cargo should be either shipped by a vehicle equipped with a unique identification system for shipments of hazmat in the restricted area. This entrance sticker would be provided to a carrier by local officials and would be visible and easy to read by observers either on the street or in another vehicle. Although the FMCSA requires shippers of radioactive materials, explosives, TIH and methane (liquefied natural gas) to possess a safety permit, this permit is not related to permission to operate in specific areas or zones. Currently, a permit system is in operation in Yellowstone National Park where all HM carriers entering the park must be permitted.

49 CFR 397 Subpart B specifies the procedure State and Indian Tribe routing officials must follow to prescribe or restrict routes for Non-radioactive Hazardous Material (NRHM). In the absence of any federal regulations, these officials could decide to require additional security controls. A vehicle could be equipped with deterrent security features or escorted by law enforcement (or a certified escort). Deterrent security features would enable law enforcement officials to be warned and interdict shipments following any attempt made to take unauthorized

control of the shipment. Security features would include but not be limited to: GPS tracking, communication devices for continuous driver contact with law enforcement, and the ability to stop the vehicle by locking its brakes remotely. Deterrent security features could be documented in a confidential route security plan that has been approved by law enforcement authorities having jurisdiction within the restricted zone. Similarly, escort personnel that are candidates for certification would be included in the security plan, if required. Plan approval would represent "certification" of escort personnel as well as deterrent security features. It should be noted that the regulations currently require that some high risk materials, specifically Division 1.1, 1.2 and 1.3 Explosives and HRCQ radioactive material shipments have some of these deterrent safety features.

2.5 Designating Routes for Security

If there is no existing hazmat route in the area, the routing authority would apply a similar approach but would select alternate routes to evaluate. These would usually include the most direct route through the area and an alternative bypass route.

Routing officials would assess potential hazmat routes for security criteria following a three step process, as outlined below. Note that the FMCSA Hazmat Routing Guidance document (FMCSA-2007) provides specific steps for conducting an evaluation of potential hazmat routes with respect to safety and security by designating and restricting routes and establishing restricted hazmat zones.

1) For the most direct route through the urban area and the proposed alternative route(s), determine the total distance traveled and the distance traveled though densely populated areas. An area is defined as densely populated if the population density on either side of the route is greater than 3,000 persons per square mile. If the evaluation is for the transport of all types of hazardous materials, the distance used to calculate density should be one half-mile on either side of the highway. If the route is being considered for specific types of hazmat, a different distance from the roadway could be used to estimate population density, taking into account the impacts from releases of the material in question. In order for an alternative route to be selected as a candidate for designation as a hazardous materials route on the basis of security criteria, the following two characteristics must be present.

    a. The ratio of the distance traveled through densely populated regions for the most direct route divided by the distance traveled through densely populated areas for the alternative route is greater than 1.5. This value was selected because there is a precedent in the current safety regulations [49 CFR 397.71(b)(4)(i)] to not select the most direct route through an urban area if the safety risk is 1.5 times larger that risk for an alternative route that avoids the populated area.

    b. If the criterion in (a) is not met but the ratio calculated in (a) is between 1.0 and 1.5, the alternative route is considered a candidate route if the total distance on the alternative route is not more than 25 miles or 25 percent greater than the most direct route, whichever is greater. This value was selected because it parallels the performance measure currently in the regulations [49 CFR 397.71(b)(4)(ii)] to select routes based on safety considerations.

2) The second step evaluates the candidate routes identified in Step 1 to determine if they provide adequate security to local, regional or national icons or critical infrastructure. A designated hazmat route cannot meet this security requirement if the roadway has a component on the critical infrastructure list. Note that both critical infrastructure and icons were identified through research of local websites and maps. This step also considers the accessibility of icons or critical infrastructure with respect to the potential use of hazmat cargo to attack these targets. The need to restrict routes or establish zones around potential targets should be based on the distance from designated hazardous material routes and the distance from law enforcement facilities to the icons/critical infrastructure. If the distance from the icons/critical infrastructure to the candidate route is significantly greater than the distance from the nearest emergency presence, then the candidate route provides adequate security for the iconic structures. If the two distances are not significantly different, the decision might be made to not establish any prescribed or restricted routes for enhancing security and to rely instead on other security methods (e.g., protective services and/or concrete barriers).
3) The third step encompasses the establishment of zones where the movement of hazmat is tightly controlled. If routing officials are unable to successfully protect icons/critical infrastructure from the use of hazmat cargo as a weapon, they may consider establishing restricted zones. In most cases, this situation would occur when performing an analysis of either through or local hazmat travel. For those icons/critical infrastructure that cannot be protected from hazmat shipments, a restricted zone with a buffer area of 0.25 miles around the structure would be established. In this area, if it were necessary to transport hazmat shipments, then such transport would be controlled by a system that might include advance notification, special equipment on the transport vehicle and, in some unique cases, escorts.

2.6 Discussions of State and Tribal Routing Officials with Local Officials

Prior to formally deciding to designate or restrict hazmat routing, the routing official must consult with potentially affected individuals, including governmental entities. These discussions must present the basis for the conclusion that designating or restricting the routes will improve safety and security and to not unnecessarily restrict commerce. **These consultations should ensure that any designated routes or restricted areas have adequately considered local situations related to such factors as the unrestricted flow of normal commerce, congestion of major routes and use of certain hazardous materials by local communities and industry.** After these discussions have occurred, routing official can issue the formal finding and disclose that the designated or restricted routes improve safety and security and do not overly restrict access to businesses receiving or shipping hazardous materials.

3.0 Preliminary Benefit/Cost Analysis

The potential routing requirements presented in Section 2.0 of this Final Report were examined in order to determine whether the enhanced benefits associated with routing hazardous materials (hazmat) around both national, regional, and local iconic structures as well as critical infrastructure exceeded the societal costs associated with applying security criteria to hazmat route selection and specifically to implementing the potential requirements. Note that in this benefit-cost analysis iconic structures and critical infrastructure are both discussed as iconic structures. Benefits to society are entirely derived from the improved safety and security of hazardous material shipments traveling on routes meeting the potential routing requirements. The vast majority of the costs are tied to the additional operating costs incurred by transporters of hazardous materials as they take more indirect routes around city centers when traveling near urban areas. Costs also include those expected to be incurred by cities when establishing and operating an entrance sticker system program, as well as costs incurred by HM carriers through the completion of entrance sticker paperwork and payment of related fees. Finally, cities would incur any signage costs associated with establishing prescribed and restricted routes. The preliminary benefit/cost analysis presented below provides an initial estimate of the anticipated benefits and costs associated with implementing the routing program. While the findings appear to be robust, the estimate was **not** prepared with the detail required for a rulemaking. In order to prepare a more reliable estimate, the estimated costs should be benchmarked against the costs currently being incurred by carriers required to meet the current security regulations imposed on Division 1.1, 1.2 and 1.3 Explosives and HRCQ shipments of radioactive materials. .

The analysis presented in this section assumes that the vast majority of routes selected for security purposes will be selected in urban areas with populations in excess of 150,000. Further, most cities with more than 150,000 inhabitants have beltways or bypass highways, enabling the comparison of these routes with the Interstate routes passing nearer the center of the city.

To determine the impact of routing restrictions on hazmat carrier operating costs, this analysis focuses on seven urban areas selected to be representative of U.S. cities:

- Baltimore, Maryland
- Columbus, Ohio
- Denver, Colorado
- Providence, Rhode Island
- Indianapolis, Indiana
- Phoenix, Arizona
- Portland, Oregon

The characteristics of these selected urban areas (e.g., the route characteristics, distance differences between alternative routes and average annual daily traffic (AADT) data for large trucks) were extrapolated to the remaining 135 urban centers in the United States.

The benefit-cost analysis presents streams of benefits and costs over a 20-year (2007-2026) timeframe but compresses these streams into present value benefits and costs using a real discount rate of 7 percent, as is prescribed by the Office of Management and Budget (OMB) for analysis of government programs.[1] The 20-year time frame was selected because this is the time

[1] Office of Management and Budget. OMB Circular A-94: Guidelines and Discount Rates for Benefit-Cost Analysis of Federal Programs. October, 1992. Washington D.C.

period that is typically used for this sort of calculation. Growth in the hazmat fleet and hazmat travel was assumed to be 1.5 percent annually, which is consistent with the 5 and 20 year averages in gasoline deliveries in the United States as reported by the U.S. Department of Energy's Energy Information Administration.[2]

3.1 The Mileage of Through Hazmat Truck Traffic Potentially Affected by Increased Routing Restrictions

One of the most significant data elements required to determine the costs of re-routing hazmat traffic around city centers is the number of additional miles that would be traveled by hazmat carriers in order to comply with the potential routing restrictions. To estimate the mileage of hazmat truck traffic potentially affected by the application of security criteria, data gathered from the examination of seven representative cities in the U.S. was extrapolated to the nation as a whole. First, the percentage population found in of all urban areas with populations in excess of 150,000 captured by the seven selected cities was calculated (7.57 percent). Next, the daily large truck traffic for the major through Interstates in the seven selected urban areas was calculated (88,951 vehicles).[3] The share of the total truck traffic represented by hazmat transporters was estimated at 5 percent.[4] Thus, the daily hazmat truck traffic for the seven selected cities was estimated at 4,448 (88,952 * .05).

To estimate the total annual hazmat traffic for all urban centers with populations in excess of 150,000, the daily hazmat traffic in the seven selected cities was multiplied by 365 and divided by the percentage of all urban areas represented by the seven selected cities (4448 * 365 / .076). The result is 21.4 million annual hazmat vehicles potentially impacted by the application of security criteria.

The data collected for this project to document current hazmat routes, shows that 31 percent of urban areas with populations in excess of 150,000 have already established hazmat routes. A tabulation of cities and their populations can be found in the U.S. Census Bureau's County and City Data Book 2007 in Table C. The total hazmat traffic represented by these jurisdictions was, estimated at 6.6 million (21.4 million * .31). Thus, there are an estimated 14.8 million annual hazmat truck movements that are not affected by current regulations. **The assumption used for this analysis is that the great majority of these existing designated hazmat routes would not be affected by the application of security criteria and the great majority of urban areas that currently have hazmat routes will retain these routes and utilize them for security purposes**. We also assume that the urban areas that have not been affected by current hazmat routing regulations would apply security criteria for selecting hazmat routes in about the same percentage (31 percent) as found for those cities with routes selected for safety.[5] Applying this assumption, 31 percent of these currently unregulated through hazmat vehicle movements would be affected by the application of new security criteria (.31 * 14.8 million or 4.6 million hazmat traffic movements). It is further assumed that only one-third of these movements would

[2] http://tonto.eia.doe.gov/dnav/pet/hist/mgfupus1A.htm, last accessed December 21, 2006.
[3] FHWA, 2004, Freight Analysis Framework for Large Trucks in 2002.
[4] FMCSA, 2001, Comparative Risk of Hazmat and Non-hazmat Materials Truck Movements.
[5] Data developed for FMCSA under this hazmat routing project.

represent through traffic.[6] Thus, the number of through hazmat truck trips potentially affected by the application of security criteria is estimated at 1.5 million.

To estimate the added miles required for through hazmat movements if forced to use longer routes that bypass the center of the urban areas, the direct Interstate routes for the seven urban areas were compared to the beltway routes. For the seven urban areas, the direct Interstate routes represent about 137.3 miles and the beltway routes are approximately 203.9 miles. For the seven urban areas examined for this analysis, the average mileage on the beltway is 29.1 miles while the average mileage on the direct routes was 19.6 miles, measuring a difference of 9.5 miles. Thus, 9.5 miles was used to represent the additional mileage that must be traveled to avoid the center of the urban area.

Based on the total hazmat traffic of 1.5 million hazmat trips potentially affected by the new security requirements, multiplying these trips by the average additional mileage of 9.5 results in a total of 14.5 million miles of additional driving as a result of the new regulations. In order to make this estimate more realistic, a sensitivity analysis was performed by using a lower and higher value for some of the key costs. If the range of values accurately represents the range of uncertainty, and the cost benefit ratio is still favorable, then there is greater certainty that the ratio is robust and will actually be realized if the program is implemented. When the sensitivity analysis was performed on this estimate, low- and high-end assumptions (plus or minus 10 percent), the range of potential impacted miles was 13.1 million to 16.0 million.

3.2 The Costs of Complying with New Hazmat Routing Restrictions

This analysis examines four cost elements:

- additional operating costs to hazmat carriers associated with diverting around city centers,
- costs to cities associated with signage on prescribed and restricted routes,
- costs to cities for establishing and maintaining an entrance sticker program, and the costs to local carriers to obtain an entrance sticker for a restrictive zone.

These costs were examined over a 20-year analysis time horizon. The basis of each cost estimate is provided in the remainder of this section.

The vast majority of the costs are those tied to the operating costs to hazmat carriers when diverting around city centers on beltways circumnavigating major urban areas. To calculate the annual operating costs, the miles affected by the new security requirements, identified as 13.1 to 16.0 million in the preceding section, were multiplied by an average per-mile operating cost of $3.10. This value is an escalation of the average per-mile operating cost estimate calculated in 2003 by the American Trucking Associations of $2.80 per mile. That included $0.551 for driver wages, $0.804 for other wages and benefits, $0.198 for fuel, and $0.651 in equipment rents and

[6] FMCSA, 2001 Comparative Risk of Hazmat and Non-hazmat Materials Truck Movements; based on analysis of hazmat commodities and assumed percentage distributed locally.

purchased transportation.[7] The per-mile operating cost of $2.80 was then inflated to 2007 dollars using the consumer price index to result in the $3.10 figure used in the analysis. Applying this operating cost assumption results in initial year costs to motor carriers of $40.5-$49.5 million. Further, it is assumed that an additional 10 percent of costs would be incurred by motor carriers navigating around cities with fewer than 150,000 inhabitants. The costs associated with avoiding smaller urban areas are estimated at $4.1-$5.0 million in the initial year following implementation of the restrictions. Thus, total initial year costs to motor carriers associated with diverting around city centers are estimated at $44.6-$54.5 million.

This analysis also considers the costs to establish restricted zones for local hazmat traffic, including the costs to establish and maintain an entrance sticker system. Although the FMCSA requires shippers of radioactive materials, explosives, TIH and methane (liquefied natural gas) to possess a safety permit, this system is not related to permission to operate in specific areas or zones. The entrance sticker system would enable local authorities to easily spot if unauthorized HM trucks were traveling in a restricted HM zone. For this analysis, the assumption was made that in order to travel in restricted zones, hazmat carriers would be required to purchase a sticker that would be exhibited prominently on the vehicle. This entrance system was assumed to be more conservative than such solutions as using a bill of lading system to demonstrate that a carrier was authorized to travel in a restricted zone. The planning costs associated with establishing the restricted zone were estimated at $3,033 per city based on the assumption that it would require 80 labor hours to establish the zone and that the average hourly wage plus fringe for state employees is $37.91.[8] The cost to establish the entrance sticker system was estimated at $1,516 per city based on the assumption that it would take 40 hours of labor to complete. The annual recurrent costs associated with maintaining the entrance sticker system were estimated at $3,033 based on an assumption of 80 annual labor hours.

To determine the total costs of establishing and maintaining an entrance sticker system, it was necessary to determine the number of new urban areas that would prescribe hazmat routes based on security considerations. This analysis assumes there are 29 such urban areas. This estimate is based on the assumption that 42 of the 135 urban areas with populations in excess of 150,000 currently have prescribed routes and that 31 percent of the remaining 92 urban areas, or 29 urban areas, would prescribe hazmat routes based on security considerations.[9] Thus, the costs associated with establishing the entrance sticker system in large urban areas with populations in excess of 150,000 were estimated at $43,976 (40 hours * $37.91 * 29 cities), while the costs of both planning for the restricted zone and maintaining the entrance sticker system were estimated at $87,951 (80 hours * $37.91 * 29 cities). As is the case with all cost elements examined within this analysis, it is assumed that an additional 10 percent ($4,398 to establish the entrance sticker system and $8,795 to establish the zones and maintain the entrance sticker system) in costs would be incurred in smaller urban areas with populations smaller than 150,000.

The costs to hazmat carriers was estimated as the product of the number of hazmat carriers operating on local routes in each city (6), the number of cities issuing entrance stickers (29) and the costs in terms of entrance sticker fees and the costs to complete the entrance sticker

[7] http://www.oregon.gov/ODOT/MCT/CVISN.shtml
[8] Bureau of Labor Statistics, National Compensation Survey. http://www.bls.gov/news.release/ecec.t03.htm
[9] Based on the survey of hazmat routes in the United States conducted for this project.

paperwork ($81.1). Based on these assumptions, the costs to carriers to obtain entrance stickers in large urban areas was estimated at $14,111, with an additional $1,411 in smaller urban areas, for a total cost of $15,522 in the initial year following establishment of the entrance sticker process. The sticker fee was assumed to be $50 while the labor costs associated with completing the entrance sticker application was estimated as the product of the time required to complete the application (1.5 hours) and the average hourly wage plus fringe benefits for office staff estimated in the Bureau of Labor Statistics' National Compensation Survey ($20.73).[10]

The cost of signage in each city was estimated as those tied both to the establishment of prescribed routes and warning sings posted along restricted routes. The cost of signage for prescribed routes in the 29 urban areas was estimated based on the assumptions that there would be 6 signs per urban area, or a total of 174 signs, installed at a cost of $3,400 per sign. Thus, the cost to install signs on prescribed routes was estimated at $591,600. Once again, to account for the signage costs at smaller urban areas, and additional $59,100 was added to the total. The costs of signage for restricted routes were estimated based on the assumptions that there would be 12 signs installed in each urban area at a cost of $500 each (total cost of $6,000). This cost was applied to all 29 large urban areas ($174,000) and an additional 10 percent ($17,400) was added to account for smaller urban areas.

The findings of the cost analysis are presented in Tables 1 (low-end cost scenario) and 2 (high-end cost scenario). The difference in terms of costs between the two scenarios reflects the impact of the sensitivity analysis conducted with respect to additional miles traveled while diverting around city centers. Based on the aforementioned assumptions, the total cost of complying with the new security requirements ranges from $1.0 billion or $51.7 million average annual (low-end scenario) to 1.3 billion or $63.2 million average annual (high-end scenario) in undiscounted 2007 dollars and $567.7-$693.4 when compressed into present value terms using a real discount rate of 7 percent. As noted previously, the most significant cost element is associated with the additional operating costs paid by hazmat carriers ($1.0-$1.3 billion). The costs to cities and motor carriers associated with identifying HM local traffic within restricted zones is relatively small at $2.6 million. The costs to cities associated with signage along prescribed and restricted routes are estimated at $842,160.

Total costs to cities include the costs associated with establishing and maintaining restricted zones and a system to allow local hazmat traffic into these zones. These costs over the 20-year analysis time period (2007-2026) are estimated at $3.1 million ($156.4 thousand average annual) in undiscounted 2007 dollars. The total 20-year costs to carriers associated with additional operating costs resulting from the requirement to divert around city centers and to obtain entrance stickers to travel in restricted zones is estimated at $1.0-$1.3 billion ($51.6-$63.0 million average annual) in undiscounted 2007 dollars.

[10] http://www.bls.gov/news.release/ecec.t01.htm

Table 1. Annual Costs Associated with Hazmat Traffic Diversion, Entrance Sticker Program and Planning, and Signage (Low-End Scenario)

Year	Hazmat Traffic Diversion Costs	Signage Costs	Entrance Sticker Planning Costs	Total Costs	Discounted Total Costs
2007	44,578,997	842,160	160,641	45,581,798	45,581,798
2008	45,247,682	-	113,952	45,361,633	42,394,050
2009	45,926,397	-	115,661	46,042,058	40,214,917
2010	46,615,293	-	117,396	46,732,689	38,147,795
2011	47,314,522	-	119,157	47,433,679	36,186,927
2012	48,024,240	-	120,944	48,145,184	34,326,851
2013	48,744,604	-	122,759	48,867,362	32,562,387
2014	49,475,773	-	124,600	49,600,373	30,888,619
2015	50,217,909	-	126,469	50,344,378	29,300,886
2016	50,971,178	-	128,366	51,099,544	27,794,766
2017	51,735,745	-	130,291	51,866,037	26,366,063
2018	52,511,782	-	132,246	52,644,028	25,010,798
2019	53,299,458	-	134,230	53,433,688	23,725,196
2020	54,098,950	-	136,243	54,235,193	22,505,677
2021	54,910,435	-	138,287	55,048,721	21,348,843
2022	55,734,091	-	140,361	55,874,452	20,251,473
2023	56,570,102	-	142,466	56,712,569	19,210,509
2024	57,418,654	-	144,603	57,563,257	18,223,053
2025	58,279,934	-	146,772	58,426,706	17,286,354
2026	59,154,133	-	148,974	59,303,107	16,397,803
Total	1,030,829,877	842,160	2,644,419	1,034,316,456	567,724,765
Annual Average	51,541,494	42,108	132,221	51,715,823	28,386,238

Table 2. Annual Costs Associated with Hazmat Traffic Diversion, Entrance Sticker System Program and Planning, and Signage (High-End Scenario)

Year	Hazmat Traffic Diversion Costs	Signage Costs	Entrance Sticker Planning Costs	Total Costs	Discounted Total Costs
2007	54,485,440	842,160	160,641	55,488,241	55,488,241
2008	55,302,722	-	113,952	55,416,674	51,791,284
2009	56,132,263	-	115,661	56,247,924	49,129,115
2010	56,974,247	-	117,396	57,091,643	46,603,787
2011	57,828,860	-	119,157	57,948,017	44,208,265
2012	58,696,293	-	120,944	58,817,238	41,935,878
2013	59,576,738	-	122,759	59,699,496	39,780,295
2014	60,470,389	-	124,600	60,594,989	37,735,514
2015	61,377,445	-	126,469	61,503,914	35,795,838
2016	62,298,106	-	128,366	62,426,472	33,955,865
2017	63,232,578	-	130,291	63,362,869	32,210,470
2018	64,181,066	-	132,246	64,313,312	30,554,791
2019	65,143,782	-	134,230	65,278,012	28,984,218
2020	66,120,939	-	136,243	66,257,182	27,494,375
2021	67,112,753	-	138,287	67,251,040	26,081,113
2022	68,119,445	-	140,361	68,259,806	24,740,495
2023	69,141,236	-	142,466	69,283,703	23,468,787
2024	70,178,355	-	144,603	70,322,958	22,262,448
2025	71,231,030	-	146,772	71,377,803	21,118,116
2026	72,299,496	-	148,974	72,448,470	20,032,606
Total	1,259,903,183	842,160	2,644,419	1,263,389,762	693,371,499
Annual Average	62,995,159	42,108	132,221	63,169,488	34,668,575

3.3 The Benefits of New Hazmat Routing Restrictions

The benefits associated with establishing new security criteria and routing hazmat traffic around city centers are entirely tied to the probability of a terrorist attack using hazardous materials on structures of national, regional, and local significance and the costs associated with such an attack. The likelihood of a terrorist attack on national, regional, and local structures was estimated at 10 percent per year, 5 percent per year, and 1 percent per year, respectively. This estimate was base on the frequency and target selection of terrorist attacks during the past twelve years in both the U.S. and to U.S. facilities abroad. Because the number of attacks is uncertain, a factor of ten is used for the estimate. This analysis assumes that the adoption of security based routing restrictions would not eliminate all terrorist attacks. Therefore, the probability that the adoption of security based routing restrictions would prevent an attack was estimated. For this

analysis, it is assumed that routing regulations would be 50 percent effective in preventing an attack.[11] Finally, the cost of a successful terrorist attack was estimated as follows:

- National structure – $40 billion
- Regional structure – $10 billion
- Local structure – $1 billion[12]

The cost estimates shown above, were based on those prepared for a limited access report prepared by Battelle for FMCSA in a 2004 project.

Based on these assumptions the benefit of protecting structures using local routing restrictions was estimated as the product of the cost of a terrorist attack ($40 billion per national structure, $10 billion per regional structure, $1 billion per local structure), the probability that a terrorist attack will occur (10 percent per year all national structures, 5 percent per year all regional structures, 1 percent per year all local structures) and the probability that routing regulations would prevent an attack (50 percent). Based on these assumptions, the estimated benefits associated with new hazmat routing restrictions is estimated at $45.1 billion ($2.3 billion average annual) in undiscounted 2007 dollars and $25.6 billion (average annual benefit of $1.3 billion) in discounted present value terms over the 20-year analysis time horizon (Table 3).

3.4 Preliminary Benefit-Cost Analysis Results

The results of the benefit-cost analysis are presented in Table 4. In both the low- and high-end cost scenarios, the benefits associated with reducing the probability of a terrorist attack on structures easily exceed the costs associated with implementing new routing restrictions based on the assumptions used in this analysis. Using low-end cost scenario assumptions, the net benefits of the routing restrictions would exceed the costs of imposing them by $24,994,042,507 (present value discounted benefits) over the 20-year analysis time horizon (2007-2026). The benefits and costs presented in Table 4 generate a benefit-cost ratio (benefits divided by costs) of 45.0. In the high-end cost scenario present value net benefits remains $24,868,395,773, generating a 36.9 benefit-cost ratio.

Using the assumptions outlined within this analysis, the benefit-cost ratio within the low-end cost scenario would remain above 1.0 provided the annual probabilities of a hazmat terrorist attack on a national, regional, and local structure were more than 0.2 percent, 0.1 percent, and 0.1 percent, respectively. The benefit-cost ratio for the high-end estimate would remain above 1.0 if the annual probabilities of a hazmat terrorist attack on national, regional, and local structures were more than 0.3 percent, 0.1 percent, and 0.1 percent, respectively. Thus, using the assumptions outlined within this analysis, even the slight risk of a hazmat-oriented terrorist attack on national, regional, and local structures would appear to validate additional hazmat routing restrictions.

[11] Based on engineering judgment.
[12] Based on estimates in a confidential FMCSA report investigating the consequences of terrorist incidents.

Table 3. Annual Benefits Associated with New Hazmat Security Requirements

Year	Benefits of Protecting Structures			Total Benefits	Discounted Benefits
	National	Regional	Local		
2007	2,000,000,000	250,000,000	5,000,000	2,255,000,000	2,255,000,000
2008	2,000,000,000	250,000,000	5,000,000	2,255,000,000	2,107,476,636
2009	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,969,604,332
2010	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,840,751,712
2011	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,720,328,703
2012	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,607,783,835
2013	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,502,601,715
2014	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,404,300,668
2015	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,312,430,531
2016	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,226,570,590
2017	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,146,327,654
2018	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,071,334,256
2019	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,001,246,968
2020	2,000,000,000	250,000,000	5,000,000	2,255,000,000	935,744,830
2021	2,000,000,000	250,000,000	5,000,000	2,255,000,000	874,527,878
2022	2,000,000,000	250,000,000	5,000,000	2,255,000,000	817,315,774
2023	2,000,000,000	250,000,000	5,000,000	2,255,000,000	763,846,518
2024	2,000,000,000	250,000,000	5,000,000	2,255,000,000	713,875,250
2025	2,000,000,000	250,000,000	5,000,000	2,255,000,000	667,173,131
2026	2,000,000,000	250,000,000	5,000,000	2,255,000,000	623,526,291
Total	40,000,000,000	5,000,000,000	100,000,000	45,100,000,000	25,561,767,272
Average Annual	2,000,000,000	250,000,000	5,000,000	2,255,000,000	1,278,088,364

Table 4. Benefit-Cost Results
(High- and Low-End Cost Scenarios)

	Low-End Cost Scenario	High-End Cost Scenario
Benefits	25,561,767,272	25,561,767,272
Costs	567,724,765	693,371,499
Net Benefits	24,994,042,507	24,868,395,773
Benefit-Cost Ratio	45.0	36.9

4.0 Characterization of Routes

This section presents a characterization of a selection of routes to test whether the methodology using security criteria to select hazmat routes functions for a variety of areas. The first step in the route characterization is to evaluate the route based on the route security criteria. The outcome of this step is one or more candidate routes. A single candidate route is carried into the second part of the analysis, considering the routes proximity to iconic structures, only if the route meets the security criteria.

4.1 Identification of Selected Candidate Routes Based on Security Criteria

A series of screening criteria have been proposed to prescribe or restrict hazmat routes and establish hazmat free zones. The first step is to identify candidate routes based on the total distance traveled and the portion of each route that passes through areas having urban densities (defined as a population density of 3,000 people per square mile within a half-mile of the roadway).

Two criteria compare the most direct route, y, with the proposed alternative route x. The first criterion considers the ratio of the distance traveled through urban zones for the most direct route, A, divided by the distance through urban zones for the proposed alternative route, B. The proposed alternative route is selected if:

$$\frac{A}{B} > 1.5$$

The second criterion is considered only if the ratio is between 1 and 1.5. The second criterion considers the total distance traveled on the most direct route, D, compared with the total distance traveled on the proposed alternative route C.

The proposed alternative route is considered a candidate route if:

$$\frac{A}{B} < 1.5 \text{ but } \frac{A}{B} > 1.0 \text{ and } \frac{C}{D} < 1.25 \text{ or 25 miles which ever is less.}$$

Expressed in words, if the ratio obtained from dividing the distance traveled through urban areas for the through (or most direct) route by the distance traveled on an alternative route is greater than 1.5, or if the ratio is between 1.0 and 1.5 and the ratio of the total distance traveled on the alternative divided by the distance traveled on the through (or most direct route) is less than 1.25 or the difference in mileage is less than 25 miles, whichever is less, then the alternative route meets the criteria for being selected as a candidate route. For regional route selections, the 1.5 ratio is reduced to 1.25, the 1.25 ratio is reduced to 1.10 and the absolute mileage criterion is not used. If neither criterion is met, then the recommendation is that both routes be selected as candidate routes. When this occurs, subsequent steps in the analysis process are used to identify prescribed or restricted routes or hazmat free zones.

Table 5 shows the results of route evaluations for 18 different urban or regional settings in various locations within the U.S. These settings are provided to illustrate the considerations that might be encountered when selecting candidate routes. The first part of the table shows urban analyses, with regional analyses shown toward the end of the table.

In reviewing the results, it can be seen that the bypass or beltway around the urban area is selected as a candidate route in the majority of cases. Where the city is completely ringed by a beltway, the shorter arc is selected as a candidate route over the longer arc. Figures 1 and 2 show the beltways around Columbus and Indianapolis, respectively, with the darker shading corresponding to areas of urban population density. In Columbus, when considering the direct route through the urban area, I-70, denoted on Figure 1 as 10 A, it is very evident from the map that using the northern beltway is much longer than using the southern beltway, denoted in the Figure 1 as 10 B. While the analysis shown in Table 5 compare the most direct route on I-70 to both the northern and southern routes on I-270, unless the shorter southern beltway is shown to be unfavorable, the longer northern beltway would probably never be considered. The same situation exists for Indianapolis, shown in Figure 2. In both cases, the northern route is the longest. Also, in both cases, the distance traveled through urban areas is greater for these northern routes; however, this may not always be the case, particularly when the lengths of the northern and southern routes are more similar. Thus, where there are two reasonable alternative routes, both should be evaluated, because the longer one might travel through mostly unpopulated areas and therefore represent a better candidate route based on security considerations.

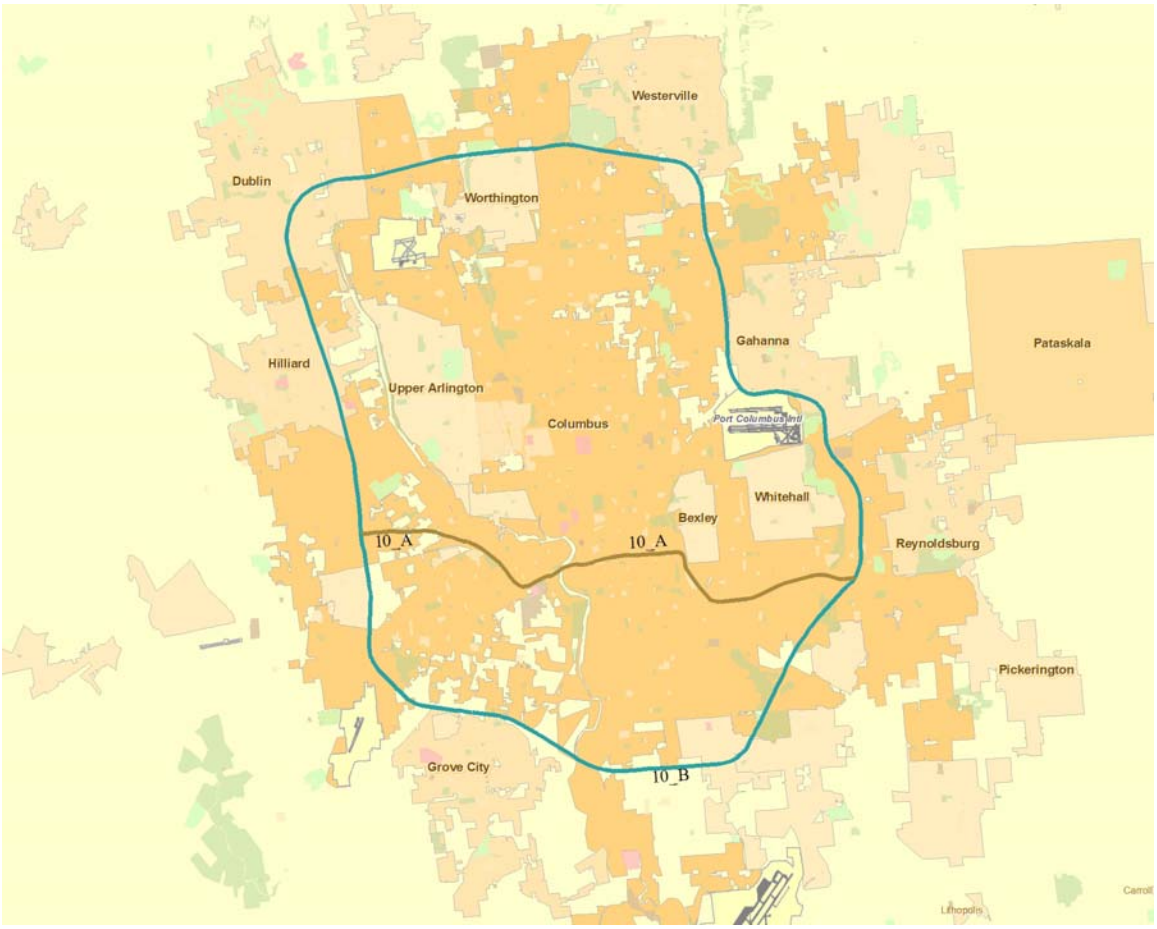

Figure 1. Possible Through Hazmat Routes for Columbus, OH

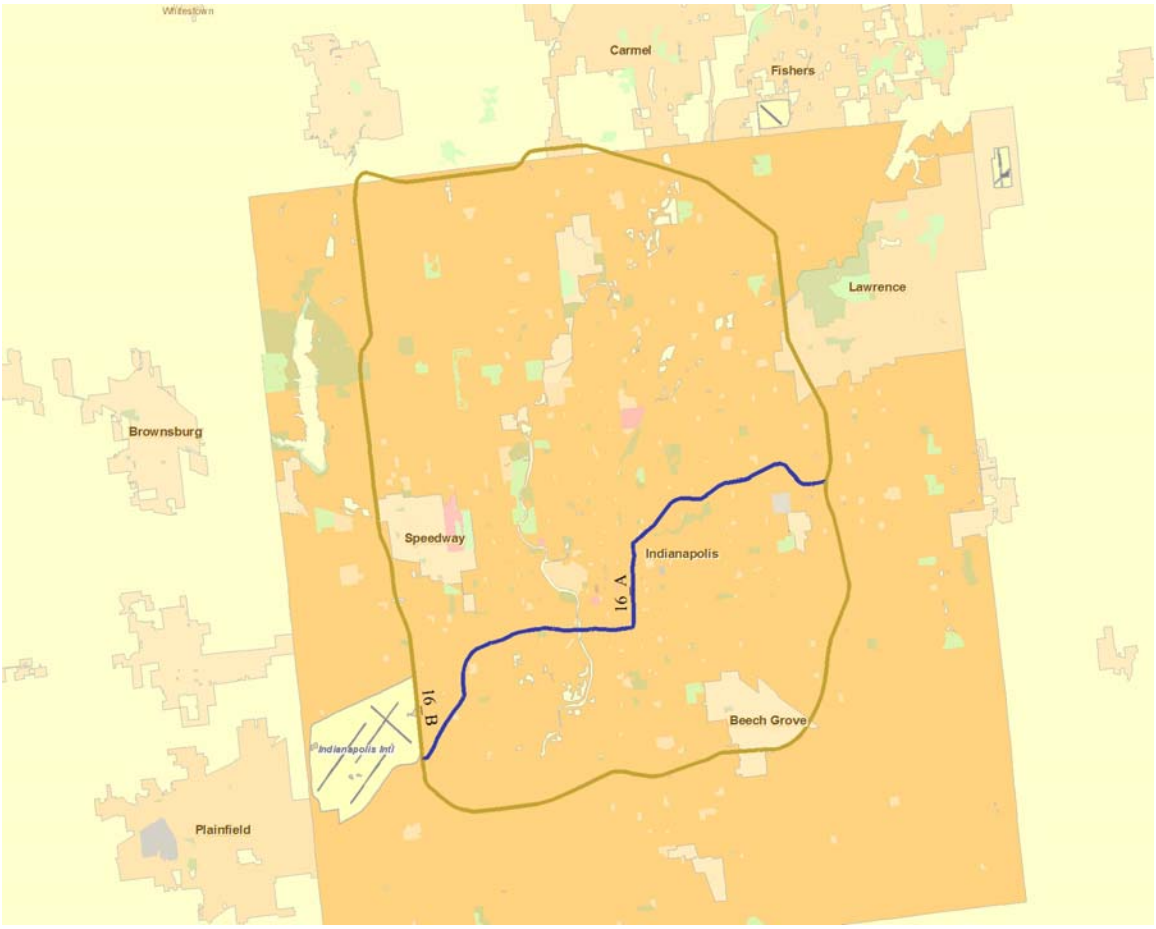

Figure 2. Possible Through Hazmat Routes for Indianapolis, IN

The shading in Figure 2 shows that both the direct route and the southern beltway are almost entirely in urban areas and the total length of both routes appear to be quite similar. This is a good example of cases where the beltway and the most direct through route have similar characteristics. The analysis results in Table 5 for Indianapolis shows that either route can be selected as the candidate route, as the differences are so small. The logic suggests that both be carried into the subsequent steps in the analysis. In this case, because the most direct route is likely to be in close proximity to several iconic structures, such as the state capitol and a major arena, one of the candidate routes, I-70, will probably fall out of the analysis as subsequent security features of the routes are evaluated.

Because both Colorado and California have designated hazmat routes in rural areas, a rural routing scenario in Colorado is shown in Table 5. Based on safety considerations, the I-141 route through the mountains was selected over the more heavily traveled US highways. Note that the security evaluation methodology was not developed to distinguish a route which is lightly traveled from one that is also rural but more heavily traveled. From a security perspective, staying on the more heavily traveled routes would provide greater security. Similarly, for Las Cruses, NM, the comparison is between a direct route that is not an interstate highway with a beltway that is an interstate highway. While the evaluation shows that the

beltway should be selected as the candidate route, there could be situations, such as Amarillo, TX, where the beltway is not built to interstate highway specifications, yet the analysis might show the beltway should be selected over the more direct through route, because no weighting has been used to distinguish routes built to interstate highway specifications from those that are not.

There is no clear dividing line between urban and regional analyses in Table 5. As the urban areas increase in size, the setting begins to resemble a regional analysis. The analysis of possible routes in Denver shows that even in a large urban area, there are sometimes bypasses with highly favorable characteristics. In this instance, State toll road SR-470 bypasses the entire Denver urban area.

Baltimore also shows an interesting characteristic that could be encountered when identifying candidate routes. The possible interstate routes for through traffic are shown in Figure 3.

Figure 3. Possible Through HM Routes for Baltimore, MD

The shortest route through Baltimore is I-95 and the shortest arc around Baltimore is I-695 on the eastern side of the city. The portion of I-695 around the western side of Baltimore is the longest of the routes shown. The population criteria are not distinguishable among the routes. If the ratios were reversed, the route with the most favorable characteristics would be the direct route through the city. The most direct route uses the Fort McHenry Tunnel and the portion of I-695 around the eastern side of Baltimore uses the Francis Scott Key Bridge. Since the distance traveled through urban areas is not a discerning factor, it is suggested that all three alternatives be designated as candidate routes. It is highly likely that the tunnel and bridge routes will subsequently be eliminated or restricted based on iconic structure (critical infrastructure) considerations.

The final part of the Table 5 describes several routes that are clearly regional. The one in Northern New Jersey considers the I-80 and I-95 route between New Jersey and Connecticut using the George Washington Bridge, and the I-287/I-87 route that bypasses much of New York City and uses the Tappan Zee Bridge over the Hudson River. The bypass is designated as the candidate route and, while both bridges might be on the critical infrastructure list, one or the other must be used. Since the Tappan Zee Bridge can be used to bring hazardous materials into New York City, it is likely that a state routing official, when considering security, would also select the I-287/I-87 route as the candidate route between New Jersey and Connecticut.

The routes in California, one in Oakland, one in San Francisco and two in Los Angeles, are situated almost entirely within urban areas. The two Los Angeles routes shown in Figure 4 are I-5 and US-101, both built to interstate highway specifications. Because the differences in route length and population density are small, both should be considered as candidate routes for the next step in the analysis process.

Figure 4. Los Angeles, CA Routes

The second Los Angeles routing evaluation compares the eastern route, I-210 and I-605, to the I-5 corridor. As shown in Table 5, since both routes are almost entirely in urban areas, if one candidate route were to be selected, it would be the shorter I-5 route. Once again, however, proximity to iconic structures might provide a basis for selection of a prescribed route. For this reason, it is suggested that all be carried into the second screening phase as candidate routes.

The analysis summarized in Table 5 shows that the proposed security evaluation using distance through urban population zones is capable of discriminating between the most direct route and proposed less direct alternative routes. In the case of Columbus, the beltway meets the security criteria. It is already prescribed as a hazmat route based on the safety regulations so in this case, there is no conflict between the proposed security criteria and the existing safety criteria. In Indianapolis the situation is much less clear because the city has spread beyond the southern beltway and travel on both the direct route and the possible alternative southern route would not suggest making the southern route a prescribed hazmat route. Indeed, the State of Indiana has specified no prescribed routes for Indianapolis based on safety and based on the information in Table 5, the security criteria would not suggest identifying a prescribed hazmat route. In the security area, there is another consideration which is not discussed in these examples, the avoidance of iconic structures. In the proposed methodology, when the population based

security and/or safety criteria do not distinguish among routes, the methodology maintains both as candidate routes and uses the next security evaluation, discussed in Section 4.2, the relative distance from the routes to iconic structures, as a possible discriminator that will enable the State or Indian Tribe routing official to recommend a prescribed or restricted hazmat route for trucks.

Overall, the results in Table 5 show that the measures used in the proposed methodology is appropriate for identifying candidate security routes in urban areas. For regional areas, the results are somewhat mixed, consequently in many cases, multiple routes should be selected as candidates that are carried forward into the next step of the analysis.

Table 5. Analysis of Urban and Regional Routing Alternatives for Selected Settings

Urban or Regional Area	Rte x (Alt)	Rte y (Direct)	Rte x Urban (A)	Rte y Urban (B)	Rte x Total (C)	Rte y Total (D)	(B/A)	(C/D)	Selection
San Antonio, TX	I 410 SE section	I-35 through rte	2.50	7.40	25.8	21.8	2.96	1.18	Alternate route (beltway) selected as candidate route
Omaha, NE	I-680	I-80	4.18	9.04	42.11	36.65	2.16	1.15	Alternate route (beltway) selected as candidate route
Oklahoma City, OK	I-240 and I-44	I-40	8.47	1.67	20.33	17.08	0.20	1.19	Direct route has less urban distance than beltway, both retained as candidate routes for iconic structure evaluation
Oklahoma City, OK (switch direct and alternative route)	I-40	I-240 and I-44	1.67	8.47	17.08	20.33	5.06	0.84	This shows that by reversing the routes and selecting the most direct route as the alternative, it would be selected as the candidate route based on the selection criteria, rather than selecting it both will be carried into the iconic structure evaluation as candidate routes
Las Cruses, NM	I-25 and I-10	US-70 (not limited access)	3.30	4.40	16.87	9.10	1.33	1.85	I-25 and I-10 not selected because of urban mileage but might be selected because they are limited access highways, retain both as candidate routes
Columbus, OH	I-270 South	I-70	13.41	14.11	20.63	15.33	1.05	1.35	Based on criteria, the alternative can not be selected as a candidate security route so both should be retained as candidate security routes and carried into the iconic structure evaluation
Columbus, OH	I-270 North	I-70	26.81	14.11	34.59	15.33	0.53	2.26	Based on criteria, the alternative can not be selected as a candidate security route so both should be retained as candidate security routes and carried into the iconic structure evaluation
Western Colorado – Whitewater to Cortez	US 50, US 550 and US 160	SR 141 and US 491	5.53	0.00	206.14	194.99	0.00	1.06	This compares a deserted State route to US Highways - from a security standpoint designate the US highway as the candidate route - have not covered in logic diagrams
State of Delaware, north of Wilmington DE	I-495	I-95	6.25	10.05	10.81	10.41	1.61	1.04	I-495 selected as candidate route

Table 5. Analysis of Urban and Regional Routing Alternatives for Selected Settings (Continued)

Urban or Regional Area	Rte x (Alt)	Rte y (Direct)	Rte x Urban (A)	Rte y Urban (B)	Rte x Total (C)	Rte y Total (D)	(B/A)	(C/D)	Selection
Lubbock, TX	SR-289 North beltway (limited access)	US-62/82 (non-limited access highway	5.47	8.92	11.91	9.32	1.63	1.28	SR-289 selected as candidate route – selected as if US-62/82 were a limited access highway
Davenport, IA	I-280	I-74 and I-80	0.00	5.92	17.92	17.92	Inf	1.00	I-280 selected as candidate route
Phoenix, AZ	I-17 from x194 to x200	I-10 from x143 to x150	2.94	4.72	6.16	6.31	1.61	0.98	I-17 is selected as the candidate route
Indianapolis, IN	I-465 South and I-74	I-70	13.48	12.16	18.50	16.14	0.90	1.15	The beltway is entirely within the urban area, can not distinguish between the beltway and the direct route, choose both as a candidate routes to be carried into the iconic structure evaluation
Indianapolis, IN	I-465 North	I-70	24.60	12.16	34.87	16.14	0.49	2.16	A large portion of the north beltway is within urban areas such that it can not be selected as a candidate route. Both should therefore be carried into the iconic structure evaluation.
Oakland to Durban, CA	SR-24 and I-680E	I-580	26.13	20.42	29.81	23.92	0.78	1.25	Alternate route not selected as candidate route so both would be carried into the iconic structure evaluation.
Oakland to Durban, CA	I-580	SR-24 and I-680E	20.42	26.13	23.92	29.81	1.28	0.80	I-580 would be selected as a candidate route if the analyses were considered to be a regional analysis; otherwise both would be retained as candidate routes to be carried into the iconic structure evaluation.
San Francisco (Golden State NP) to Daly City	U-101 and I-280	SR-1 (surface street)	11.83	7.38	12.54	7.61	0.62	1.65	Surface street better meets population criteria, but considered less secure, comparison of different highway types not considered in logic diagrams

Table 5. Analysis of Urban and Regional Routing Alternatives for Selected Settings (Continued)

Urban or Regional Area	Rte x (Alt)	Rte y (Direct)	Rte x Urban (A)	Rte y Urban (B)	Rte x Total (C)	Rte y Total (D)	(B/A)	(C/D)	Selection
Los Angeles, CA	I-5 Sun Valley to Los Angeles	SR 170, US 101 and SR 10	18.63	18.04	18.63	18.04	0.97	1.03	Both routes are urban limited assess highways and since selection criteria are not met, both would be retained as candidate routes and carried into the iconic structure evaluation.
Los Angeles, CA (switch direct and alternate route)	SR 170, US 101 and SR 10	I-5 Sun Valley to Los Angeles	18.04	18.63	18.04	18.63	1.03	0.97	Both routes are urban limited assess highways and since selection criteria are not met, both would be retained as candidate routes and carried into the iconic structure evaluation.
Los Angeles, CA	I-410 and I-605	I-5 Sun Valley to Sante Fe Springs	47.37	34.79	52.34	37.23	0.73	1.41	Both routes are urban limited assess highways, the alternative actually has more urban miles and since selection criteria are not met, both would be retained as candidate routes and carried into the iconic structure evaluation.
Los Angeles, CA (switched route designation to see if direct route should be candidate)	I-5 Sun Valley to Sante Fe Springs	I-410 and I-605	34.79	47.37	37.23	52.34	1.36	0.71	Both routes are urban limited assess highways, the alternative actually has more urban miles and since selection criteria are not met, both would be retained as candidate routes and carried into the iconic structure evaluation.
Baltimore, MD	I 695 (Francis Scott Key Bridge)	I-95 (Ft McHenry Tunnel)	15.20	9.88	24.22	14.79	0.65	1.64	Both routes are urban and the alternative actually has more urban miles does not meet the selection criteria so both routes should be taken into the critical infrastructure/iconic structure evaluation
Baltimore, MD	I-695 West	I-95 (Ft McHenry Tunnel)	25.43	9.88	26.95	14.79	0.39	1.82	The alternative route has many more urban miles and thus does not meet the selection criteria so both routes should retained as candidate routes and taken into the critical infrastructure/iconic structure evaluation.
Baltimore, MD	I-695 West	I 695 (Francis Scott Key Bridge)	25.43	15.20	26.95	24.22	0.60	1.11	Both routes are urban, the alternative actually has more urban miles and since selection criteria are not met, both would be retained as candidate routes and carried into the critical infrastructure/iconic structure evaluation.

Table 5. Analysis of Urban and Regional Routing Alternatives for Selected Settings (Continued)

Urban or Regional Area	Rte x (Alt)	Rte y (Direct)	Rte x Urban (A)	Rte y Urban (B)	Rte x Total (C)	Rte y Total (D)	(B/A)	(C/D)	Selection
Baltimore, MD (switch I-695 West and I-95 - Ft McHenry Tunnel to show I-95 has lowest urban mileage)	I-95 (Ft McHenry Tunnel)	I-695 West	9.88	25.43	14.79	26.95	2.57	0.55	The most direct route is really the only route that meets the selection criteria. Rather than removing the others, all should be retained as candidate routes and taken into the critical infrastructure/iconic structure evaluation. In that evaluation one of the routes with critical infrastructure might be selected with the restriction that placarded vehicles be escorted.
Denver, CO	SR-470 East Branch (Toll)	I-25	0.10	11.00	46.8	33.8	110.00	1.38	SR-470, a limited access toll road, selected as candidate route
Parsippany, NY to Port Chester, NY	I-287/I-87 via the Tappan Zee Bridge	I-80 and I-95 via George Washington Bridge	12.40	29.00	56.40	51.60	2.34	1.09	I-287 selected as candidate - both might have critical infrastructure elements – major bridges over Hudson River – Tappan Zee Bridge designated HM route into NYC based on safety criteria and might be the prescribed regional route based on security as well.

4.2 Evaluation of Candidate Through Routes based on Proximity to Iconic Structures

This part of the analysis evaluates the candidate routes carried forward from analyses shown in Table 5 of Section 4.1 and first determines if there is any critical infrastructure on the candidate routes and then evaluates the proximity of the remaining candidate routes to iconic structures. Throughout the document, the term iconic structure has been used to include both iconic structures and critical infrastructure. In this part of the evaluation it is necessary to treat any critical infrastructure on the candidate routes separately from other critical infrastructure and iconic structures near the route. This is because, if the critical infrastructure on a particular route is treated as an iconic structure, the distance criteria used to evaluate the adequacy of the response will never be met.

If there are multiple candidate routes and only one has critical infrastructure, it is logical to flag the candidate route as requiring escorts and then continue with the assessment of any iconic structures, including other critical infrastructure, not on the candidate route.

The first application of the iconic structure evaluation is Columbus, OH. Figure 5 presents a map of Columbus, Ohio, showing the direct route, I-70, the southern bypass, I-270S and the Iconic Structures in downtown Columbus.

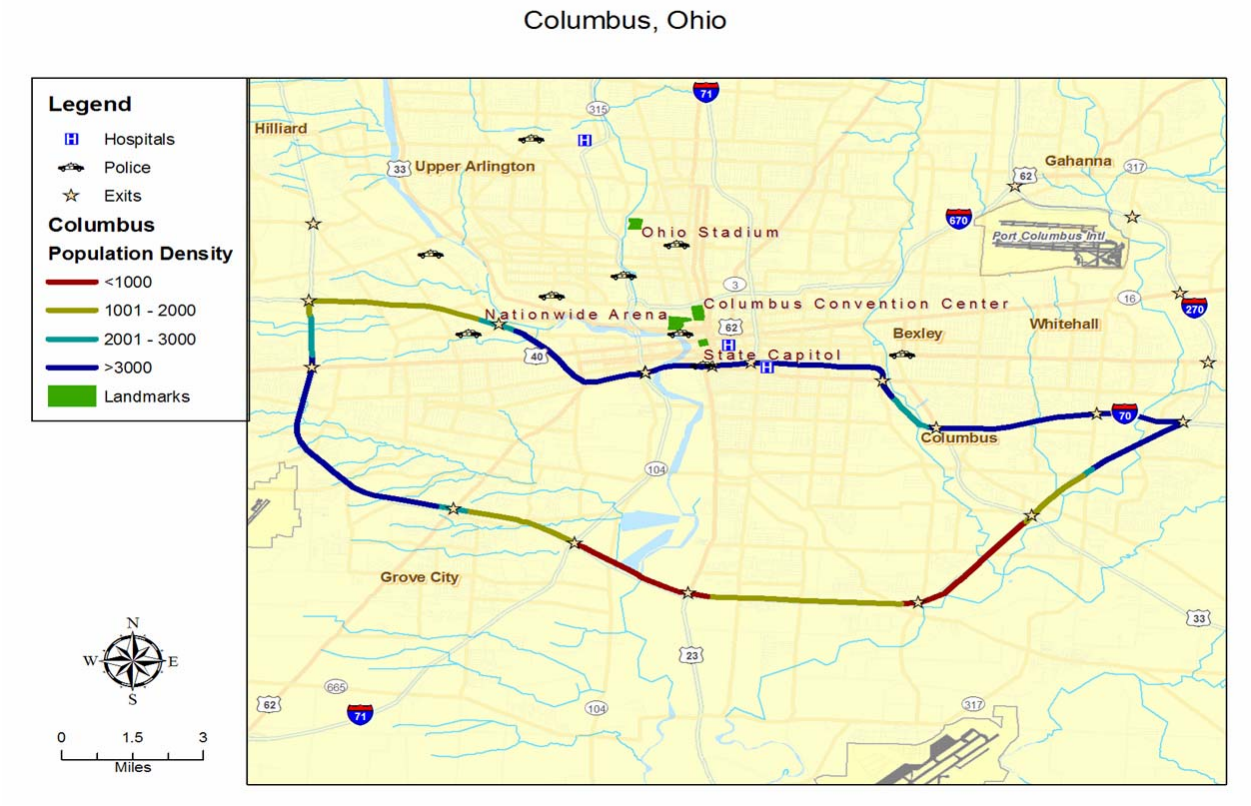

Figure 5. Map of Columbus Ohio Showing Routes and Iconic Structures

In Section 4.1, both the direct route, I-70 and the southern beltway, I-270 were retained as candidate routes. As a point of reference, Columbus already has a designated through hazmat route, the I-270 beltway that completely encircles the city. A map of the Columbus area showing the through route, the southern bypass route, and the iconic structures appears in Figure 5. The color codes clearly show that there are more sections of I-70 having high population densities than the beltway. The reason why the bypass could not be selected as the sole candidate route was because of the significant portions of the route that are classified as urban.

No critical infrastructure elements have been identified on the interstate highways in Columbus, Ohio. However, iconic structures have been identified in Columbus. The State Capitol and the Nationwide Arena are considered to be regional icons and the Convention Center is considered to be a local icon (see Figure 5). Although not shown in Figure 5, the Columbus Central Police Station is located equidistant from all three iconic structures, approximately 0.5 miles away. All three structures are located well away from I-270, so any security concerns related to through hazmat transport are easily met. However, local hazmat routing would take the hazmat vehicles much closer to all three iconic structures. Table 6 shows the results of the calculation for through hazmat transport on I-70, travel currently prohibited because the bypass highway has already been prescribed as the through hazmat transport route based on safety considerations.

Table 6. Security Evaluation of Iconic Structures for I-70 though Columbus

Icons	Symbol	State Capitol *Region*	Nationwide Arena *Region*	Convention Center *Local*
Distance from Prescribed Route (mi)	A	0.64	1.36	5
Icon Weight (C)	C	2	2	1
Weighted Distance	A/C	0.32	0.68	5
Distance from Police Facility (mi)	B	0.47	0.25	0.55
Response Effective?	B < A/C	No	Yes	Yes

It can be seen that the closest weighted distance (A/C) from I-70 to each of the iconic structures is greater than the distance from a law enforcement facility for all but the State Capitol. The analysis will now be continued for the other candidate route, I-270, the southern bypass. The results are shown in Table 7.

Table 7. Security Evaluation of Iconic Structures for I-270 around Columbus

Icons	Symbol	State Capitol *Region*	Nationwide Arena *Region*	Convention Center *Local*
Distance from Prescribed Route (mi)	A	6	7	7
Icon Weight (C)	C	2	2	1
Weighted Distance	A/C	3	3.5	7
Distance from Police Facility (mi)	B	0.47	0.25	0.55
Response Effective?	B < A/C	Yes	Yes	Yes

It can be seen that the closest weighted distance (A/C) from I-270 to each of the iconic structures is greater than the distance from a law enforcement facility for all three iconic structures. This from a security standpoint, the southern bypass, I-270 would be the prescribed through route using both safety and security considerations.

Figure 6 and Table 8 shows a map and iconic structure analysis for Baltimore, Maryland. Both I-95 and I-895 traverse the Baltimore Harbor in a tunnel. In Figure 6, I-895 is not highlighted it goes under the harbor near the same eastern location as the I-95 tunnel but goes southwest thereby avoiding the urban center of Baltimore, eventually rejoining I-95 in Elkridge, Maryland.

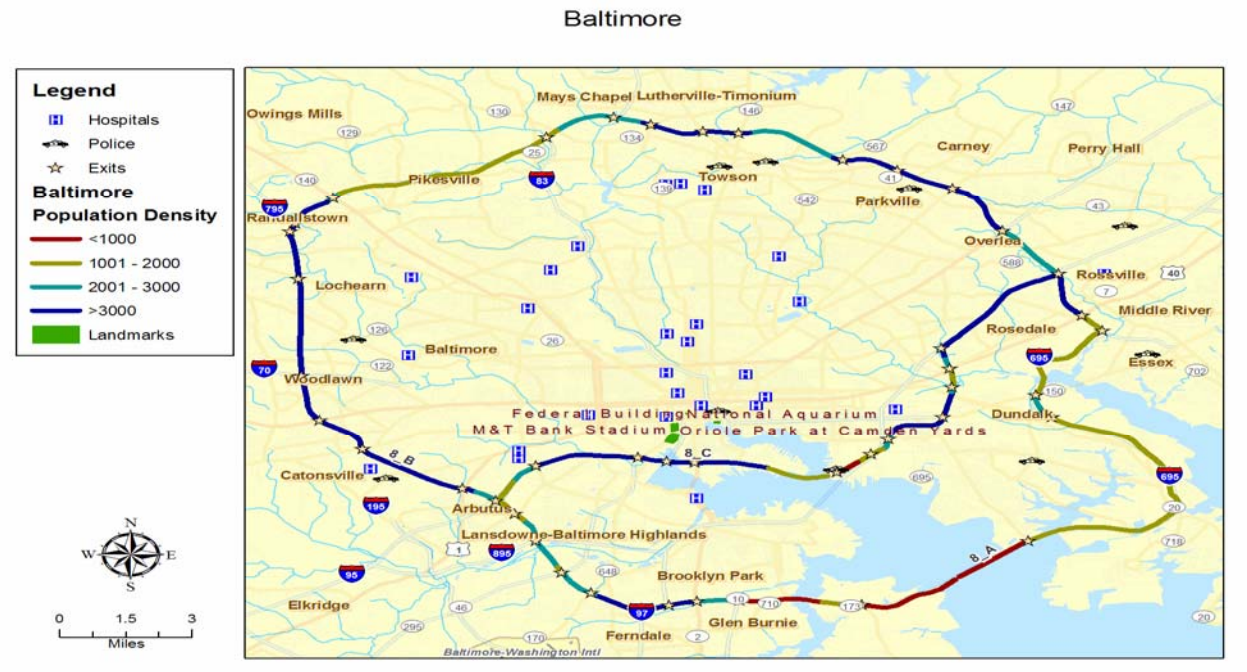

Figure 6. Route Map aid Iconic Structures for Baltimore, MD

Table 5 in Section 4.1 concluded that all the routes remained as candidate routes after the first security evaluation step. Regarding critical infrastructure, I-95 has the Fort McHenry Tunnel, I-895 has the Harbor Tunnel and I-695 south has the Francis Scot Key Bridge. Only I-695 on the north and west side of Baltimore does not have critical infrastructure elements. Thus, I-95, I-896 and I-695 must be flagged as requiring escorts if they are chosen after the iconic structure analyses as the prescribed route for through hazmat traffic in Baltimore.

Table 8. Iconic Structure Analysis for Interstate Routes in Baltimore

Iconic Structures	Federal Building	National Aquarium	Oriole Park at Camden Yard	M&T Bank Stadium	Meets Iconic Structure Distance Criterion
Distance from I-95 (A1)	1.74	1.72	0.98	0.66	
Distance from I-895 (A2)	4.71	4.34	4.55	3.81	
Distance from I-695S (A3)	5.51	5.81	5.36	4.21	
Distance from I-695W (A4)	5.9	6.21	5.74	4.61	
Attractiveness Scale (C)	2	2	2	2	
Police Station Distance (B)	0.64	0.25	1	1.44	
A1/C>B for I-95	Yes	Yes	No	No	No for I-95
A2/C>B for I-895	Yes	Yes	Yes	Yes	Yes for I-895[a]
A3/C>B for I-695S	Yes	Yes	Yes	Yes	Yes for I-695S[a]
A4/C>B for I-695W	Yes	Yes	Yes	Yes	Yes for I-695W

[a] This route has critical infrastructure so may require using escorts for HM that could damage structures

It can be seen from Table 8 that all the routes except I-95 meet the separation distance criterion between the routes and the four iconic structures being considered in this analysis. Thus the routing official would have the choice of selecting I-695W as the prescribed route for through hazmat traffic with no restrictions or picking either I-895 or I-695S as the prescribe route with the additional restriction that escorts be required for all placarded shipments or for just those shipments that could damage the critical infrastructure on those routes.

A similar analysis was also performed for Indianapolis, Indiana. The map is shown in Figure 7 and the results of the iconic structure evaluation are shown in Table 9.

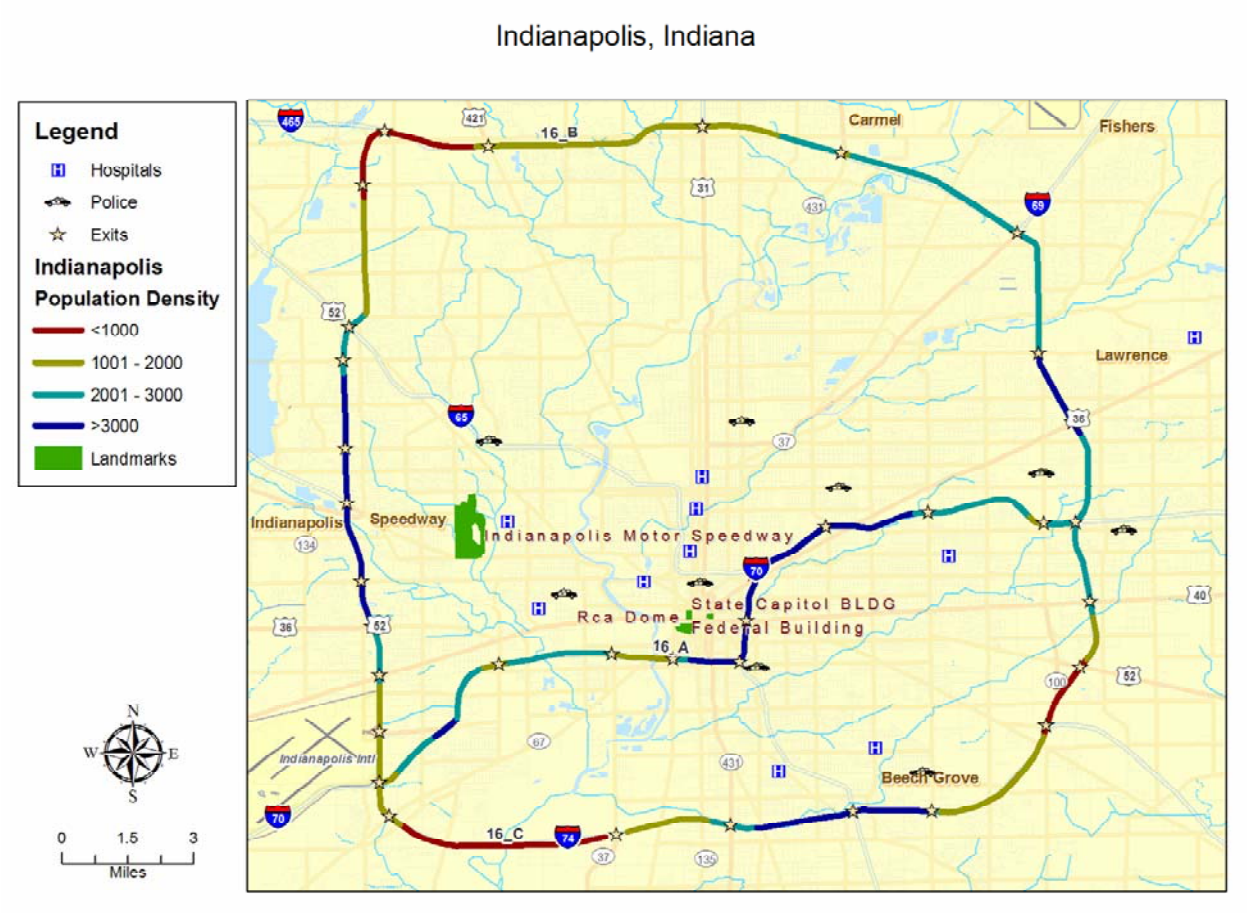

Figure 7. Map of Indianapolis, Indiana Showing Routes and Iconic Structures

Just as with the cases for Columbus, Ohio and Baltimore, Maryland, following the first security screening step, all the routes remained as candidate routes. In the case of Indianapolis, even the beltway had too much urban density along the route to meet the security criteria for being picked as the sole candidate route to be evaluated for iconic structures. Like Columbus, there are no critical infrastructures on the routes being evaluated in Indianapolis. The two routes are I-70 through downtown or I-465S/I-74 between the east and west junction with I-70. The results of the Iconic Structure evaluation are shown in Table 9.

Table 9. Iconic Structure Analysis for Interstate Routes in Indianapolis

Iconic Structures	Federal Building	State Capital	RCA Dome	INDY 500 Speedway	Meets Iconic Structure Distance Criterion
Distance from I-70 (A1)	0.67	1.02	0.73	7.17	
Distance from I-465 (A2)	6.2	6.32	6.03	7.17	
Attractiveness Scale (C)	2	2	2	2	
Police Station Distance (B)	0.85	0.8	1.09	2.006	
A1/C>B for I-70	No	No	No	Yes	No for I-70
A2/C>B for I-465	Yes	Yes	Yes	Yes	Yes for I-465

Based on the separation distance calculation shown in Table 9, of the two candidate routes, I-465S/I-74 meets the Iconic Structure separation distance criterion and therefore could be selected as the prescribed through hazmat route based on security criteria.

4.3 Evaluation of Local Hazmat Routes based on Security

The through hazmat iconic structure tables, Tables 6 through 9 can all be used to evaluate the security of local hazmat travel. If the routes are acceptable for through hazmat traffic, they are certainly acceptable for local hazmat traffic. The only question arises when the iconic structure criteria are not met for the routes. In that case, additional routes may have to be considered. Looking at the situation in Columbus, Ohio, I-70 is shown to be too close to the State Capital in Table 6. The first consideration would be to restrict travel on I-70 on the portion of the route shared with I-71. For the local analysis to be comprehensive, additional local analyzes would have to be performed for other limited access routes near the three icons considered in Table 6. If this were done, both Nationwide Arena and the Convention Center are adjacent to I-670 so that route would have to be blocked as well. If both the northern and southern parts of the inter beltway surrounding downtown Columbus must be blocked, then there is really no way for local hazmat traffic to freely traverse the city from west to east. Since the data in Table 6 show that hazmat travel on I-70 is considered too close to just the State Capital, a good compromise for local hazmat traffic would be to establish a hazmat restricted zone around the State Capital and allow local hazmat traffic on I-70 but restrict it on I-670 between SR-315 and I-71. If a quarter-mile hazmat-free zone was established around the Capitol, it would be approximately bounded on the north by Spring Street, on the west by the Scioto River, on the south by Main Street, and on the east by Grant Street. Within that zone, all hazmat travel would be restricted and any required hazmat transport other security measures would be considered that provide some level of monitoring of these shipments. It could be a GPS tracking system that alerts law enforcement personnel when a hazmat vehicle approaches the area containing the iconic structure. In some cases, for example Yellowstone Park, advance approval is required for a HM vehicle to use the main park roads and then only at specific times of the day. Some have proposed use of immobilizing devices such as required by the Nuclear Regulatory Commission for HRCQ shipments. The exact form of the security feature used is really at the discretion of the routing official. Since it must not pose an undue burden on commerce and any proposed measure will

have to be discussed with local representatives and affected parties, the exact nature of such measures will vary from one community to the next and is impossible to predict.

For local hazmat travel in Baltimore and Indianapolis, restricting local hazmat traffic on the portion of I-95 between its juncture with I-895 would appear not to restrict local hazmat traffic. For Indianapolis, to restrict local hazmat traffic on I-70 between the eastern junction with I-465 and the west junction with I-74 might be too restrictive. The alternative would be to restrict just a downtown segment of I-70 between the northern and southern interchange with I-65, thereby permitting hazmat traffic to service locations near downtown from either the west or east. Basically, a local hazmat shipment originating on the western side of Indianapolis and ending on the eastern edge of downtown would be expected to use the I-695 beltway to I-70 on the east and then use the eastern portion of I-70, getting off before it joins with I-65 and turns south past the eastern side of downtown where most of the iconic structures are located.

4.4 Summary of Route Security Evaluations

This section has evaluated possible hazmat routes using two sets of security screening criteria. The first set of screening criteria evaluated the population near a route with the goal of selecting a candidate route that put fewer people at risk of exposure to a release of the hazardous material. These screening criteria are very similar to the screening criteria currently being used for prescribing a through hazmat route based on safety considerations. The only difference in the method is the replacement of population risk safety criteria with miles through an urban area representing security criteria. Analyses were performed for over a dozen routes with the results summarized in Table 5. The goal of the evaluation was to look at both some typical and atypical route conditions that might be encountered by a state routing official. The conclusion drawn from the security evaluation is that the beltway around the urban area should always be considered as a possible candidate route when performing the security evaluation. Such an evaluation would be consistent with the evaluations currently being performed to demonstrate the beltway as a designated hazmat route using safety considerations. Since many of these routes have already been prescribed at the through hazmat route based on safety considerations, for these cities the security designation simply gives added weight their current designation as a prescribed route. The analysis also shows that for some urban areas, particularly large urban areas, there is little difference between the most direct and alternative routes all have major route segments that must be considered to be urban. For these situations, the security methodology employees an additional screening step, the proximity of the routes to iconic structures.

The iconic structure evaluation was performed for three urban areas, Columbus, Ohio; Baltimore, Maryland; and Indianapolis, Indiana. The results of these evaluations are shown in Section 4.2. These evaluations basically show that even where a route can not be designated for through hazmat traffic based on population considerations, this second screening, their proximity to iconic structures, is frequently able to prescribe through hazmat routes. In all three of the cities evaluated, several candidate routes remained after the first population screening criteria were used and it all cases, by looking at their proximity to iconic structures, it was possible to discriminate among the routes and designate one or more alternatives as the prescribed through hazmat route. By looking at Baltimore, it was possible to look at critical infrastructure (a subset of iconic structures) on the routes since three of the four routes considered had major tunnels or

bridges. In this case, it was possible to show that one of the routes, the most direct route, was too close to iconic structures but that the other three were not. Two of the three had critical infrastructure. If the routing official decided to pick one of the routes with critical infrastructure as the prescribed route, the methodology proposes that some restrictions be imposed. Escorts are commonly used to address safety concerns for these structures and such a restriction would also address security concerns. In one case the damage would be accidental in the second, purposeful.

In summary, a comprehensive and workable security assessment methodology has been developed. The methodology is flexible enough to handle a wide variety of route characteristics and is able to identify situations where prescribing a route for security has significant benefits. All the information used in these evaluations can be obtained from GIS databases by individuals trained in their use. Most State routing officials would have access to these data and staff that is trained in the use of GIS databases. A web based application has been developed that implements the logic described in this section. While not intended to replace the decision maker, the methodology provides the decision maker with information that can be used to justify prescribing or restricting hazmat routes based on safety and security.

5.0 Conclusion

This hazmat routing project has seven objectives. The accomplishment of each objective resulted in the production of a product. The major project objectives are listed below.

1) To survey the existing and proposed hazmat routes in the United States
2) To determine if there are obstacles to hazmat truck traffic between the United States and either Canada or Mexico
3) To survey stakeholders to determine their positions and concerns on establishing hazmat routes for security reasons
4) To develop a guidance document that contains a methodology for selecting hazmat routes based on security criteria
5) To develop an internet based routing tool that provides routing officials with user friendly assistance in applying the methodology
6) To prepare potential requirements for security based hazmat routing
7) To conduct a preliminary benefit/cost analysis of the potential requirement

The project team has achieved all of the project objectives. An evaluation of each follows with conclusions relating to achieving each objective.

1) To survey the existing and proposed hazmat routes in the United States

   This labor intensive effort resulted in the production of a thorough and consistent update of the 2000 Federal Register listing. Officials in every state were contacted to survey existing and proposed hazmat routes. Officials in the western states were asked if they were aware of any Indian Tribes in their state who may have passed regulations. In Oregon and Idaho, Indian officials responsible for routing were contacted and their regulations were included in the state listings. Their responses were tabulated to produce and updated compilation. The updated compilation of hazmat routes can be used by Federal and state officials and carriers to identify hazmat routes for travel. Surprisingly, the majority of hazmat routes were designated before the safety based routing regulations were developed. Furthermore, despite the events of 9/11, relatively few new hazmat routes have been designated since 2001.

2) To determine if there are obstacles to hazmat truck traffic between the United States and either Canada or Mexico.

3) Commerce between the United States and Mexico and the United States and Canada is important to the economic health of all three nations. Achieving this objective was designed to show if there were any specific obstacles to trans-border truck movement between the United States and its neighbors to the north and south. Research to achieve this objective showed that restrictions to the free flow of hazmat existed predominantly between the United States and Canada. The major obstacles to cross border hazmat truck traffic are restrictions to hazmat travel on bridges between Ontario Canada and the United States. By careful routing, carriers hauling certain hazmat should be able to avoid

these chokepoints and select crossings with no restrictions on their hazmat cargo. With route planning hazmat cargo should move smoothly between the United States and Canada. There are also some "routing conflicts" at border crossings between the United States and Mexico. The only border restrictions for HM truck shipments along the Mexican border are in California. These restrictions apply to explosives, inhalation hazards and highway route controlled quantities of radioactive materials (HRCQ). All other HM may be shipped across any of the three border crossings between California and Mexico that allow commercial truck traffic. At the San Ysidro Border Crossing, although none of the HM classes are restricted on I-5 down to the border, commercial truck traffic is not permitted to cross the border.

4) To survey stakeholders to determine their positions and concerns on establishing hazmat routes for security

   The success of developing and implementing a requirement for hazmat routing using security criteria, or convincing carriers or state officials to use a security based routing methodology, is dependent on stakeholder input and buy-in. To achieve this objective, a survey of stakeholders concerning their feeling about the development of a potential requirement for applying security to hazmat routing was conducted. Responses to the stakeholder survey were mixed. In general, carriers were hesitant about taking on additional regulations requiring routing. State officials on the other hand, were far more willing to consider any potential regulation relating to establishing routes based on security criteria.

5) To develop guidance document that contains a methodology for selecting hazmat routes based on security criteria

   The development of a methodology for selecting a hazmat route based on security criteria is probably the most innovative part of the project. The methodology was designed to enable a routing official to employ the security related criteria of population, distance, the relative location of iconic structures (including icons and critical infrastructure) and the location of law enforcement personnel to select a route that would help protect the security of both the cargo and potential targets. Sufficient flexibility was built into the methodology to address a variety of situations that might be encountered by a routing official. These include the ability to perform route assessments for through transport of hazmat in a regional and urban setting and local hazmat in an urban setting. In addition, the methodology provides assistance for dealing with areas where hazmat cargos cannot be conveniently kept away from a potential target by recommending establishing restrictive zones. The Guidance Document provides the routing official with a step by step method to select hazmat routes with respect to safety and security criteria. As shown in Section 4, the methodology provides a comprehensive and workable security assessment methodology. It is flexible enough to handle a wide variety of route characteristics and is able to identify situations where prescribing a route for security has significant benefits. All the information used in these evaluations can be obtained from GIS databases by individuals trained in their use. Most State routing officials would have access to these data and staff that is trained in the use of GIS databases. The methodology is not intended to be completely prescriptive so as to replace the decision maker; instead, the methodology provides the decision maker with information that gives

good justification for prescribing or restricting hazmat routes based on security. The methodology can also provide information to the decision maker that would justify that no prescribed or restricted hazmat routes are necessary based on security considerations.

6) To develop an internet based routing tool that provides routing officials user friendly assistance in applying the methodology

   The routing tool complements the Guidance Document by providing a web based tool that enables the routing official to follow a clear set of steps that allow the methodology to be ore easily used. The tool provides interactive screens that move the user smoothly from step to step in the methodology and from screen to screen and facilitates applying security criteria to the selection of a route. Only those screens that meet the requirements of the user will be used to direct the routing official towards selection of the final route.

7) To prepare potential requirements for security based hazmat routing

   The potential security based routing requirement is included in Section 2.0 of this Final Report and provides FMCSA with a practicable potential requirement for implementing a process to select hazmat routes based on security criteria.

8) To conduct a preliminary benefit/cost analysis of the potential requirement.

   The preliminary benefit/cost analysis of the potential requirement is included in this Final Report. The preliminary analysis shows that if the potential requirement for security were adopted, the benefits from this adoption were unlikely to outweigh the costs.

Final Report: Designation of Highway Routes for Hazardous Materials Shipments: Literature Review

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1.0 Overview

The purpose of this task was to review prior studies that have focused on the designation of truck routes for hazardous material shipments, in order to identify key lessons learned that might benefit the current routing study. This review included both published literature on the subject and activities undertaken by agencies that have considered designated routes.

The result of this review yielded a number of important observations, both in terms of the processes used by routing agencies in making routing decisions as well as the techniques used to apply routing criteria in evaluating candidate routes within the region of interest. Among these are the following:

- When state and local governments have conducted route designation studies, the highway network of interest has been primarily focused on through routing of hazardous materials between entry and exit points to the region. Consequently, controlled-access highways and other major arterials have comprised the road network under consideration. Physical constraints are used to refine the list of candidate routes.
- The primary analysis criteria used to evaluate candidate routes have been measures of risk and trip efficiency. Risk has typically been defined as the likelihood of an accident times the expected consequence, where population is used as the proxy measure for expected consequence. Trip efficiency has often been measured as the deviation in trip distance or travel time relative to the minimum distance (travel time) path. A variety of other criteria, including proximity to emergency response, type of hazardous material and certain roadway/traffic conditions, were considered to be of moderate importance. Subjective criteria have also been used to further characterize candidate routes, although these criteria do not appear to have the same level of importance in the decision-making process.
- Varying the routing criteria and/or importance ratings often leads to the identification of different preferred routes. Consequently, routing agencies are usually faced with understanding and accepting tradeoffs in selecting a final route.
- Comprehensive off-the-shelf route risk assessment software is available to support analyses based on multiple criteria in determining a preferred route. These tools can be applied anywhere in the continental United States and produce results in both tabular and map form. Their applicability and ease of use is due to the advent of geographic information systems (GIS) technology and the proliferation of relevant route data being collected in a GIS format.
- Different approaches have emerged in terms of the order in which analytical tools and subjective judgment are applied to routing decisions. One approach relies on local knowledge to identify a set of candidate routes from which quantitative analysis is performed to identify preferred routes. In contrast, another approach uses quantitative analysis initially to identify candidate routes, and then relies on local knowledge to select a preferred route from among these candidates. In either case, it is apparent that the routing agency believes that subjective judgment based on local knowledge plays an important role in the decision process.

- While routing studies are managed by a lead agency, formation of a task force to advise the lead agency throughout the study process has proven to be an effective strategy. Task force members typically represent involved parties from government, industry, the community and special interest groups. When properly utilized, a task force can help guide the route risk assessment process and provide feedback from key stakeholders when proposed routes are being circulated for review. This has tended to dissuade public opposition to selected routes.

In summary, routing agencies have shown familiarity with the federal routing guidelines and demonstrated the ability to apply routing criteria both quantitatively and subjectively in making routing decisions. From these experiences, a hierarchy of important routing criteria has emerged along with recognition that the preferred route may differ depending on what routing criteria are utilized and the importance ratings associated with them. The decision process has been inclusive of other stakeholders and comprehensive tools are available to support identification and evaluation of candidate routes.

The findings from this review bode well in terms of the potential for augmenting the current federal routing guidelines to account for both safety and security criteria. However, guidance will be needed to help routing agencies understand the effect of current safety criteria on security as well as how to measure and apply additional security criteria as part of the route decision-making process.

2.0 Literature Review

A considerable amount of literature has been published on highway routing of hazardous materials. Some of this literature has been more theoretical in nature while other work has been more applied-oriented. Similarly, some articles and reports have focused on modeling while others offer practical insights into the route decision-making process. In the discussion to follow, this literature is reviewed in the context of the following considerations: 1) processes for establishing designated routes, 2) selection of routing criteria and 3) route risk assessment modeling.

2.1 Processes for Establishing Designated Routes

Perhaps the most important archival literature regarding designation of highway routes for hazardous materials shipments comes from a special study that was conducted on the subject roughly a decade ago (Transportation Research Board, 1998). The study provided a synthesis of highway route designation practices at that time, utilizing numerous sources from across the nation. The survey also identified the principal agencies responsible for routing, as well as other agencies that typically participate in the routing plan.

Of the forty states and tribes that responded to the survey, sixteen indicated that they had designated routes for the transport of hazardous materials. Some of these states designated routes for several classes of hazardous materials, while others did so for only certain hazard classes.

The state department of transportation had primary responsibility for routing decisions in the majority of states. State police, state emergency management agencies and state public safety departments also had primary responsibility in some states. Many other agencies, however, were involved in some capacity in the routing decision-making process.

About half of the states that designated routes indicated a formal process existed for resolving intrastate routing issues, while fewer states had a formal process to deal with neighboring states. The majority of states that designated routes sought public participation in the process, most often by public notices and comment periods, meetings with industry, and meetings with other jurisdictions. When consulted, industry feedback had generally been that, while the designation of highway routes is a reasonable requirement for the transport of hazardous materials, there are concerns about consistency of routes, time-of-day restrictions and tunnel restrictions.

2.2 Routing Criteria

As part of its study in the mid-1990s, the Transportation Research Board conducted a survey of state agencies that asked respondents to rate the importance of twenty-four criteria in establishing routing policy (Transportation Research Board, 1998). The NCHRP ratings were based on a 4-point scale, as follows:

0 – not important
1 – somewhat important
2 – important
3 – very important
4 – critical

These results are shown in Table 1.

Table 1. Relative Importance of Routing Criteria

Criteria	Mean Rating
Population density	3.47
Location of special populations	3.27
Accident history	3.00
Type of highway	2.93
Availability of alternative routes	2.80
Type and quantity of hazmat	2.73
Underpass and bridge clearances	2.67
Emergency response capability	2.60
Through routing	2.53
Relative impact zone	2.50
Roadway geometric design	2.47
Congestion	2.47
Vehicle weight and size limits	2.40
Location of sensitive environments	2.40
Proximity of emergency response	2.40
Effects on commerce	2.20
Degree of access control	2.13
Number of lanes	2.07
Terrain considerations	1.60
Property value at risk	1.53
Cost to transporter	1.47
Median and shoulder structures	1.37
Climate considerations	1.27
Highway drainage system	0.97

The most important criteria for route evaluation from the list supplied to respondents, was population density, followed by location of special populations, accident history and type of highway. The next set of criteria were bunched together in terms of their relative importance; these included characteristics associated with roadway and traffic conditions, vehicle and cargo considerations, and proximity to emergency response.

2.3 Route Risk Assessment Modeling

Many researchers have addressed this topic, in part because of the logistical challenge of routing vehicles across networks when multiple criteria are involved, some of which are associated with the network itself and others located in proximity to the network. Several route risk assessment models have been developed to address route designation of radioactive shipments (Bowler & Mahmassani, 1998; Moore; Toth, 1994). Other researchers have addressed route risk analysis from the perspective of hazardous wastes as a general commodity (Turnquist & List, 1991; Panwahr, Anderson & Pitt, 2000), some modeling work has been performed on a specific class of hazardous material (Saccomanno, Van Aerde & Queen, 1988), while other routing models are more generic in nature (Verter & Kara, 2001).

Collectively, the contribution of these authors has been principally in quantifying various routing criteria, along with the work of others (US Department of Transportation, 1998). Routing criteria considered in these modeling efforts have included:

- Trip distance
- Travel time
- Accident rate
- Population exposure (residential and employment)
- Risk (accident rate times population exposure)
- Spill damage potential
- Access to emergency response capability
- Proximity of special populations (e.g., schools, hospitals, day care centers)
- Number of potential evacuees
- Road type
- Time of day
- Weather
- Environmental justice (minorities, low-income populations)
- Exposure to environmentally sensitive areas

Several of these studies also demonstrated that when various routing criteria are considered or different importance ratings (weighting factors) are applied, different preferred routes emerge. The tradeoff in the preferred route from varying criteria and importance ratings has been the subject of other studies as well. In one instance, it was found that route designation based solely on minimizing risk will often result in circuitous routes that appear to be economically infeasible and concurrently lead to a higher likelihood of a release-causing accident (Abkowitz, Lepofsky & Cheng, 1992). Moreover, routes that appear to offer reduced risk may often be accompanied by poor response coverage. In another case, a routing analysis performed on a variety of origin-destination shipping pairs concluded that the minimum risk routes, on average, reduced population exposure ten-fold, but reduced risk (accident rate times population exposure) by only six-fold because of the influence of other factors like road type and distance on accident likelihood (Glickman & Sontag, 1995).

The aforementioned activity, in general, did not result in the development of route risk assessment models that could be applied to large transportation networks or transferable to

applications anywhere in the country. One impediment at the time was difficulty in collecting data that could be used to routing criteria of interest.

This situation has changed with the introduction and proliferation of geographic information systems (GIS) technology. Not only has GIS enabled modelers to quantify many routing criteria more easily, it has also spawned a nationwide data collection effort, supporting the application of route risk assessment models virtually anywhere in the country. One recent notable effort in this regard is the characterization of soils and groundwater in proximity to transportation routes, for purposes of determining the risk of hazardous materials spills into soils and groundwater as routing criteria (Anand & Barkan, 2006). In another study, the exposure of poor and minority neighborhoods to the risk of a toxic release during transport was quantified using GIS (Schweitzer, undated). GIS has also motivated the development of new criteria, such as "vulnerability", calculated as a function of the distance of a facility from the transportation route and the corresponding population of the vulnerable facility (Panwahr, Anderson & Pitt, 2000).

The route risk modeling community has responded accordingly, with the development of comprehensive tools that leverage GIS technology and data availability. On the market today are off-the-shelf, sophisticated route risk assessment software products capable of evaluating highway routes between origins and destination anywhere in the country, utilizing a variety of desirable routing criteria.

Notable among these products are the following:

- *Transportation Routing Analysis Geographic Information System (TRAGIS)*. Developed by the Department of Energy, TRAGIS has been used to plan radioactive transport routes within the continental United States, using rail, truck, and waterway transportation modes (USDOE, undated). In addition to origin/destination nodes for nearly every major city and intersection, the TRAGIS database contains other specialized nodes for locations of nuclear reactors, DOE sites and military installations. Prescribed and alternative routes can be evaluated. Among the routing criteria represented in TRAGIS are population density, accident history, type of highway, relative impact zone, and some roadway geometrics.
- *VRiskRoute*. This product is a multi-modal tool for assessing route risks and evaluating risk reduction strategies between origin/destination nodes anywhere in the continental United States (Visual Risk Technologies, 2006). Prescribed and alternative routes can be evaluated; optimal routes can also be found based on the criteria selected by the user and the importance rating assigned to each criterion. VRiskRoute considers a variety of safety, security and environmental criteria. This includes population density, location of special populations, accident history, type of highway, type of hazardous material, proximity to emergency response capability, relative impact zone, location of sensitive environments, and some roadway geometrics. Moreover, VRiskRoute contains a module where the user can define security risks (in terms of critical infrastructure) which can be applied as a routing criterion while preserving the sensitivity of the information.

3.0 Case Studies

Several jurisdictions have conducted hazardous material truck routing studies in the recent past that offer insights into both the route designation process as well as how routing criteria were defined and applied. In the discussion below, six case studies are presented, collectively representing different regions of the country, routing agencies, hazardous materials under consideration, criteria used and its relative importance, and geographical scope.

3.1 Fallon, Nevada

The purpose of this initiative was to identify a preferred through route for transporting hazardous materials through the Fallon, Nevada urban area. A technical advisory committee (TAC) guided this study. Project evaluation criteria included those required by Federal regulation along with additional optional elements, resulting in consideration of 22 routing criteria.

Each criterion was assigned an importance rating on a scale of 1 to 4, with 1 being least important and 4 being of greatest importance. The criteria and their assigned importance ratings were:

1. Population Density (4): exposure of the general population within a potential impact zone, including special populations such as schools, hospitals, prisons, and senior citizen homes; population growth potential was also considered.
2. Type of Highway (3): physical characteristics, such as vehicle weight and size limits, underpass and bridge clearances, roadway geometric condition, number of lanes, degree of access control, and median and shoulder structures.
3. Emergency Response Capabilities (2): proximity and capability of emergency response facilities.
4. Affected Persons (2): comments and concerns expressed by affected persons and entities.
5. Exposure to Sensitive Areas (3): distance to homes and commercial buildings; special populations in hospitals, schools, handicapped facilities, prisons and stadiums; water sources and natural areas.
6. Terrain Considerations (2): topography along and adjacent to route which could impact the potential severity of an accident, dispersion of hazmat material upon release, and control and clean up of a release.
7. Continuity of Routes (1): continuity of routes with adjacent jurisdictions.
8. Alternative routes (2): Availability of alternative routes to compare with benchmark (most probable) route.
9. Effects on Commerce (1): determination as to whether candidate route presents an unreasonable burden to interstate or intrastate commerce.
10. Delay in Transportation (1): assessment of whether candidate route presents unnecessary delays to transportation.

11. Climatic Conditions (1): weather conditions unique to a route such as snow, wind, ice, fog, or other climatic conditions that could affect safety; the dispersion of hazmat upon release; or difficulty of control and clean up of a release.
12. Congestion & Accident History (2): traffic conditions unique to a route, such as congestion, accident experience, or other traffic considerations that could affect the potential for an accident; exposure to the public of a release; ability to perform emergency response operations; or temporary closing of a highway for cleaning up any release to be given appropriate consideration.
13. Conformity with Master Plan (4): compatibility of candidate route with area master plans.
14. Right-Of-Way Requirements (2): determination of whether acquisition of right-of-way is required due to expansion of existing roads or construction of new roadways necessary for use as a hazmat transportation route.
15. Constructability (3): the ability to build a suitable facility over the route under consideration, including geological and soil conditions, major topographic features, or sensitive or restricted lands.
16. Staging Capability (2): the ability to implement a particular route in a timely manner to meet the demands of hazardous materials shipments.
17. Benefit to Overall Transportation System (3): the extent to which the candidate route would be utilized by other uses to benefit transport mobility.
18. Proximity to Truck Stop Locations (1): access to trucking facilities for fueling, maintenance, etc.
19. Impact to Corridor Businesses (1): economic impact on local businesses.
20. Construction Costs (4): costs for constructing new facilities, widening/improving roads, and for major structures.
21. Widening Impacts to Existing Infrastructure (3): effect on adjacent property owners and construction costs by modifying access and/or building set-backs.
22. Potential Opposition by Adjacent Landowners (2).

For each routing alternative, each criterion was measured on a scale of 1 to 5, with 1 representing a low (undesirable) value and 5 representing a high (desirable) value. For each alternative, each criterion value was multiplied by its importance rating, and then summed to arrive at an overall "score". Those route alternatives with the highest scores became final candidates for selection consideration by the technical advisory committee. Ultimately, the committee recommended a designated route that was a combination of two of the final candidates.

3.2 Dallas, Texas

This study consisted of two phases: 1) establishing a regional system of through routes in the greater Dallas area, and 2) comparing the risk associated with hazardous materials shipments on the freeway facilities to those on a city-designated arterial street-routing system in the Dallas

urban core. The North Central Texas Council of Governments (NCTCOG) served as the lead agency in this effort.

In the first phase, the greater Dallas area was defined by 12 entry/exit points on interstate or state highways that formed the perimeter of the region. The study network within the region was defined as follows:

- All freeways (i.e., controlled access facilities)
- Potential through routes entering and exiting the metropolitan area that serve as direct paths to other major metropolitan areas or the interstate system and were comprised of controlled access facilities (wherever possible)
- Inclusion of freeway-to-freeway travel movements not served by direct ramp connections
- Exclusion of toll road facilities and non-contiguous freeway facilities.

The following criteria were considered in the analysis: 1) accident likelihood (rate), 2) population exposure (residential and employment), 3) physical constraints such as weight limitations on bridges, height restrictions on overpasses, inadequate shoulders for breakdowns or extensive construction, and 4) trip distance circuity (compared to the most direct route).

Several subjective criteria were also considered, most notably emergency response accessibility, proximity to populations with special evacuation needs and proximity to municipal water supplies. While no attempt was made to quantify these factors, a number of overlay maps were used to examine the location of all fire stations, hospitals, schools, shopping centers and water supply reservoirs in the region. The results of this process indicated that the majority of the routes under consideration were located in proximity to municipal fire departments, hospitals, schools and activity centers. This information was considered descriptive in nature and did not affect route designation recommendations.

The risk equation used for each route segment was a function of segment accident rate and population exposure. Population exposure was defined as the sum of residential and employment population located along that segment. Routing software was used to first generate minimum travel times between nodes in the regional transportation network. The program then determined the least risk paths from all entry/exit points based upon an objective of minimizing overall risk. A benefit/cost ratio of total risk change divided by total travel time change was then computed, which served as the basis for making routing recommendations.

In order to gain input from all levels of government and the trucking industry, NCTCOG formed a technical study committee of forty members to review the project at key points in the study. This committee consisted of local representatives from transportation planning and emergency response offices of major cities in the region, the Texas State Department of Highways and Public Transportation, the Federal Highway Administration, the Dallas-Fort Worth Council of Safety Professionals, area trucking firms, trucking interest groups, and the previously established NCTCOG Hazardous Materials Task Force.

The technical study committee approved the routing recommendations. The study recommendations were then approved by the NCTCOG Hazardous Materials Task Force, the NCTCOG Executive Board and the Regional Transportation Council. The final step was the approval of the Texas State Department of Highways and the Federal Highway Administration.

Because of the involvement of local governments in the technical study committee, local residents had an avenue for voicing concerns and participating in the planning process. As a result, all of the communities who took part in the study review process agreed with the routing recommendations. Many community representatives commented that, while they were concerned from an emergency response standpoint about the presence of a designated route through or adjacent to their community, they recognized that a route must be provided.

The second phase of the study focused on a concern regarding hazardous materials being shipped on Interstate highways near the Dallas central business district. It was felt that the potential existed for motorists to be trapped either on elevated portions of the freeway or in depressed canyon-type segments of the freeway without a means of escape. This was evaluated by estimating the number of motorists within a potential impact area of a hazardous materials accident, as well as the population and employment within that impact area. Due to the significant differences in the amount of activity and travel during the day versus night in downtown Dallas, the route risk assessment also examined potential accident consequences for both the day and night periods.

Based on qualitative information, it was determined that problems do exist on the freeways with regard to geometries and emergency vehicle access. In a relative sense, however, the risks associated with the arterial routes were considered more significant. These included proximity to large crowds, numerous industries, and retail businesses; difficult geometries for truck movements; narrow streets due to on-street parking and warehouse operations; dangerous intersections, tunnels and grade crossings; and additional travel time likely for shipments to travel through these areas.

Therefore, the analysis findings did not support the use of arterial routes for hazardous materials shipments in proximity to the Dallas central business district. It was recommended, however, that a time of day routing restriction should be imposed in which trucks would use Interstate highways at night and arterial routes during the day.

3.3 Cleveland, Ohio

The Northeast Ohio Areawide Coordinating Agency (NOACA) performed a routing study in 1993 involving through shipments of hazardous materials in northeast Ohio. NOACA formed a task force consisting of voting representatives from local governments, public interest groups and local industry, and non-voting representatives from various state agencies.

NOACA divided the expressway system in northeast Ohio into segments and developed measurements for each of the thirteen criteria listed in the federal standards. Decision rules were subsequently adopted to weigh the importance of each criterion. Segments were combined into

through-region directional corridors and compared to the relative risk of alternative routes. Recommended routes were determined by selecting those with the least risk. Once these routes were selected, a public hearing was held to present the draft regional routing plan and to solicit comments. The resulting routing recommendations were forwarded to NOACA for approval and then to the Public Utilities Commission of Ohio for consideration. A hazardous materials advisory panel was formed to advise the Commission, which subsequently led to the designation of prescribed routes for hazardous materials shipments as well as other routes where such shipments are prohibited.

3.4 Duluth, Minnesota

In 1989, Interstate 35 was extended through the City of Duluth. The extension included three tunnels along the route, with hazardous materials initially restricted from travel through the tunnels. Instead, carriers transporting hazardous materials were required to take State Route 61 around the tunnel. Both industry and the community expressed concerns over the use of Route 61 for this purpose, because it passes through downtown Duluth, near government office buildings, a county courthouse and jail, and two major hospitals. In addition, Route 61 has numerous signalized intersections and many of the cross streets along this road have steep grades, some up to 10%. As a result of these concerns, the City of Duluth requested that the Minnesota Department of Transportation (MNDOT) evaluate the risks posed by hazardous materials transport along both routes.

MNDOT formed an interagency task force as part of the risk assessment process. The task force consisted of representatives from federal, state, county and city agencies. Using statistics on accident, spill and fire rates, it was determined that hazardous materials transport on Route 61 had a higher risk than transport through the tunnels on I-35. The task force also recognized I-35 as a preferred option because of the following:

- It avoids business areas, residents, schools and hospitals
- The tunnels would be easier to evacuate and secure in the event of an incident
- Containment and cleanup of a spill would be more efficient on I-35.
- The tunnels are equipped with fire hydrants, emergency phones and communication systems.
- In the event of an incident, structural damage would be limited to the tunnel rather than across a more widespread area.

The task force unanimously recommended that the restriction on hazardous materials transport through the I-35 tunnels be lifted. However, the task force suggested that hazardous materials transport continue to be restricted during peak travel hours to further reduce the likelihood of an incident. Following the task force's recommendations, MNDOT proceeded to lift the ban on hazardous materials transport through the I-35 tunnels in Duluth.

3.5 State of California

This initiative was prompted by the passage of Assembly Bill 2705 by the California State Legislature, requiring the designation of routes for transporting inhalation hazard commodities. Route risk assessments were subsequently performed in accordance with the federal guidelines.

At the outset, a survey was conducted of the origins and destinations of inhalation hazard commodities within the state. These were combined with points of entry into or exiting from California to form the shipping pairs that needed to be served by the designated routing system. The network of candidate routes for consideration was limited to Interstates, U.S. and State highways, and major county roads.

Routing criteria used in the analysis included: 1) accident likelihood (rate), 2) residential population exposure, 3) physical and legal constraints that would prevent or prohibit hazardous materials transportation, 4) subjective factors, such as the location of special populations and sensitive ecological areas, 5) capabilities of emergency response personnel near the proposed routes, 6) shipment travel times and trip distances, and 7) ability to accommodate safe stopping places and vehicle inspections.

For each segment under consideration, risk was defined as the segment accident rate multiplied by the population exposure residing within a 5-mile buffer (on each side of the road). Routing analyses were performed considering both risk and travel time as criteria, varying the weights so that a set of alternative routes was identified representing all non-inferior combinations of the two criteria. The State used a geographic information systems (GIS) route risk assessment software product to perform this analysis.

The California Highway Patrol (CHP) served as the lead agency on this effort. To assist with the implementation process requirements, an Inhalations Hazard Task Force was established, comprised of representatives from chemical manufacturers and transporters, the aerospace industry, Department of Health Services, Office of the State Fire Marshal, Office of Emergency Services, the California Department of Transportation, Air Resources Board, local fire/emergency responders, and the California Assembly Transportation Committee. This task force played a critical role in the development and review of the proposed routing regulations.

Draft maps of the proposed routes were distributed to the state police, state department of transportation, local police, fire/emergency responders, county sheriff offices and other administering agencies with jurisdiction along the proposed routes. Several public hearings were also held, allowing residents throughout the state to express their opinions. Comments received from this process led to the performance of additional routing analyses prior to final route selection. The designated routes were assembled into a document that was issued as a rulemaking, in accordance with the requirements of Assembly Bill 2705.

Because of the involvement of local governments in the Inhalation Hazards Task Force, local residents had an avenue for voicing concerns and participating in the planning process. In listening to local input, the CHP recognized that hazardous materials routing was a sensitive issue for certain communities. Where this concern was raised, the CHP identified a set of

alternative routes that the agency considered feasible, and then left the final decision of the preferred route to the local community. This had several advantages. First, it gave each community an opportunity to be part of the planning process. Secondly, by asking a community to select the preferred route, the final decision had to be debated within the community, thereby removing CHP from any criticism regarding the selection process. As a result, opposition from residents was not encountered.

3.6 U.S. Department of Energy Route Designation Studies

Foreign Research Reactor Spent Fuel Transportation

This program is administered by U.S. Department of Energy (DOE). It involves truck shipments of foreign research reactor spent fuel from certain ports to an interim storage facility at Idaho National Laboratory.

The route selection process began with DOE identifying representative truck routes based on the speed and distance for each segment in the network and adjacent population densities. Highway routes under consideration were constrained to comply with DOT regulations regarding use of Interstate highways or state-designated alternate preferred routes, use of Interstate bypasses around cities, and minimizing the distance traveled between origin and destination points and the Interstate. Expected fatalities from radioactive exposure during routine transport, from radioactive releases in severe accidents and from conventional accidents (i.e., where the nature of the cargo is not a factor) were considered. Available network routing software was used to compute these measures and apply them to identify preferred routes. The risk estimation procedure did not employ data for specific road segments about traffic condition, accident rates, road quality or places of public gatherings. DOE preferred for these factors to be addressed in consultation with individual states and tribes.

Identified routes were subsequently presented for discussion with potentially affected states and tribes through working groups. For highway transportation in South Carolina, the State rejected DOE's recommended route, because it passed near the urban areas of Columbia and Augusta, and included an interchange with a high accident frequency. The State proposed an alternate route that followed mostly roads other than Interstate highways but was shorter in length. Moreover, the alternative route avoided Columbia and Augusta, as well as the high-accident interchange of concern. Selection of the alternate route appears to have been based on local knowledge and professional judgment of state/local officials, although it was reported that a comparison of accident rates on each route was performed.

State regional governments (SRGs) were involved in separate discussions regarding interstate shipments to Idaho National Laboratory. Among the factors considered in the route selection were: 1) DOT highway route selection regulations, 2) state and tribal advice regarding road conditions and construction zones, planned events, emergency response and radiological training needs, shipment and truck inspection requirements, and rush hour periods through cities, 3) radiological exposure due to accidents, and 4) shipment schedule, particularly the season of the year. Of representative routes identified by DOE, some were eliminated due to concerns about weather and terrain. Some of the state recommendations were based on more detailed

examination of physical route characteristics than DOE had carried out. The states also favored routes that had been used earlier for radioactive waste shipments, because emergency responders along these routes had already received training.

This approach reflected DOE's position that the states and tribes are competent and responsible for selecting highway routes and, in particular, for having detailed and current local knowledge about accident rates, road and traffic conditions, and events. Other factors, such as cost, administrative feasibility, local preferences and political considerations were also taken into account. As a result, route selection was not determined solely by a qualitative risk assessment because DOE recognized that these other factors must also be considered.

Yucca Mountain Transportation Route Planning

Two SRGs, the Midwest Council of Governments (MCOG) and the Northeast Council of Governments (NCOG), have been working on processes to identify and evaluate alternative routes that might be designated as part of the Yucca Mountain Project national transportation plan. In both cases, the SRG has focused on identifying a suite of designated routes rather than a single route, so that transport can be effectively carried out through better security and flexibility during repository construction, bad weather and special events.

In the case of the MCOG, models were used to characterize a variety of criteria, with individual weights applied to each criterion to arrive at overall route risk scores from which candidate routes were identified. Primary routing criteria consisted of equal weighting of: 1) risk to the public during normal transport, 2) risk to the public in the event of an accident, and 3) risk to the economy and the environment in the event of an accident. Secondary routing criteria was also considered, weighted as follows: urban areas traversed (50%), accident rates along route (20%), road quality (15%) and traffic density along route (15%). As a next step, the preferred suite of routes will be presented to states, carriers and other interested parties for consultation with a goal of achieving consensus on preferred routes that can be forwarded to DOE for consideration.

In contrast, the NCCOG consulted the knowledge and experience of the transportation industry first to select candidate routes, and then used models to characterize risks on those routes. Routing criteria consisted of: 1) avoiding metropolitan areas, 2) minimizing affected population and 3) minimizing travel time. Other factors included weather, emergency response capability and access, proximity to historical sites, traffic density, economic impacts, accident rates, and perceptions of environmental, cultural and social risks. The result of the study will be used by NCCOG to generate its preferred suite of routes, eventually leading to routing recommendations for DOE to consider.

Tribes have also shown an interest in Yucca Mountain transportation route selection. Among routing criteria of concern are: 1) protection of the land base and ecosystem, 2) preservation of sacred areas and 3) avoiding traditional use areas.

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Hazardous Materials Routing Regulations and Truck Transport Border Conflicts

Final Project Report

Prepared for:

Federal Motor Carrier Safety Administration

U.S. Department of Transportation

March 31, 2008

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1.0 Introduction

This white paper is designed to accomplish two major objectives related to hazardous materials (hazmat) routing regulatory analysis: 1) to describe the most important aspects of the Federal routing regulations; and 2) to describe the major routing conflicts that exist for truck shipments of hazmat between the United States and both Canada and Mexico.

The Federal Motor Carrier Safety Administration's (FMCSA) regulations for transporting hazardous materials by motor vehicle documented in 49 CFR Part 397 (49 CFR, 2006) Subparts C and D, address the regulations for routing non-radioactive hazardous materials (NRHM) and radioactive hazardous materials (RAM), respectively. Subpart E specifies the preemption procedures to be followed if an individual including state or local government or Indian tribal official desires a preemption from a route prescribed under either Subpart C or D. Following a brief summary in Section 2.0, these sections are summarized in detail.

There are routing conflicts between the United States and both Canada and Mexico. The major routing conflicts that exist for truck shipments of hazmat occur mainly between the United States and Canada and more specifically between the province of Ontario and the states of Michigan, Minnesota, and New York. Specific routing conflicts for HM between the United States and Canada are summarized in the table in Section 3.0 of this paper. The only border restrictions for HM truck shipments along the Mexican border are in California. These restrictions are also discussed in Section 3.0.

2.0 Major Routing Regulations

2.1 Summary

While both Subpart C and D state that the routes to be used by motor carriers should be selected to minimize risk, the NRHM subsection specifies requirements that must be followed should a state or Indian tribe choose to designate or restrict routes for the transport of placarded quantities of NRHM. The RAM subsection specifies that the preferred route is the Interstate Highway System for which an alternative route has not been designated by a State Routing Agency. The RAM subsection further specifies that for Highway Route-Controlled Quantities (HRCQ) of radioactive material, the Interstate System bypass or Interstate Highway beltway around a city, when available, shall be used in place of a preferred route through the city, unless the state routing agency has designated an alternative route. The NRHM subsection states that the designated or restricted routes must provide reasonable access to terminals, points of loading or unloading, and facilities for food, fuel, repairs, rest, and safe havens. The RAM subsection specifies that the most direct route from the pick-up and drop-off point to the Interstate Highway System must be used unless it can be shown that a less direct route poses less radiological risk and is not more than 25 miles farther or 5 times longer than the most direct route.

Both subsections specify route characteristics to be considered when prescribing a route; both require consultation with local officials and both specify separate but similar preemption procedures to be followed by any person or entity desiring to challenge the routing designation. These include states, political subdivisions, or Indian tribes directly affected by any routing designation. The NRHM subsection requires a written route plan for Division 1.1, 1.2, and 1.3 Explosives as does the RAM subsection for HRCQ of radioactive materials. The driver of a vehicle carrying HRCQ of radioactive material must be trained and the written training records must be available for inspection. Section 2.2.2 of this white paper includes a detailed list of Federal standards that must be considered when selecting hazmat routes for NRHM.

As with any routing designation, an important part of the requirements is to specify the preemption procedures to be followed when an individual, state or local government entity, or Indian tribe determines that the routing determination adversely affects the movement of hazardous materials. These preemption procedures, the steps to be taken by the administrator making the preemption finding, as well as the steps that can be taken to seek a waiver from the preemption determination, are listed in Subpart E.

In summary, both the NRHM and RAM regulations have many commonalities. The major difference is that a RAM shipment must use the Interstate Highway System unless an alternative route has been designated by the state or Indian tribe routing representative. In contrast, for NRHM, the motor carrier can select routes believed to minimize risk unless the state or Indian tribal routing official has designated or restricted transport routes.

2.2 §397 Subpart C – Routing of Non-Radioactive Hazardous Materials (NRHM)

This regulation applies to any state or Indian tribe that establishes, maintains, or enforces any routing designations that state non-radioactive hazardous materials (NRHM) may or may not be

transported by motor vehicle. The regulations also apply to motor carriers that transport placarded or marked NRHM in commerce.

2.2.1 Motor Carrier Responsibility

Motor carriers transporting NRHM must comply with state or Indian tribe NRHM routing designations.

If the hazardous material is required to be placarded or marked in accordance with 49 CFR §117.823, and is not subject to NRHM routing designations, the motor carrier must operate the vehicle on routes that do not pass through or near heavily populated areas, places where crowds are assembled, tunnels, narrow streets, or alleys, except where the motor carrier determines that:

- There is no practical alternative.
- A reasonable deviation is necessary to reach terminals, points of loading and unloading, facilities for food, fuel, repairs, rest, or a safe haven.
- A reasonable deviation is required by emergency conditions such as a detour that has been established by a highway authority, or a situation exists where a law enforcement official requires the driver to take an alternative route.

Operating convenience is not a basis for determining whether it is practical to operate a motor vehicle in accordance with the above exceptions.

Before requiring or permitting a motor vehicle to transport Class 1 explosives, a carrier or its agent must prepare a written route plan that complies with this section and must provide a copy to the driver. If the trip begins at a location other than the carrier's terminal, the driver may prepare the written plan as the agent for the motor carrier.

2.2.2 Federal Standards

While establishing, maintaining, or enforcing specific NRHM routing designations, a state or Indian tribe must comply with the Federal standards described below:

- *Enhancement of public safety*

  The state or Indian tribe must prepare a finding that any NRHM routing designation enhances public safety in the areas subject to its jurisdiction and in other areas that are directly affected by such highway routing designations.

  They must also take into consideration the DOT "Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials," and the following factors:

  - Population density
  - Type of highway
  - Types and quantities of NRHM
  - Emergency response capabilities
  - Results of consultation with affected persons

- Exposure and other risk factors
- Terrain considerations
- Continuity of routes
- Alternative routes
- Effects on commerce
- Delays in transportation
- Climatic conditions
- Congestion and accident history

- *Public participation*

  Before establishing any NRHM routing designation, the state or Indian tribe must ensure participation by the public through the following actions:

  - Provide the public with a 30-day comment period for any proposed NRHM routing designation
  - Provide a 30-day notice if a public hearing will be conducted
  - Publish both the comment period and public hearing in at least two newspapers of general circulation in the affected area

- *Consultation with others*

  Before establishing any NRHM routing designation, the state or Indian tribe must provide notice to, and consult with, officials of affected political subdivisions, states and Indian tribes, and any other affected parties.

- *Through-routing*

  Before establishing any NRHM routing designation, the state or Indian tribe must ensure continuity of movement so as to not impede or unnecessarily delay the transportation of NRHM.

- *Agreement of other states; burden on commerce*

  Any NRHM routing designation that affects another state or Indian tribe must be established, maintained, or enforced only if it does not unreasonably burden commerce, and it is agreed to by the affected state or Indian tribe within 60 days of the sent notice.

- *Timeliness*

  The establishment of a NRHM routing designation by any state or Indian tribe must be completed within 18 months of the notice given to solicit public participation.

- *Reasonable routes to terminals and other facilities*

  States or Indian tribes must use the shortest practical route that considers the public safety factors listed above to reach: terminals; points of loading, unloading, pick-up and delivery; and facilities for food, fuel, repairs, rest, and safe havens.

- *Responsibility for local compliance*

  If a state or Indian tribe chooses to establish, maintain, or enforce any NRHM routing designation, the Governor or Indian tribe must designate a routing agency. The routing agency must ensure that all NRHM routing designations within its jurisdiction comply with the Federal standards.

2.2.3 Public Information and Reporting Requirements

States and Indian tribes must make information on NRHM routing designations available to the public through maps, lists, road signs, or some combination thereof.

Through its routing agency, each state or Indian tribe must provide information identifying all NRHM routing designations that exist within their jurisdiction to the FMCSA, Office of Enforcement and Compliance. This information must include route descriptions along with dates they were established. FMCSA will make this information available and published annually in whole or as updates in the Federal Register.

2.2.4 Dispute Resolution

One or more states or Indian tribes may petition the administrator to resolve a dispute relating to an agreement on a proposed NRHM routing designation. The administrator will resolve this dispute while providing the greatest level of safety possible without unreasonably burdening commerce, and ensuring compliance with the Federal standards.

Each petition for dispute resolutions must be:

- Filed to the administrator of the Federal Motor Carrier Safety Administration.
- Identified by the state or Indian tribe filing the petition and any other state, political subdivision, or Indian tribe whose NRHM routing designation is the subject of dispute.
- Certified by the petitioner that they complied with notification requirements including a list of the names and addresses of each state, political subdivision, or Indian tribe official who was notified of the petition filing.

2.3 §397 Subpart D – Routing of Class 7 (Radioactive) Materials

2.3.1 Motor Carrier and Driver Responsibility

If the hazardous material being shipped is a Class 7 (radioactive) material, as defined in 49 CFR §172.403 and is required to be placarded in accordance with 49 CFR §172, the carrier or motor vehicle operator must:

- Operate the motor vehicle on routes that minimize radiological risk.
- Determine the level of radiological risk by taking into account available information on accident rates, transit time, population density and activities, the time of day, and day of the week on which transportation will take place.

- Operate the motor vehicle only on preferred routes; for RAM, the preferred routes are the Interstate Highway System for which an alternative route has not been designated by a state routing agency.
- For HRCQ of radioactive materials, select routes to reduce transit time on the preferred route portion of trip; an Interstate System bypass or Interstate System beltway must be used, when available, in lieu of a preferred route through a city unless an alterative route was designated by a state routing agency.

A motor vehicle may be operated on a non-preferred route only under the following circumstances:

- The deviation is required to pick-up or deliver an HRCQ of Class 7 (radioactive) materials to make necessary rest, fuel, or motor vehicle repair stops, or because emergency conditions cause the use of the preferred route unsafe or impossible.
- The non-preferred route must be the shortest distance from the pick-up site to the closest preferred route entry and the shortest distance to the delivery site from the closest preferred route exit. Deviation from the shortest distance pick-p or delivery route is allowed if the deviation:

    - Minimizes the radiological risk.
    - Does not exceed the shortest distance pick-up or delivery route by more than 25 miles and 5 times the length.
    - Is necessary for rest, fuel, motor vehicle repair, or emergency conditions.

A carrier of HRCQ of radioactive materials must prepare a written route plan and provide a copy to the driver and shipper before departure. Any variation between the route plan and actual routes used and reason for it must be reported in an amendment to the route plan provided to the shipper as soon as possible but within 30 days of the deviation.

The route plan must include:

- A statement of origin and destination, all planned stops, and estimated departure and arrival times.
- Telephone numbers that access emergency assistance in each state that will be entered.

HRCQ quantities of radioactive materials may not be transported on public highways unless:

- The driver has received written training in the prior two years on:

    - The requirements in 49 CFR Parts 172, 173, and 177 relating to the transport of Class 7 (radioactive) materials.
    - The properties and hazards of Class 7 (radioactive) materials.
    - Procedures to follow in case of an accident or emergency.

- The driver must have in their immediate possession a certificate of training and a copy placed in their qualification file showing:

- Driver's name and operator's license number
- Dates training was provided
- Name and address of trainer
- The driver has been trained in the dangers and characteristics of Class 7 (radioactive) materials
- A statement from the trainer that the information on the certificate is accurate.

- The driver has the required route plan in their possession and operates the motor vehicle according to the route plan.
- Irradiated reactor fuel may only be transported in compliance with 49 CFR §173.22, which ensures physical security of the material. Variations are permitted providing they meet the imposed requirements or those imposed by the U.S. Nuclear Regulatory Commission in 10 CFR part 73.
- Except for packages shipped in accordance with U.S. Nuclear Regulatory Commission in 10 CFR part 73 within 90 days of package acceptance, each carrier that accepts Class 7 (radioactive) material must file the following information concerning the transportation of such package with the Office of Enforcement and Compliance (MC-ECH):

  - The route plan including all required amendments.
  - A statement with the names and addresses of the shipper, carrier, and consignee.
  - A copy of the shipping paper or the description of the Class 7 (radioactive) material.

2.3.2 Requirements for State Routing Designations

The state routing agency must choose routes to minimize radiological risk using, "Guidelines for Selecting Preferred Highway Routes for Highway Route-Controlled Quantity Shipments of Radioactive Materials", or an equivalent routing study that effectively takes into account overall risk to the public. In addition, there must be prior independent consultation with affected local jurisdictions and any other affected states to ensure all impacts are considered and continuity of designated routes is maintained.

State routing agencies may designate preferred routes as an alternative to, or in addition to, one or more Interstate System highways including Interstate System bypasses, or Interstate System beltways.

- *The state-designated route is effective when*:

  - The state provides written notice by certified mail to the Office of Enforcement and Compliance (MC-ECH).
  - Receipt of that notice is acknowledged in writing by the FMCSA.

A list of state-designated preferred routes and a copy of the "Guidelines for Selecting Preferred Highway Routes for Highway Route Controlled Quantity Shipments of Radioactive Materials" can be requested from the Office of Enforcement and Compliance (MC-ECH).

2.3.3 Subpart E: Preemption Procedures

Any person, including a state, political subdivision thereof, or Indian tribe directly affected by any highway routing designation for hazardous materials may apply to the administrator for a determination as to whether that highway routing designation is preempted.

A state, political subdivision thereof, or Indian tribe may apply to the administrator for a waiver of preemption with respect to the highway routing designation.

2.3.3.1 Standards for Determining Preemption

Any highway routing designation is preempted if:

- Compliance with the highway routing designation and any requirement under the Act (49 U.S.C. 5101) or of the regulation issued under the Act is not possible.
- The highway routing designation as applied or enforced creates an obstacle to the accomplishment and execution of the Act or the regulations issued under the Act.
- The highway routing designation is preempted pursuant to 49 CFR 397.69(b) because it is in violation of Section 105(b)(4) of the Hazardous Materials Transportation Act [49 U.S.C. app. 1804(b)(4)].

2.3.3.2 Preemption Application

The regulations specify the content of the application that must be made in writing to the Administrator of the Federal Motor Carrier Safety Administration.

The application must include:

- The specific provisions of the Act or the regulations issued under the Act under which the applicant seeks preemption.
- The reasons why the applicant is seeking preemption.
- A quantification of how the highway routing designation adversely affects the applicant.

2.3.3.3 Preemption Processing

The regulations specify that the administrator may make a decision to deny the preemption application or convene a hearing or conference if such hearing or conference would advance the evaluation of the application.

2.3.3.4 Preemption Determination

The regulations also include a timetable for making a determination including a written justification for the determination.

2.3.3.5 Waiver of Preemption Application

Any individual, as defined above, upon the issuance of a preemption determination, may request a waiver of the preemption application. This paragraph lists the contents of such a waiver. The preemption can be waived if such a waiver:

- Affords an equal or greater level of protection to the public than afforded by the Act or the requirements under the Act.
- Does not unreasonably burden commerce.

2.3.4 Waiver Notice

The waiver notice shall be sent to all affected parties.

3.0 Border Conflicts for Hazmat Transportation

3.1 Overview

One important regulatory issue relates to determining existing regulatory conflicts between the United States and both Canada and Mexico. In order to address this issue, the project team investigated routing restrictions along the borders between the United States, Canada, and Mexico. The team interviewed contacts in: border states, Canadian provinces, and at the Federal level in Mexico. In addition, both Internet and published information sources were consulted.

The research concluded that the only special hazmat routing restrictions between the United States and Mexico exist between California and the Mexican state of Baja California Norte. Although Mexico itself has no restrictions on the shipment of HM across its borders, the current restrictions result from California regulations. Michel, 2007). Between Canada and the Unites States, restrictions exist at bridges and tunnels between Ontario and the adjacent states of Michigan and New York (Brown, 2006).

In general, Canada and the United States have similar requirements for regulating the shipment of hazardous materials (dangerous goods in Canada) across national boundaries. The process generally requires importers and exporters to notify and obtain approvals for specific shipments from designated government agencies (U.S. EPA or Environment Canada) and to track the material's life-cycle from its point of generation to its final destination.

Both countries rely on the concept of prior informed consent (PIC). The PIC concept affirms that hazardous materials or dangerous goods may only be exported to another country with the importing country's prior consent, and depend on effective information sharing.

3.2 Routing Conflicts Between the United States and Mexico

The only border restrictions for HM truck shipments along the Mexican border are in California. These restrictions apply to explosives, inhalation hazards and highway route controlled quantities of radioactive materials (HRCQ) and are found in California regulations. All other HM may be shipped across any of the three border crossings between California and Mexico that allow commercial truck traffic The bulleted list below lists each border crossing and those hazardous materials that are restricted from crossing either from or into California at that point.

- San Ysidro Border Crossing (I-5) — None*
- Otay Mesa Border Crossing — Explosives, Inhalation Hazards and HRCQ
- Tecate Border Crossing (Route 188) — Explosives, Inhalation Hazards and HRCQ
- Calexico Border Crossing — Inhalation Hazards and HRCQ

* None of the HM classes are restricted from traveling to or from the Mexican border. However, this crossing is closed to all commercial truck traffic. Therefore, no HM truck shipments can cross the border at San Ysidro.

3.3 Routing Conflicts Between the United States and Canada

The table below, Hazmat Truck Traffic Border Crossing Conflicts Between the United States and Canada, shows hazmat (dangerous goods) conflicts between the two countries. The table illustrates that the major restrictions are at bridge crossings and, in one case, a tunnel between the two countries. All of the bridges are operated by bridge authorities with the exception of the Blue Water Bridge, where the Michigan side is operated by the Michigan Department of Transportation.

Although in some instances, Canada and the United States define dangerous goods and hazardous materials somewhat differently; all restrictions on the crossings apply equally to hazardous materials trucks carrying hazmat from either Canada or the United States. The major differentiator is related to the type of hazmat being transported by the carrier. In the case of the crossing between Ontario and Michigan at Detroit, although there are restrictions for both the Ambassador Bridge and a ban on hazmat using the Detroit-Windsor Tunnel, hazmat of all types can be moved between Detroit and Windsor by using the Detroit-Windsor Truck Ferry.

Hazmat Truck Traffic Border Crossing Conflicts Between the U.S. and Canada[1]			
Border Crossing	**Ontario City**	**US City**	**Dangerous Goods (Canada) Hazardous Materials (US)**
Ontario / Michigan			
The Tunnel	Windsor	Detroit, MI	Hazmat prohibited
Ambassador Bridge[1]	Windsor	Detroit, MI	These classes are prohibited: Class 1 – Explosives Class 3 – Flammables Class 7 – Radioactives Class 8 – Corrosives
Barge Ferry Crossing	Windsor	Detroit, MI	All hazmat permitted
Blue Water Bridge	Sarnia	Port Huron, MI	Prohibited: Class 5.2 (organic peroxide in a refrigerated tank or bulk) All Class 1 – Explosives (except 1.4) must be escorted and cross bridge from 2AM to 8AM Class 7 – Radioactive: Needs at least $50 million in insurance to cross bridge All other hazmat can cross without special requirements
Sault Ste. Marie Bridge	Sault Ste. Marie	Sault Ste. Marie	All hazmat is permitted to cross but Class 1 – Explosives must be escorted

Hazmat Truck Traffic Border Crossing Conflicts Between the U.S. and Canada[1]

Border Crossing	Ontario City	US City	Dangerous Goods (Canada) Hazardous Materials (US)
Ontario / New York			
Queenston/Lewiston Bridge[3]	Queenston	Lewiston	Class 1.1, 1.2, 1.3 – Explosives prohibited Class 7 – Radioactive: Only radioactive waste prohibited; certain radioactive materials such as isotopes are permitted on the bridge
Peace Bridge[4]	Fort Erie	Buffalo	Class 1 – Explosives and Class 7– Radioactive materials must be escorted across the bridge. All other hazmat permitted without special requirements
Seaway Bridge	Cornwall	Massena	All hazmat permitted to cross bridge
Ogdensburg-Prescott Bridge	Prescott	Ogdensburg	Prohibited: Class 7 – Radioactive:
Thousand Islands Bridge	Ivy Lea	Collins Landing	Prohibited: Class 7 – Radioactive if required to have an escort in either Ontario or New York. For example, spent fuel would be prohibited.
Whirlpool Rapids Bridge	Niagara Falls	Niagara Falls	Commercial motor vehicles prohibited
Rainbow Bridge	Niagara Falls	Niagara Falls	Commercial motor vehicles prohibited
Ontario / Minnesota			
Pigeon River Bridge	Ontario Hwy 61	Minnesota	All hazmat permitted
Fort Frances / International Falls Bridge	Fort Frances	International Falls	All hazmat permitted
Baudette / Rainy River Bridge	Rainy River	Beaudette	All hazmat permitted

[1] Brown, Alf, e-mail and telephone correspondence: Dangerous Goods Coordinator, Ministry of Transportation, Ontario, October 2006, April 2007.
[2] Jolly, Dave, Ambassador Bridge, telephone conversation, May 2, 2007
[3] Gallaugher, Brent, Queenston/Lewiston Bridge, telephone conversation, May 3, 2007
[4] Caperchione, Greg, Peace Bridge, telephone conversation May 2, 2007

4.0 References

49 CFR Part 397, Pipeline and Hazardous Materials Safety Administration, U.S. Department of Transportation, October 2006.

Brown, Alf, Dangerous Goods Coordinator, Ministry of Transportation, Ontario, telephone communication and e-mail correspondence, October 2006.

Caperchione, Greg, Peace Bridge, telephone conversation, May 2, 2007

Gallaugher, Brent, Queenston/Lewiston Bridge, telephone conversation, May 3, 2007

Jolly, Dave, Ambassador Bridge, telephone conversation, May 2, 2007

Michel, Gerardo, Director of Supervision, Autotransporte Federal, Mexico, telephone communication and email correspondence, February 2007.

Hazardous Materials Routing Survey Analysis

Project Report

Prepared for:

Federal Motor Carrier Safety Administration

U.S. Department of Transportation

November 30, 2006

Prepared by:

Battelle
The Business of Innovation

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1.0 Introduction

Battelle is conducting the Hazmat Routing Safety & Security Risk Analysis Project for the U.S. DOT Federal Motor Carrier Safety Administration (FMCSA) that emphasizes hazardous material routes in the United States. The project has a number of focuses that include the following:

1) Determine the location of existing and proposed hazardous material routes in the United States, Canada, and Mexico.
2) Characterize hazardous material routes in the United States to determine if their selection was made in concordance with the existing safety regulations.
3) Determine if there are any conflicts between hazardous materials routes in the United States and those in Canada or Mexico.
4) Investigate if additional criteria are needed to include security considerations when selecting routes in addition to the current safety criteria.

Based on project goals and to obtain information on several important issues in regard to hazmat route designations, associations, carriers, shippers, and DOT state representatives were contacted and requested to respond to a series of questions. This report summarizes the responses obtained from these various organizations. Survey questions and responses are included in the appendices.

2.0 Stakeholder Responses

2.1 Association Responses

Several associations were asked to respond to the hazmat (HM) routing survey questions. Three associations replied and the survey questions and responses are included in Appendix A (Survey Questions and Responses for Associations). The associations that responded included:

1) A major national motor carrier association
2) A trade association representing tank truck operations
3) A trade association representing manufacturers of extremely volatile hazardous materials

Of these three, only one believed that hazmat routing improved public safety and security, and this association added the caveat that safety and security were only improved if the routing was risk-based. Interstates were discussed as being safer and more secure than secondary roads because vehicles are constantly moving, thus reducing vulnerability. The need for districts to discuss hazmat routing with neighboring districts and the problematic nature of decisions based on “not-in-my-backyard” ideology were also listed among the factors important for consideration when determining hazmat routes.

Current communication of hazmat routes is not deemed adequate by the three associations. Although FMCSA maintains a website of hazmat routes that is occasionally updated, this website is considered inadequate and cumbersome to use by the associations. Enforcement could

be improved by standardizing and improving the signage communicating designated hazmat routes and by increasing the number of roadside inspections.

When asked about the operational impacts of hazmat routing, two associations replied that hazmat routing increases delivery times and miles driven, which negatively impacts carrier safety and productivity. Carrier costs can be reduced by utilizing expedited hazmat routes.

In general, the associations were familiar with Federal Routing Regulations and found these regulations easy to understand. Typically, route designations are based on the presence of interstates, common destinations, and political and public considerations. Many of the designated routes were grandfathered in from before there were regulations. Designation of routes should be based on safety analyses and security and safety considerations need to be balanced.

The associations responded that materials that could easily be weaponized (such as explosives) should have special safety and security consideration during hazmat routing planning. The only suggestion that was made to improving hazmat routing decision-making was to utilize greater Federal oversight to avoid one jurisdiction making decisions that would simply route hazmat movements through another jurisdiction.

When asked to rate the impacts of current hazmat routing regulations on safety, security, and carrier productivity with 1 being no benefit at all and 7 being extremely beneficial, the carriers responded on average:

- Safety benefits: 4
- Security benefits: 2.5
- Carrier productivity benefits: 1.5

The associations explained some of their comments by the fact that there is no record of terrorists seizing a load in commercial transport (terrorists obtain their weapons legally to reduce the risk of detection) and that carriers often have to deviate from routes for reasons outside of their control.

2.2 Carrier and Shipper Responses

Carriers and shippers were also asked to respond to the hazmat routing survey questions. Twelve carriers replied and the survey questions and responses are supplied in Appendix B (Survey Questions and Responses for Carriers and Shippers). The size of carriers that replied ranged from 16 to 26,000 power units and 30 to 42,000 drivers.

Half (6) of the carriers believed that hazmat routing improved public safety and one-fourth (3) did not. Two carriers replied that sometimes hazmat routing takes carriers from primary routes to more dangerous secondary routes. Hazmat routing can also make it more difficult for carriers and shippers to access their customers.

When hazmat routes are not designated, carriers consider a number of factors in determining the safest route including:

- Tunnels
- Bridges
- Population exposure
- State regulations
- Directness of route

Many carriers seem to consider the shortest, most direct routes to be the safest.

One-fourth of the carriers assigned priority consideration to certain factors, which included utilization of interstates and multi-lane highways, mileage, and time.

None of the carriers were consulted to evaluate hazmat routing designations. The government does not communicate changes in hazmat routing to the carriers; the carriers rely on state associations, state websites, and commercial publications to stay updated on routing information. Several carriers mentioned that having a central source of information on hazmat routing would be helpful in staying informed as to designated hazmat routes.

Nearly half (5) of the carriers felt that designating both local and through hazmat routes would most effectively enhance safety and security.

All of the carriers responded that designating hazmat routes increased their operational costs. These carriers referenced costs associated with additional mileage resulting from traveling along hazmat designated routes. Other costs described included training costs, additional labor costs, costs associated with changing travel routes, and higher insurance costs due to negative (unintended) safety consequences.

Nine of the 12 carriers responded that they were familiar with the hazmat regulations and the other three did not respond to this question. Of those that were familiar, suggestions for additional regulations included any material that could be considered a weapon, any material that would require an evacuation of an area greater than 1,000 feet if breached, and special permit toxics.

Carriers seem to disagree on ways to enhance hazmat security. Many carriers responded that there needs to be more flexibility in determining hazmat routes and that the regulations need to account for route exceptions that will actually work to improve the safety and security for the cargo. On the other hand, one carrier responded that safety and security could be improved by stricter enforcement of the current regulations. Another carrier responded that instead of basing regulations on routing, hazmat safety and security regulations should focus on utilizing technology to track hazardous material shipments and respond in emergency situations.

Carriers were asked to rate the impact of hazmat routing regulations on safety, security, and carrier productivity. The average ratings, with 1 being no benefit at all and 7 being extremely beneficial, are listed below:

- Safety benefits: 3.0
- Security benefits: 2.6
- Carrier productivity benefits: 1.7

Of the factors that contribute to safety benefit impacts, the carriers responded that routes with lower traffic density enhance safety, but that there are very few safety benefits in general.

The responses given to the impacts on security benefits by the motor carriers were mixed. One carrier replied that hazmat routes improved security because drivers were less likely to stop, which reduced the risk of hijacking. Another carrier responded that such routes increased security risks because terrorists would be able to identify the location of hazmat shipments.

All of the carriers agreed that hazmat routes negatively impacted company productivity.

2.3 State Responses

Various state DOT representatives were also asked to respond to the hazmat routing survey. The questions and their responses are shown in Appendix C (Survey Questions and Responses for States). Six state representatives responded including:

1) One large northwestern state
2) One large southern state (only one city jurisdiction)
3) One large northern state
4) One mid-size eastern state
5) Two mid-size midwestern states

When asked if they believe that the designation of hazmat routes improves public safety and security, five of the six states replied positively and one replied negatively. The large northwestern state answered "no" that in their state they have so few highways, especially interstates, that the routing regulations are not applicable. They felt that other rural states probably have the same issue. They replied:

> "It's a good idea to keep hazmat shipments out of populated areas when possible but in our case it's just not practical. We would rather have hazmat transportation on the interstate than on a poorly maintained two-lane highway that surrounds a heavily populated area."

One of the midwestern states replied that it may help public safety but as far as security, the vehicles would be in a predictable location for a possible terrorist hijacking.

According to the state representatives, the following government organizations are involved in designating HM routes in their jurisdiction:

- State Police
- State Department of Transportation
- Office of Homeland Security
- Emergency Services
- Office of Public Works
- Fire Department

According to the state representatives, the following offices initiate the process of hazmat designation:

- State Police
- Office of Homeland Security
- Emergency Services
- Fire Department

The large northern state replied that if the route is on a highway managed by the DOT, they would be the routing agency to initiate the process. If the route is on local roads, the appropriate jurisdiction would start the process. One of the midwestern states replied that the party seeking the route designation would initiate the process.

The state representatives were also asked to what extent the existing HM routes were selected in their jurisdiction based on pre-1993 methods (before the implementation of 49 CFR Part 397) or on the routing regulations in 49 CFR Part 397. The large northwestern state replied that they only have one officially designated HM route in their state and it was designated prior to 1993. The large northern state stated that they also have only one designated route, through a tunnel, which was established in 1971.

One midwestern state replied that they do not have any designated hazmat routes in their state. The other midwestern state answered that route designations were based on Pipeline and Hazardous Materials Safety Administration (PHMSA) methods and requirements.

When asked if there is a formal procedure followed to evaluate HM routes, three of the six states answered in the affirmative and one answered “no”. The other two states did not answer because they do not have designated hazmat routes in their states. The large northwestern state answered negatively because they stated they do not have the need at the current time. The large northern state answered,

> “For those highways managed by our DOT, a committee is established to discuss the alternatives. Participation is requested from the local government(s) that the highway route restriction would affect. The DOT would comply with the requirements set in 49 CFR 397.71, including public notification and participation. We would also consult with the political subdivisions affected by the proposed routing.”

One of the midwestern states answered that their procedure requires following 49 CFR 397.

Five of the six state representatives replied that their formal procedure for designating hazmat routes has not changed since 9/11. The large northern state replied that after 9/11 some local governments established temporary route restrictions on local streets. Their DOT has not

changed any formal procedure as the routing requirements of 49 CFR Part 397 have not changed since 9/11.

Four of the six state representatives answered that all of the hazmat routes in their jurisdiction are on the FMCSA Route Registry website. Two of six did not answer this question since they do not have any designated hazmat routes in their state.

When asked to list the approaches used to communicate designated hazmat routes to the trucking industry and enforcement agencies, the following information was obtained. The large northwestern state replied that they use the listings on the Route Registry and signs on the Interstate. The large northern state answered,

> "The last time HM routes were changed in [our state] was in the early 1990s when restrictions were removed from newly constructed tunnels. Requests to review the HM routing restrictions came from the local police and fire departments. Official notice of the Commissioner's Order was published in our State Register. Press releases were issued and notifications sent to trucking organizations. If a new route restriction was proposed today, public notification would include those methods and notices published on the DOT website. DOT would notify and consult with officials of affected political subdivisions as required by 49 CFR 397.71 (b) (3)."

One of the midwestern states answered that the Public Utilities Commission Office has a website that displays hazmat route designations. They will also offer information over the telephone to interested parties.

Hazmat route designations and restrictions are enforced in several ways according to the state representatives. The large northwestern state admits there is very little enforcement due to limited manpower. It is a low priority with the limited resources they have available. The large northern state replied that the State Patrol and local police agencies with jurisdiction in specific locations have authority to enforce posted route restrictions. Those agencies can make referrals through the FMCSA VISOR complaint system and request a compliance review on the responsible carrier. One midwestern state answered that route designation is enforced through roadside observation and inspection.

Two of the states did not answer the question because they do not have any designated hazmat routing in their state.

Four of the six state representatives stated that the language of the Federal hazmat routing regulations (49 CFR Part 397) is easy to understand. The large northern state did not feel the same way. They stated that FMCSA should provide more guidance on 49 CFR 397 subparts C and D. No guidance is available on the FMCSA website for these subparts. The regulations are not clear on when a public hearing is necessary and what actions are required for modifications of routes, for example changing regulatory signs on routes. The large southern state answered that they were not familiar with 49 CFR Part 397 as they have not studied the designation of HM routes in their jurisdiction.

When asked about the routing criteria used in the regulations, the following information was obtained. The large northwestern state answered "none" because they do not have the need and do not anticipate the need to designate more routes due to the rural nature of their state. The large northern state replied that they have not established any new routes since the current regulations took effect. If a new or modified route would be proposed, they would follow the requirements in 49 CFR part 397 subparts C and D, as applicable. If new routes are proposed, they would evaluate methods for collecting data. One midwestern state replied they would use 49 CFR 397 as described in the Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials.

Two of the states did not answer the question because they do not have any designated hazmat routing in their state.

Five of the six state representatives did not answer whether or not they assign priority consideration to certain criteria. One midwestern state answered that they use the Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials.

When asked what additional criteria they would use in the regulations if data were available, all six state representatives did not reply or the question was not applicable to their state.

All six state representatives also did not answer a question about additional safety criteria that should be included that currently are not contained in the regulations.

Five of the six state representatives did not answer a question about what security criteria should be included that currently are not contained in the regulations. The large northern state replied that they should address emergency situations such as existed after 9/11.

There were varying responses from the state representatives regarding what is most effective for enhancing safety and security among the following:

- Prohibiting all HM from selected routes
- Prohibiting only certain HM classes from selected routes
- Designating routes that should be used for all HM shipments
- Designating that certain HM classes use selected routes
- Designating selected routes for HM and prohibiting carriers from using other routes simultaneously
- Designating both local and through HM routes

The large northwestern state felt that designating routes that should be used for all HM shipments is most effective. The large northern state thought that prohibiting only certain HM classes from selected routes and designating that certain HM classes use selected routes is most effective. One midwestern state agreed that designating certain HM classes use selected routes is best. The large southern state felt that designating selected routes for HM and prohibiting carriers from using other routes simultaneously is most effective.

Two of the states did not answer the question because they do not have any designated hazmat routes in their state.

None of the six states have applied criteria in the Highway Route Controlled Quantities (HRCQ) of radioactive materials regulations to routing non-radioactive hazardous materials.

When asked whether certain classes of hazardous materials should have special safety and security criteria applied for route selection, the following information was obtained. The large northwestern state thought that it would be a good idea, if practical, but that it was not practical in their state. One midwestern state answered that the hazardous materials that require a safety permit as listed in 49 CFR 385.403 should have special safety and security criteria applied. The southern state replied in the affirmative as well and stated that radiological materials and liquid nitrogen gas (LNG) should have special criteria applied.

Three of the states did not answer this question.

State representative were asked to rate the impact of hazmat routing regulations on safety, security, and carrier productivity. The average ratings, with 1 being no benefit at all and 5 being extremely beneficial, are listed below:

- Safety benefits: 3.5
- Security benefits: 3.5
- Carrier productivity benefits: 2.0

2.4 Tribal Responses

Questionnaires were also sent to a number of tribal representatives. Unfortunately, no completed questionnaires were returned. However, at a DOE-sponsored meeting held in Green Bay, Wisconsin in the fall of 2006, a representative of a tribe whose reservation is on a route used for the shipment of radioactive materials made a statement. Based on our professional judgment, he was a good representative of tribal issues concerning routing. He emphasized that tribes have been concerned with routing criteria related to a number of topics they consider essential when selecting hazardous materials routes. The most important of these criteria include: (a) protection of the land base and ecosystem; (b) preservation of sacred areas; and (c) avoiding traditional use areas.

3.0 Conclusion

Results obtained from surveys administered to carriers and shippers, state agencies, and several transportation associations tended to provide diverse feedback regarding the designation of hazardous material routing. In general, the shippers and carriers believe that although the use of hazmat routes are beneficial for safety, any diversion from the most direct route adds additional operating costs based on traveling added mileage along designated hazmat routes. Furthermore, they had mixed opinions as to whether criteria are needed to ensure security. Among those carriers that thought security criteria could be beneficial, they commented that criteria could be applied only to those materials that could be used as a weapon and specifically to any materials that would require an evacuation of at least 1,000 feet.

The associations that responded to the questionnaire believe that interstates are much safer than other roads with respect to security because any potential terrorists would have less access to vehicles on limited access highways. The associations were also concerned about the process whereby routes are designated and believe that routes can not be selected in a vacuum and that any routing entity must consult with adjacent entities to ensure that routing conflicts do not arise. The associations were skeptical about the benefits that would be derived from adding security criteria. This was in part because they were unaware of any terrorist incidents in the United States that stemmed from the hijacking of a hazmat cargo on the highway.

Results obtained from the state representatives in response to the questions in the questionnaire were, for the most part, far more favorable towards the concept of enhanced safety and security being derived from routing regulations. The state officials believe that, wherever possible, hazmat should be routed on limited access highways to improve both safety and security. The states were more positive about the impact of hazmat routing on both safety and security than the shippers and carriers. The states judged both the safety and security benefits to be rated 3.5 out of a scale of 1 to 5 where 5.0 is extremely beneficial. On the other hand, the shippers and carriers gave safety benefits a rating of 3.0 but the security benefits a score of only 2.6 out of 7.0.

APPENDIX A

SURVEY QUESTIONS AND RESPONSES FOR ASSOCIATIONS

1) Do you believe that the designation of HM routes improves public safety and security?

   If you answered no, explain why the HM route designation process is deficient in achieving these purposes.

2) HM Route Designation Process
   a. Are you generally consulted as part of the process government agencies use to evaluate HM routes?
      If yes, what sort of information are you asked to provide?

   b. How are the designated HM routes communicated to you?
      Does this work well or can you suggest a better method to communicate this information?

   c. List the enforcement tools used to enforce the designation of HM routes. Could this enforcement process be improved? If you answered yes, please list suggested methods.

3) Which is more effective for enhancing safety and security?
   - Prohibiting HM from selective routes
   - Designating routes that should be used for HM
   - Designating routes for HM and prohibiting HM simultaneously
   - Designating both local and through HM routes

4) How does the designation of HM routes affect motor carrier cost of operations?
   a. What factors increase these costs and by how much?
   b. What factors decrease these costs (insurance, incident occurrence and severity) and by how much?

5) Federal Routing Regulations
   a. Are you familiar with the HM routing regulations? (CFR Part 397)? If so:
   b. Is the language of the Federal HM routing regulations (49 CFR Part 397) easy to understand? If not, what is the source of the confusion?
   c. What routing criteria are typically used when such designations are made? What data sources are used?
   d. Is a higher priority assigned to certain criteria? If this is the case, then please list the criteria where this applies.
   e. What additional criteria should be used in the regulations if more data was available?
   f. What additional <u>safety</u> criteria should be included that currently are not contained in the regulations? How would the inclusion of these criteria affect carrier or shipper cost of operations?

g. What security criteria should be included that currently are not contained in the regulations? How will the inclusion of these criteria affect carrier or shipper cost of operations?

6) Should certain classes of hazardous materials have special safety and security criteria applied for route selection? If so, please list the materials that should be subject to this condition and list the criteria that should be used.

7) What changes in the routing regulations would you make to better address security concerns or route-specific vulnerabilities?

Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 7 being extremely beneficial.**

Safety Benefits	1……..2..…..3.……...4.……...5.……...6.……...7
Security Benefits	1……..2..…..3.……...4.……...5.……...6.……...7
Carrier Productivity Benefits	1……..2..…..3.……...4.……...5.……...6.……...7
Other, please specify: _____	1……..2..…..3.……...4.……...5.……...6.……...7

For any answer below 3 or above 5, please indicate the primary issue:

Safety Benefits Explanation: _____

Security Benefits Explanation: _____

Productivity Benefits Explanation: _____

"Other" Explanation: _____

Table A-1 shows the responses received from the three associations. "NA" in Table A-1 means data not available.

Table A-1. Association Responses

Question	Association #1	Association #2	Association #3
1. Do you believe that the designation of HM routes improves public safety and security? If no, please explain why the HM route designation process is deficient in achieving these purposes.	Under certain circumstances, HM routing may improve public safety; however, routing if not done properly may undermine safety by forcing carriers to travel additional vehicle miles or force carriers to use less safe or secure routes. For example, interstate highways generally are safer (have lower accident rates) than secondary roads. Similarly, interstates would be more secure since there are fewer intersections and stopping points along a route. Trucks are most secure when they are in motion. Stops at traffic lights or intersections increase vulnerability.	I believe that the current requirement for a jurisdiction to "consult its neighbors" prior to enacting a routing/time of day restriction should be reinforced and refined. A nod and handshake between a couple of local pals should not be sufficient. For example, there should be a written record in terms of the nature and scope of such consultations.	Yes, route designations are deficient if driven by NIMBY.
2a. Are you generally consulted as part of the process government agencies use to evaluate HM routes? If yes, what sort of information are you asked to provide?	No. Our association is not generally consulted about a proposed route change. Information about routing changes sometimes is passed on from state trucking association executives. Regulations require consultation with affected neighboring jurisdictions, but does not require consultation with the affected industries (carriers and shippers based in the route restricted area).	In many cases, a local HM restriction (enacted by a local jurisdiction) will contain an exception for either "local deliveries" or the need for a "permit". If transportation activities in a given jurisdiction is deemed to be "unsafe", then neither a permit nor local need would make such transportation "safe".	No

Table A-1. Association Responses (Continued)

Question	Association #1	Association #2	Association #3
2b. How are the designated HM routes communicated to you? Does this work well or can you suggest a better method to communicate this information?	They are not. FMCSA should publish all hazmat routes annually. Currently, there is a web site that is cumbersome to use.	Did not answer	Signage – FMCSA is supposed to periodically publish and update a list of state-designated routes. This effort has been fraught with errors and generally not effective.
2c. List the enforcement tools used to enforce the designation of HM routes. Could this enforcement process be improved? If you answered yes, please list suggested methods.	Unfortunately, motor carriers often discover prohibited hazmat routes by receiving tickets from local law enforcement agents. There should be a federal requirement to post signs and to standardize signage for hazmat routes or restrictions. Some local jurisdictions use the term hazardous cargo, which is not a DOT defined term and creates confusion.	Did not answer	Roadside compliance and inspection – Yes. Better communication of routes to industry as well as options if recommendations to vary routes for security reasons become requirements.
3. Which is more effective for enhancing safety and security? • Prohibiting HM from selective routes • Designating routes that should be used for HM • Designating routes for HM and prohibiting HM simultaneously • Designating both local and through HM routes	Designating routes that should be used for HM (#1)	Did not answer	Prohibiting HM from selective routes (#1). Designating routes that should be used for HM (#2). Designating routes for HM and prohibiting HM simultaneously (#3). Designating both local and through HM routes (#4).

Table A-1. Association Responses (Continued)

Question	Association #1	Association #2	Association #3
4a. How does the designation of HM routes affect motor carrier cost of operations?	Route restrictions increase vehicle miles traveled and the time that it takes to deliver freight. This has a negative impact on carrier productivity.	Did not answer	Increased time and miles statistically translates to a less safe operation
4b. What factors increase these costs and by how much?	Quantification of costs may be obtained by individual motor carriers.	Did not answer	Time/Miles. Depends on the deviation required.
4c. What factors decrease these costs (insurance, incident occurrence and severity) and by how much?	Motor carriers already have economic incentives to choose the most direct, least congested roads. In the vast majority of circumstances, this results in motor carriers using the interstate highway system. A lower accident rate could lower insurance premiums; however, route restrictions result in increased vehicle miles traveled and often require the use of secondary roads, which could increase accident frequency.	Did not answer	In the long run, unless routes expedite shipment, does not decrease costs.
5a. Are you familiar with the HM routing regulations? (CFR Part 397)?	Yes	Did not answer	Yes
5b. Is the language of the Federal HM routing regulations (49 CFR Part 397) easy to understand? If not, what is the source of the confusion?	Yes	Did not answer	Yes

Table A-1. Association Responses (Continued)

Question	Association #1	Association #2	Association #3
5c. What routing criteria are typically used when such designations are made? What data sources are used?	Politics and public perception. Most routes were grandfathered in and established before the federal regulations went into effect.	Did not answer	Destinations, interstates, known state restrictions/designations.
5d. Is a higher priority assigned to certain criteria? If this is the case, then please list the criteria where this applies.	Unsure; however, the emphasis should be placed upon the comparative safety analysis of the current route and the proposed new route.	Did not answer	Expedited time to delivery.
5e. What additional criteria should be used in the regulations if more data was available?	Better information on accident rates and traffic flow on specific routes.	Did not answer	Available safe havens
5f. What additional safety criteria should be included that currently are not contained in the regulations? How would the inclusion of these criteria affect carrier or shipper cost of operations?	Regs require consultation with neighboring states. This however does not guarantee that a city or local jurisdiction will consult with Cambridge, Waltham or Somerville (all other affected cities within Massachusetts.)	Did not answer	Did not answer
5g. What security criteria should be included that currently are not contained in the regulations?	Location of iconic value targets - although a terrorist will likely not attack these with a commercial vehicle, but rather will attack them with a vehicle that is not placarded or likely to draw attention of local law enforcement (van, limousine). Location of safe harbors/secure rest areas along the route.	Did not answer	Security concerns should not trump safety. E.g., varying routes has to be balanced with time and distance.

Table A-1. Association Responses (Continued)

Question	Association #1	Association #2	Association #3
6. Should certain classes of hazardous materials have special have special safety and security criteria applied for route selection? If so, please list the materials that should be subject to this condition and list the criteria that should be used.	Yes. Many hazardous materials pose a danger to the environment or require special handling in the event of an incident, but do not pose a danger to the general public even when released. Materials that are immediately weaponized. Explosives above a certain threshold quantity (55 lbs) PIH materials depending upon their quantities and toxicity. None. Routing restrictions will not enhance security and may actually compromise it. Greater federal control would help assure that local jurisdictions do not enact restrictions that simply export risk to a neighboring jurisdiction or are made without properly evaluating the impacts to the commercial transportation of hazardous materials.	Did not answer	Already applied to explosives. Written plans must accompany shipments. Other criteria SSI. Other criteria based on SLP-27 and current route rules.
7. What changes in the routing regulations would you make to better address security concerns or route specific vulnerabilities?	Did not answer	Did not answer	Did not answer

Table A-1. Association Responses (Continued)

Question	Association #1	Association #2	Association #3
Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 7 being extremely beneficial.**		Did not answer	
a. Safety Benefits	4	NA	4
b. Security Benefits	1	NA	4
c. Carrier Productivity Benefits	1	NA	2
d. Other, please specify		NA	
For any answer below 3 or above 5, please indicate the primary issue:			
a. Safety Benefits		NA	
b. Security Benefits	There has never been a terrorist attack in the US using freight that is in commercial transportation. Terrorists will obtain weapons through legitimate means to avoid the risk of detection prior to launching the attack. Most materials are available elsewhere. **Terrorists will not placard loads and will not obey routing requirements;** therefore, routing regulations will only impact the commercial transportation of hazardous materials and will not prevent a terrorist attack.	NA	

Table A-1. Association Responses (Continued)

Question	Association #1	Association #2	Association #3
c. Carrier Productivity Benefits		NA	A lot of effort goes into generation of the route plan. For reasons, beyond the carrier's control, deviation from the route is often required.
d. Other, please specify		NA	

APPENDIX B

SURVEY QUESTIONS AND RESPONSES FOR CARRIERS AND SHIPPERS

1) Do you believe that the designation of HM routes improves public safety and security?

   If you answered no, explain why the HM route designation process is deficient in achieving these purposes.

2) In areas where HM routes are not designated, what criteria do you use to route HM shipments?
   Do you assign priority considerations to certain criteria?
   If the answer is yes, which criteria are assigned priorities?

3) Please list, in order of usefulness, your top three sources of information on HM route locations and restrictions?

   1._____
   2._____
   3._____

4) HM Route Designation Process

   a. Are you generally consulted as part of the process government agencies use to evaluate HM routes?
      If yes, what sort of information are you asked to provide?

   b. How are the designated HM routes communicated to you?
      Does this work well or can you suggest a better method to communicate this information?

   c. List the enforcement tools used to enforce the designation of HM routes
      Could this enforcement process be improved?
      If you answered yes, please list suggested methods.

5) Which is more effective for enhancing safety and security?

   - Prohibiting HM from selective routes
   - Designating routes that should be used for HM
   - Designating routes for HM and prohibiting HM simultaneously
   - Designating both local and through HM routes

6) Does the designation of HM routes increase the cost of your operations?

   a. If you answered yes, please list the factors accounting for this cost increase?
   b. What fraction of your annual HM shipment miles is on designated routes?
   c. What cost multiplier would you attribute to travel over designated HM routes?

7) Please estimate the total annual operating cost per tractor for your fleet.

8) Please estimate the annual increased cost for your business. Please provide an approximate estimate of the size of your operation using numbers of drivers and power units

9) Are you familiar with the HM routing regulations? (CFR Part 397)? If so:

   a. What additional safety criteria should be included that currently are not contained in the regulations?
      How will the inclusion of these criteria affect your cost of operations?
   b. What security criteria should be included that currently is not contained in the regulations?
      How will the inclusion of these criteria affect your cost of operations?

10) Should certain classes of hazardous materials have special have special safety and security criteria applied for route selection? If so, please list the materials that should be subject to this condition and list the criteria that should be used.

11) What changes in the routing regulations would you make to better address security concerns or route specific vulnerabilities?

Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 7 being extremely beneficial.**

Safety Benefits	1……..2..……..3……...4……...5……..6……...7
Security Benefits	1……..2..……..3……...4……...5……..6……...7
Carrier Productivity Benefits	1……..2..……..3……...4……...5……..6……...7
Other, please specify: _____	1……..2..……..3……...4……...5……..6……...7

For any answer below 3 or above 5, please indicate the primary issue:

Safety Benefits Explanation: _____
Security Benefits Explanation: _____
Productivity Benefits Explanation: _____
"Other" Explanation: _____

Table B-1 displays the responses received from the 12 carriers. "NA" in Table B-1 means data not available.

Table B-1. Carrier Responses

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
1. Do you believe that the designation of HM routes improves public safety and security? If no, please explain why the HM route designation process is deficient in achieving these purposes.	Yes. In general, however, some customers may be blocked entirely and then a local permit is required.	Yes and No. This all depends on who has looked at the route. When you look at the earlier PA Turnpike tunnel restrictions as a basis, you could not transport a lot of placarded loads through those tunnels. That took the driver from the most direct route to a rural back road, increase public/residential areas, and poorer condition roadways. If the unit is being taken off the most direct route, then it should be for increased safety/security concerns.	Yes	Yes	No. There is a definite difference in my opinion between public safety and security matters. Some of the items that we designate for public safety sacrifice security. When you define a specific route-then that route is a "known" route and terrorists could watch that route for patterns of operation.	No. We have not seen any evidence or data to support that restricted HM routs improve safety or security.
2a. In areas where HM routes are not designated, what criteria do you use to route HM shipments?		Our routes are evaluated for safety and ease to and from the terminal locations. Most direct, safest, securest route utilized.	Routings are based on state designations.		HM routes are not necessarily the shortest or most practical route. The practical route may be the one where the load is suppose to spend the least amount of time on the road. This route may be OK for a small truck - but not for an 18 wheeler or combination vehicle. There may be lots of hills or curves.	

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
2b. Do you assign priority considerations to certain criteria?	Yes			Yes	Yes.	No. We do not alter our routing process in any way.
2c. If the answer is yes, which criteria are assigned priorities?	Use of National Network and Time			Priority to interstate and multi-lane highways.	Different products require different routes. We may be operating in an area where a trip is only 20 miles or it may be 400 miles. (tunnels, etc.)	
3. Please list, in order of usefulness, your top three sources of information on HM route locations and restrictions?	None. The FMCSA hazmat route registry is insufficient since none of the "local" jurisdiction restrictions are included.	Due to known evaluated routes, not really utilized. Keller Online is my best resource to see the information per state.	#1 Hazardous Materials Compliance Manual JJ Keller. #2 DTOD. #3 DOT websites, individual state	#1 State DOT websites. #2 Historical information within our company. #3 Driver tips.	#1 Rand McNally. #2 PC Miller. #3 Driver route suggestions.	#1 State highway or DOT information. #2 ATA notices. #3 State association information.
4a. Are you generally consulted as part of the process government agencies use to evaluate HM routes? If yes, what sort of information are you asked to provide?	No	No	No	No	No	No

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
4b. How are the designated HM routes communicated to you? Does this work well or can you suggest a better method to communicate this information?	We never receive notification of changes. Since all hazardous materials carriers are now registered with the PHMSA, notice should be provided to the carrier contact on the registration; Also, route database suppliers (e.g. ALK Associates, TeleAtlas, Navteq, etc.) should receive updates to incorporate into routing products.	Not communicated.	Updates from JJ Keller for their compliance manual. Immediate notification of updates would be the optimum choice to ensure full compliance. If PHMSA created a section to post the State regulations regarding routing on their website and if it would allow carriers to register to receive updates, that would be very effective.	State TA and driver tips. Generally works well if you belong to the state TA.	Rand McNally, PC Miler, Internet and driver suggestions. Works for us.	The Pennsylvania Turnpike publishes a guide. Would prefer to see one source; such as a federal database or web page.
4c. List the enforcement tools used to enforce the designation of HM routes. Could this enforcement process be improved? If you answered yes, please list suggested methods	Yes, actual vehicle tracking data could be used by enforcement officials to verify routes.	Signage, Not sure how well it is enforced.	Local and state police, DOT roadside inspections, Highway Watch program.	Yes, warnings and fines, driver tips. Quick notice to drivers company email or other notice sent to CMV business when new or changes are implemented.	Yes, many communities put hazmat routes in place with an ordinance, but mark the routes very poorly with small signs or only one sign on the route.	Mainly roadside enforcement.
5. Which is more effective for enhancing safety and security?			NA			NA
a. Prohibiting HM from selective routes		X				
b. Designating routes that should be used for HM				X		
c. Designating routes for HM and prohibiting HM simultaneously	X					

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
d. Designating both local and through HM routes					X - Answer d is best - however, I again stress there is a difference between security and safety.	
6. Does the designation of HM routes increase the cost of your operations?	Yes	Yes	Yes	Yes	Yes	Yes
a. If you answered yes, please list the factors accounting for this cost increase?	Variable and mileage-based costs for extra distance (labor, fuel, insurance, vehicle maintenance and repair, etc.), administrative costs to recoup differences from actual vs. "rated" miles.	Fuel, driver time/mileage, etc.	Additional fuel, wear and tear on vehicles due to more miles.	Increased mileage pay, additional fuel consumption and decreased handling time because of later arrivals at our terminal.	Reporting practices, manpower requirements, and additional miles driven requires more drivers and equipment, loss of time due to delays in deliveries frustrates many good drivers.	Any operational change out of the ordinary can potentially have a negative impact to our company. The more restrictive it becomes to move HMs, the more our operation would be forced to deviate from their trailer loading plans. That type of interruption is not good. Additionally, alternative routing adds mileage to our linehaul routes, which delays freight. It also adds labor costs for drivers (mileage).
b. What fraction of your annual HM shipment miles is on designated routes?	Approximately 50% since most are not designated.	Due to PA Pike opening up, our restrictions are really low. Tunnels in and around Baltimore and Pittsburgh.	Not available	Don't know for sure but it would be substantially below 1%.	5%	About 30%
c. What cost multiplier would you attribute to travel over designated HM routes?	1.15-1.20x for 500-1,000 miles	??	Not available.	Unknown	3-5%	Less than 5%

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
7. Please estimate the total annual operating cost per tractor for your fleet.		6,341.00	Fleet is still owner operators, cost per tractor would vary for each owner operator and that information is not available to us.	172,000	Need more information to answer this question. Are you asking for tractor depreciation, fuel, insurance, driver costs, maintenance, taxes, license plates, benefits, etc.? You can easily have $60,000+ in driver wages, plus $30,000 in benefits, $50,000+ in fuel, $10,000 in maintenance, etc. These amount to over $150,000 in costs.	$4,400.00 per tractor per year.
8. Please estimate the annual increased cost for your business. Please provide an approximate estimate of the size of your operation using numbers of drivers and power units	NA	1000 / 1400	1500 / 2500	172. Per tractor – 2900 / 3800	3-5% - 140 / 145	about 5% per year - 6700 / 12200
9a. Are you familiar with the HM routing regulations? (CFR Part 397)? If so:	Yes	NA	NA	No	Yes	NA

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
9b. What additional safety criteria should be included that currently are not contained in the regulations? How will the inclusion of these criteria affect your cost of operations?	Carriers should be able to track vehicles and deviations in routes of travel within 15 minutes and have near instantaneous emergency response notification. Each state should designate and publish a 24 hour emergency response number to communicate hazmat incidents with manifest information (via phone and electronically). 2-5% cost increase	NA	Parking and attendance regulations should apply to all hazmat not only certain classes. Locks should be required on all cargo doors transporting placarded amounts of hazmat. We comply with the above suggestions at this time. Cost of implementation was minimal.	NA	Limit 4-wheel traffic on truck routes for hazmat. (Either eliminating completely or not allowing certain lane traffic. Probably higher taxes as additional roads are increased in size.	Requirements should be kept in place as is.
9c. What security criteria should be included that currently are not contained in the regulations? How will the inclusion of these criteria affect your cost of operations?	Trailers should be tracked via wireless transponders with location and status (door, lock) information; a chain of custody form identifying specific drivers should accompany all hazmat shipments. 5% cost increase.	NA	See above suggestions.	NA	Again-when everyone knows that there are specific hazmat routes-the terrorists can zero in on these activities. Traffic congestion will potentially cause delays or crashes.	Security regulations for in-route travel should mirror HM-232 rules. None, since we have these rules in place already.

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
9d. Should certain classes of hazardous materials have special safety and security criteria applied for route selection? If so, please list the materials that should be subject to this condition and list the criteria that should be used.	Yes. Weapons should also be included.	NA	Yes. All table 1 materials in the placarding table. Same criteria used for Class 1 and Class 7 materials.	Yes. Hazmat requiring highway route control and other materials that if released would require an evacuation area greater than 1,000'. Limit to interstate highways and other designated major highways) except for pick up, delivery, and secured holding at company terminal.	There are a lot of chemicals and other products that are used by many factories, etc. They are not limited like explosives or radioactive materials in total locations. Many cities/towns go where the land is and are continually expanding. Schools have been placed on roads that we have regularly used to deliver products. This all affects the routes we feel have been safe to use.	Yes. The agency should have one definitive list of extremely hazardous materials. Should be consistent with ATA's petition to consider a subset of HM's being designated "extremely hazardous materials.
9e. What changes in the routing regulations would you make to better address security concerns or route specific vulnerabilities?	Acknowledge the need to deviate from designated routes for security purposed (similar to armored car service).	NA	NA	NA	Again – designating certain routes in my opinion decrease your security capabilities- especially if time schedules are set-up.	None

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 7 being extremely beneficial.**						
a. Safety Benefits	5	1	5	4	4	NA
b. Security Benefits	4	1	5	4	2	
c. Carrier Productivity Benefits		1	5	1	2	
d. Other, please specify						

Table B-1. Carrier Responses (Continued)

Question	Carrier #1	Carrier #2	Carrier #3	Carrier #4	Carrier #5	Carrier #6
For any answer below 3 or above 5, please indicate the primary issue:						
a. Safety Benefits				Generally less traffic density, reduced accident risk.	More traffic on detours or designated routes.	With the exception of tunnel or bridge restrictions, restrictive HM routing has little history of benefit. It would not be in the best interest of those carriers that mostly transports HMs of insignificant risk in limited quantities to have to adhere to a multitude of designated routes. It would increase the cost of transportation, a cost that would be passed on to the consumer. We should oppose any change in law that would amend Part 397 that creates less of burden for local jurisdictions or states and allows them to designate special routes.
b. Security Benefits				Drivers less likely to stop; reduced hijack risk.	Terrorists know routes to follow	
c. Carrier Productivity Benefits					Lower productivity – but may get paid better for delays	
d. Other, please specify					Restrict 4-wheel vehicle travel on hazmat routes.	

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
1. Do you believe that the designation of HM routes improves public safety and security? If no, please explain why the HM route designation process is deficient in achieving these purposes.	No. The current process used by states and other groups to designate hazmat routes leaves driver's and companies guessing on what routes are considered legal or illegal for hazmat because of the patchwork process currently used. We feel that any designation of a route for hazardous materials leads to less security. It makes the hazmat load an easier target.	Yes. In some instances yes as it keeps them within controlled known areas and prevents them from being in "stop and go" traffic and away from crowds, tunnels, etc. However, the same may be said that it increases odds of likelihood in those designated areas that still have the motoring public on the roadways and from a security standpoint is known where hazmat will be traveling. With that process increases cost to the carriers by having to incur out of route miles.	Yes. For those commodities that a terrorist could utilize for mass destruction such as tankers of petroleum or compressed gases or high explosives.	Yes and No, in the Boston area designated routes and times are being enforced under the 9/11 pretext. Are terrorist adhering to the same regulation that we have to?	Yes - to a minimal amount	As a Fuel carrier in the Greater Atlanta and regional area, our greatest concern would be the creating of inaccessible areas where we might not be able to service existing customers, be they private locales or even some form of public entity. Also, while being routed in a more “security sensitive” route, might that routing involve exposing the vehicle to more unsafe roadway’s or situations, i.e.…steep ditches, unable to access locale from defined direction (many routes we take are to gain access to locales where roadways have been significantly altered since the locale was built making normal/original plan access not a possibility.

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
2a. In areas where HM routes are not designated, what criteria do you use to route HM shipments?	Shortest distance, type and condition of highway, exposure and other risk factors, terrain, continuity of route, possible delays and effects on commerce, climate, and accident history all weighed against alternative routes of travel. This is used for all of our routing requirements, not just hazardous materials.	Out of route miles is probably our first consideration tying back to tunnels, bridges, population. Other factors considered are shortest route, parking, neighborhood, tunnels, bridges, alleys, large congregations of people, etc.	[We] currently embargo all commodities requiring route restrictions. The vast majority of the routing utilized by the corporation is the interstate highway system. If the interstate highway system does not traverse through the area, the most direct route would be utilized. Naturally HM routes for city delivery are basically impractical as freight is destined for specific customers. Many customers ship sporadically and it would be extremely difficult to establish a route for this LTL freight.	Traffic density, type of zone (commercial/residential) roadway type, site assessment for best possible route prior to delivery or thru traffic.	STAA considerations	We do not utilize HM routing.
2b. Do you assign priority considerations to certain criteria?	No		No		Yes	
2c. If the answer is yes, which criteria are assigned priorities?					Mileage, ease of use, traffic congestion.	
3. Please list, in order of usefulness, your top three sources of information on HM route locations and restrictions?	#1 State Trucking Associations. #2 Drivers. #3 Other ABF company personnel in the local area, various media such as Internet listings like the PA Turnpike	#1 US EPA, Designated and Restricted Routes. #2 FMCSA – Route registry. #3 Atlas	#1 Interstate routes. #2 Population densities. #3 Most direct route.	#1 Local Fire Department. #2 State DOT or DOS. #3 State Police	#1 State STAA route maps. #2 Local restrictions for size and weight. #3 Driver feedback which initiates department route	#1 General area knowledge/past experience. #2 Web-based info. #3 Customer input

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
	Authority web site, road signs, etc.				designations.	
4a. Are you generally consulted as part of the process government agencies use to evaluate HM routes? If yes, what sort of information are you asked to provide?	No	No	No	No	No	No
4b. How are the designated HM routes communicated to you? Does this work well or can you suggest a better method to communicate this information?	Please see the answer to number 3 above. This does not work well. We need a single source that carriers and drivers can refer to for HM routes.	They aren't. I reference the web sites above. Works ok, but could be a bit more user-friendly. Could have a routing tool out there such as "Mapquest" that lists out restricted and designated routes on it to assist in trip planning.	No answer	Research via the Internet. Local jurisdictions should provide this information when and if a change is contemplated.	Highway postings and signage.	No answer
4c. List the enforcement tools used to enforce the designation of HM routes. Could this enforcement process be improved? If you answered yes, please list suggested methods	I am not really aware of any enforcement. We follow the designated routes and I do not have any history of enforcement action against our company for violating routing restrictions.	Unsure what the enforcement tools reference back to?	Drivers are designated the most direct route which is controlled by the pay per mile for a specific dispatch. Drivers caught off a specific route receive disciplinary actions.	The only HM route that we travel is through the city of Boston; from our own enforcement all of our units are equipped with GPS. The local enforcement is the Boston P.D. and it does not matter if you're on the HM route, you will be stopped and cited, they	Mileage paid for designated route only.	

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
				don't want trucks in the city, to them the HM route is I-95/128.		
5. Which is more effective for enhancing safety and security?						
a. Prohibiting HM from selective routes	X					
b. Designating routes that should be used for HM			X - B is most practical but no totally iron clad.			
c. Designating routes for HM and prohibiting HM simultaneously						
d. Designating both local and through HM routes		X		X - as long as we work together on it.	X	X

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
6. Does the designation of HM routes increase the cost of your operations?	Yes	Yes	Yes	Yes	Yes	Yes
a. If you answered yes, please list the factors accounting for this cost increase?	More miles traveled and administrative costs such as training and electronic route file maintenance for proper route designations.	Out of route includes fuel, driver time, and wear and tear on the tractor unit.	Route deviations adding more miles would increase the cost to operate dramatically plus would delay service. Many shippers do not stockpile commodities and rely on carriers to provide "just in time" service.	An additional 38 miles to go around, someone has to pay.	Increased mileage in certain areas.	Fuel costs, increased costs to customers, burdening an already disruptive traffic system, more payroll costs for compensating drivers, possible higher insurance costs for vehicles being exposed to unnecessary risks
b. What fraction of your annual HM shipment miles is on designated routes?	This is a number that we don't currently track.	10-15%	Most freight hazardous or non hazardous travel via interstate but none travel on designated routes unless a city or a tunnel or bridge would restrict placarded loads.	3-4%	100%	Zero, we do not adhere to current routes
c. What cost multiplier would you attribute to travel over designated HM routes?	????	Our operating cost for a truck/mile is approximately $1.75-1.85	Increased mileage plus increase fuel!	We have not arrived at that, we are currently evaluating a "blanket city surcharge"	10%	Zero
7. Please estimate the total annual operating cost per tractor for your fleet.	$49,739	Approximately $198,000 in general operating cost for a network truck.	Linehaul equipment estimated cost would be $110,000 per tractor including fuel and city equipment would cost $27,200. Linehaul makes up 40% of the fleet.	NA	$244,000	$80,000

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
8. Please estimate the annual increased cost for your business. Please provide an approximate estimate of the size of your operation using numbers of drivers and power units	This is not a number available to me immediately in order to get this survey in today and I don't believe this is an answer we would be willing to give – 4285 / 6965	Haven't been able to obtain reliable information across the divisions on this	The estimated costs would be very difficult to estimate. HM is a 3-4% of the entire business which would necessitate an increased cost to the shipping public. Embargoing those restricted types/quantities would be the most practical approach to compliance – 26000 / 42000	70 / 115	7% - 10% increase per unit at 4527 [units] - $108,648.00 increase operational expense	$16,000 (20%) +/- (16 / 30)
9a. Are you familiar with the HM routing regulations? (CFR Part 397)? If so:	Yes	NA	Yes	NA	NA	No
9b. What additional safety criteria should be included that currently are not contained in the regulations? How will the inclusion of these criteria affect your cost of operations?	I don't have any suggestions	Bridges and Dams. In most cases avoiding bridges connecting two land masses could be high cost to route around.	None, remember that terrorists have available small quantities of hazardous material through retail outlets similar to commodities found in an LTL environment. Bulk shipments and commodities such as high explosives in class 1.1, 1.2 and 1.3 or zone A poison gas could be utilized for these purposes but 1,000 lbs. of small arms ammunition would be difficult to weaponize.	None.	None	NA

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
9c. What security criteria should be included that currently are not contained in the regulations? How will the inclusion of these criteria affect your cost of operations?	I have no suggestions.	No formulated answer on this.	None	None	None	NA
9d. Should certain classes of hazardous materials have special safety and security criteria applied for route selection? If so, please list the materials that should be subject to this condition and list the criteria that should be used.	Yes. There must be uniformity across the country so my suggestion is to keep routing requirements based on placarded loads or to limit it to a sub group such as the items that require the Hazardous Materials Safety Permit.	Yes. PIH/toxic, Flammable Gas, Radioactive, Explosives. Affected exposure radius and effects, total commodity amount, packing group or risk group.	Yes. Only those items that could easily be weaponized!	Just adhere to the current regs.	Yes. Special permit commodities only.	Yes. In certain cases, such poisonous gases and poisons.
9e. What changes in the routing regulations would you make to better address security concerns or route specific vulnerabilities?	I don't have any suggestions for this question.	Instead of focus on designated routes, maybe legislation towards tracking capabilities or a "panic button" that ultimately shuts the truck down within a specified time.	None	The current regulations if enforced in a uniform manner are adequate; unfortunately some areas use the loose interpretation as revenue enhancement again under the pretext of safety.	NA	Vastly improve general knowledge and utilize system identification where these roads are clearly identifiable to the driver.

Table B-1. Carrier Responses (Continued)

Question	Carrier #7	Carrier #8	Carrier #9	Carrier #10	Carrier #11	Carrier #12
Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 7 being extremely beneficial.**						
a. Safety Benefits	2	5	1	NA	1	2
b. Security Benefits	1	5	1		1	2
c. Carrier Productivity Benefits	1	2	1		1	1
d. Other, please specify						
For any answer below 3 or above 5, please indicate the primary issue:						
a. Safety Benefits	Safety benefits are minimal but there are benefits when dangerous routes are restricted. This potentially prevents being involved in an accident.				STAA and HM routes are identical in most areas.	
b. Security Benefits	No security benefits that we are aware of, actually less secure in our opinion.				Same	
c. Carrier Productivity Benefits	Less productive. Any designated routing equals more miles which equals less production.	Cost			Some urban benefits to non-designated routing.	
d. Other, please specify						

APPENDIX C

SURVEY QUESTIONS AND RESPONSES FOR STATES

1) Do you believe that the designation of HM routes improves public safety and security?
_____Yes _____No

   If you answered no, please explain why the HM route designation process is deficient in achieving these purposes:

2) HM Route Designation Process

   a. What government organizations are involved in designating HM routes in your jurisdiction?
   b. Who initiates this process?
   c. To what extent were the existing HM routes selected in your jurisdiction based on pre-1993 methods (before the implementation of 49 CFR Part 397) or on the routing regulations in 49 CFR Part 397?
   d. Is there a formal procedure that is followed to evaluate HM routes?
      If yes, is public participation and input from shippers and carriers included in the process?
   e. Has this formal procedure for designating routes changed since 9/11?
      If yes, please list any changes in procedure.
   f. Are all of the routes in your jurisdiction on the FMCSA Route Registry website?
   g. Please list the approaches used to communicate designated HM routes to the trucking industry and enforcement agencies.
   h. How are the HM route designations/restrictions enforced? Are you satisfied with these enforcement actions? If not, how can the process be improved?

3) Federal HM Routing Regulations

   a. Is the language of the Federal HM routing regulations (49 CFR Part 397) easy to understand? If not, what is the source of the confusion?
   b. What routing criteria in the regulations do you use? How do you obtain the data for these criteria?
   c. Do you assign priority consideration to certain criteria? If so, which one(s)?
   d. What additional criteria would you use in the regulations if data were available?
   e. What additional safety criteria should be included that currently is not contained in the regulations?
   f. What security criteria should be included that currently is not contained in the regulations?

4) Which is more effective for enhancing safety and security? (you can select more than one category)

   - Prohibiting all HM from selected routes
   - Prohibiting only certain HM classes from selected routes
   - Designating routes that should be used for all HM shipments
   - Designating that certain HM classes use selected routes
   - Designating selected routes for HM and prohibiting carriers from using other routes simultaneously
   - Designating both local and through HM routes

5) Have you applied criteria in the Highway Route Controlled Quantities (HRCQ) of radioactive materials regulations to routing non-radioactive hazardous materials?
   If yes, what lessons have you learned from your experience with the HRCQ regulations?

6) Should certain classes of hazardous materials have special safety and security criteria applied for route selection?
   If so, please list the materials that should be subject to this condition and list the criteria that should be used.

Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 5 being extremely beneficial.**

Safety Benefits	1……..2..……..3.……...4.……...5
Security Benefits	1……..2..……..3.……...4.……...5
Carrier Productivity Benefits	1……..2..……..3.……...4.……...5
Other, please specify: _____	1……..2..……..3.……...4.……...5

For any answer below 2 or above 4, please indicate the primary issue:

Safety Benefits Explanation: _____

Security Benefits Explanation: _____

Productivity Benefits Explanation: _____

"Other" Explanation: _____

Table C-1 displays the responses received from the six state representatives. "NA" in Table C-1 means data not available.

Table C-1. State Responses

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
1) Designation of HM Routes						
1. Do you believe that the designation of HM routes improves public safety and security? If no, please explain why the HM route designation process is deficient in achieving these purposes.	No - At least in my state, Idaho, we have so few highways, especially interstates, that the routing regulations are not very applicable. Other rural states have the same issue. In most cases there is only one option. It's a good idea to keep HM shipments out of populated areas when possible but in our case it's just not practical. We would rather have them on the interstate than a poorly maintained two lane highway that goes around a populated area.	Yes	Yes	Yes and No - It may help public safety. As far as security, it would be possible to have the vehicles in a too predictable location.	Yes	Yes
2) HM Route Designation Process						
2a. What government organizations are involved in designating HM routes in your jurisdiction?	State Police and State Transportation Department	Office of Homeland Security and Emergency Services	The Minnesota Department of Transportation (Mn/DOT) and local governments, including their public works and fire or emergency management departments.	NA - We do not have any non-radioactive routing in Iowa.	The Public Utilities Commission of Ohio	TXDOT, Transportation Engineering, Police Dept., Fire Dept.

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
2b. Who initiates this process?	State Police would if there was ever a need.	Office of Homeland Security and Emergency Services	If the route is on a highway managed by the [State DOT], we would be the Routing Agency. If the route is on local roads, the appropriate jurisdiction would start the process.	NA - We do not have any non-radioactive routing in Iowa.	The party seeking the route designation	Fire or Police Department request
2c. To what extent were the existing HM routes selected in your jurisdiction based on pre-1993 methods (before the implementation of 49 CFR Part 397) or on the routing regulations in 49 CFR Part 397?	We only have one officially designated HM route. It was designated for Hazardous Waste that is going to a disposal site in [a rural county]. The purpose of this route is to keep the trucks transporting the waste out of [a nearby city]. The highways going to the waste site go through [that city] so routes on County roads were designated so trucks would go around it. I'm not sure [of] the year the route was selected but I believe it was prior to 1993.	NA	The only HM route restriction in [our state] is [a city tunnel restriction on a major interstate. This route was established in 1971.	NA - We do not have any non-radioactive routing in Iowa.	Route designations were based on RSPA methods and requirements	NA - Our jurisdiction does not have any designated hazmat routes

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
2d. Is there a formal procedure that is followed to evaluate HM routes? If yes, is public participation and input from shippers and carriers included in the process?	No, because we currently don't have the need.	Yes and Yes	For those highways managed by [the State DOT], a committee is established to discuss the alternatives. Participation is requested from the local government(s) the highway route restriction would affect. [The State DOT] would comply with the requirements set in 49 CFR 397.71, including public notification and participation. We would also consult with the political subdivisions affected by the proposed routing.	NA - We do not have any non-radioactive routing in [our State].	Yes - Procedure requires following 49 CFR 397 - Yes	NA - Our jurisdiction does not have any designated hazmat routes
2e. Has this formal procedure for designating routes changed since 9/11? If yes, please list any changes in procedure.	NA	No	After 9/11, some local governments established temporary route restrictions on local streets. [The State DOT] has not changed any formal procedure, as the routing requirements of 49 CFR Part 397 have not changed since 9/11.	NA - We do not have any non-radioactive routing in [our State].	No	No
2f. Are all of the routes in your jurisdiction on the FMCSA Route Registry website?	Yes	Yes	Yes	NA - We do not have any non-radioactive routing in [our State].	Yes	NA - Our jurisdiction does not have any designated hazmat routes

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
2g. Please list the approaches used to communicate designated HM routes to the trucking industry and enforcement agencies.	Listed on the Route Registry and signs on the Interstate.	None	The last time HM routes were changed in [our state] was in the early 1990's when restrictions were removed from newly constructed tunnels on [an interstate in a medium sized city in the north]. Requests to review the HM routing restrictions came from the local police and fire departments. Official notice of the Commissioners Order was published in the [official State register]. Press releases were issued, and notifications sent to trucking organizations. If a new route restriction was proposed today, public notification would include those methods, and notices published on the [the State DOT] website. [The State DOT] would notify and consult with officials of affected political subdivisions as required by 49 CFR 397.71 (b) (3).	NA - We do not have any non-radioactive routing in [our State].	[Our state public utility commission] website and telephone communications with interested parties.	NA - Our jurisdiction does not have any designated hazmat routes

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
2h. How are the HM route designations/restrictions enforced? Are you satisfied with these enforcement actions? If not, how can the process be improved?	Very little enforcement is done due to limited manpower. This is a low priority with the limited resources we have available.	There are no designated routes in [our State].	The State Patrol, and local police agencies with jurisdiction in specific locations, have authority to enforce posted route restrictions. Those agencies can make referrals through the FMCSA VISOR complaint system and request a compliance review on the responsible carrier.	NA - We do not have any non-radioactive routes in [our State].	Route designations are enforced through roadside observation and inspection.	NA - Our jurisdiction does not have any designated hazmat routes
3) Federal HM Routing Regulations						
3a. Is the language of the Federal HM routing regulations (49 CFR Part 397) easy to understand? If not, what is the source of the confusion?	Yes	Yes	No, FMCSA should provide more guidance on 49 CFR 397 subparts C and D. None is available on the FMCSA website for these subparts. The regulations are not clear on when a public hearing is necessary, and what actions are required for modifications of routes, for example changing regulatory signs on routes.	Yes	Yes	Not familiar with 49CFR Part 397 as we have not studied the designation of HM routes

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
3b. What routing criteria in the regulations do you use? How do you obtain the data for these criteria?	Currently none because we don't have the need and don't anticipate the need to designate more routes due to the rural nature of our state.	NA - no designated routes in [our State]	[The State DOT] has not established any new routes since the current regulations took effect. If a new or modified route would be proposed we would follow the requirements in 49 CFR part 397 subparts C and D, as applicable. If new routes are proposed, we would evaluate methods for collecting data.	Regulations 397.67	49 CFR 397 - As described in Guidelines for Applying Criteria to designate Routes for Transporting Hazardous Materials.	NA
3c. Do you assign priority consideration to certain criteria? If so, which one(s)?	NA	NA - no designated routes in [our State]	NA	Did not answer	See Guidelines for Applying Criteria to designate Routes for Transporting Hazardous Materials.	None
3d. What additional criteria would you use in the regulations if data were available?	NA	NA - no designated routes in [our State]	Unknown at this time	Did not answer	NA	NA
3e. What additional safety criteria should be included that currently are not contained in the regulations?	NA	NA - no designated routes in [our State]	No comment	Did not answer	NA	NA
3f. What security criteria should be included that currently are not contained in the regulations?	NA	NA - no designated routes in [our State]	Address emergency situations such as existed after 9/11	Did not answer	NA	NA

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
4) Enhancing Safety and Security						
Which is more effective for enhancing safety and security? (you can select more than one category)		NA			NA	
a. Prohibiting all HM from selected routes		NA			NA	
b. Prohibiting only certain HM classes from selected routes		NA	X		NA	
c. Designating routes that should be used for all HM shipments	X	NA			NA	
d. Designating that certain HM classes use selected routes		NA	X	X	NA	
e. Designating selected routes for HM and prohibiting carriers from using other routes simultaneously		NA			NA	X
f. Designating both local and through HM routes		NA			NA	X

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
5) HRCQ Regulations						
5. Have you applied criteria in the Highway Route Controlled Quantities (HRCQ) of radioactive materials regulations to routing non-radioactive hazardous materials? If yes, what lessons have you learned from your experience with the HRCQ regulations?	No	No	No	No	No	No
6) Route Selection Criteria						
6. Should certain classes of hazardous materials have special safety and security criteria applied for route selection? If so, please list the materials that should be subject to this condition and list the criteria that should be used.	It would be a good idea if practical but it's not in our state.	No	Did not answer this question	Yes - The hazardous material that require a safety permit as listed in 49 CFR 385.403	NA	Yes - radiological materials, LNG

Table C-1. State Responses (Continued)

Question	Large Northwestern State	Midsize Eastern State	Large Northern State	Midsize Midwestern State	Midsize Midwestern State	Large Southern State
7) Effectiveness of HM Route Restrictions						
Please indicate the impact or effectiveness that existing HM routes/restrictions have on the following outcomes, with **1 being no benefit at all and 5 being extremely beneficial.**		Did not answer this question.	Did not answer this question.	Did not answer - NA		NA
a. Safety Benefits	3				4	
b. Security Benefits	3				4	
c. Carrier Productivity Benefits	2				No answer	
d. Other, please specify					No answer	
For any answer below 2 or above 4, please indicate the primary issue:						
a. Safety Benefits						
b. Security Benefits						
c. Carrier Productivity Benefits						
d. Other, please specify						

Guidance Document: Hazardous Materials Routing Using Safety and Security Criteria

Final Report

Prepared for:

Federal Motor Carrier Safety Administration
U.S. Department of Transportation

March 19, 2008

Prepared by:

Battelle
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Guidance Document: Hazardous Materials Routing Using Safety and Security Criteria

1.0 Background

1.1 Introduction

The Department of Transportation (DOT) has enacted regulations that specify the rules motor carriers are to follow when selecting hazardous materials (HM) transport routes and the standards state and Indian tribe routing authorities must follow when prescribing HM routes (49 CFR Part 397). For route controlled quantities of spent nuclear fuel, the regulations direct the use of the interstate highway system unless a state or Indian tribe designates an alternative route. For the highway transport of non-radioactive hazardous materials, the regulations define standards to be used by state and Indian tribe routing authorities when establishing, maintaining or enforcing routing designations. These standards were promulgated to ensure safe transport of hazardous materials in populated areas.

Terrorist activities, leading to the tragic events in Oklahoma City and on September 11, 2001, as well as those that have occurred in other countries, highlight a concern that both safety and security considerations should be used to designate routes for truck transport of hazardous materials. Consequently, this dictates the need to consider two types of HM incidents, those that are accidental in nature and those that are the direct result of intentional acts, incidents in which HM are used as a weapon. Thus, where previously routing decisions could be based solely on safety criteria, now these decisions should be based on both safety and security considerations. The approach taken here will be to provide guidance for designating HM routes and restricted zones by adding security criteria to the existing safety criteria.

1.2 Purpose of the Guidance Document

The purpose of this Guidance Document is to develop an approach for incorporating security considerations into the existing process routing officials must follow to designate HM truck routes using the safety regulations contained in 49 CFR, Part 397. When designating highway routes for transporting non-radioactive hazardous materials (NRHM), 49 CFR Part 397 lists nine standards a routing official must follow. This Guidance Document will not change or abrogate any of these standards. Rather, this Guidance Document proposes to add steps to the route evaluation process so that security concerns are also addressed. While this Guidance Document attempts to anticipate many of the situations a routing official will face when trying to designate a route that meets both safety and security criteria, there will be cases where the selection will have to rely on one of the standards in the current routing regulation, namely the requirement that the routing official must consult with local officials prior to designating a HM route in area particular jurisdiction. It is assumed that the unanticipated situations not covered by this Guidance Document will be addressed and resolved during these consultations.

When considering route security, the proposed approach uses segment length, trip distance through urban zones, and the proximity of a route to attractive terrorist targets in conjunction with the proximity of these targets to law enforcement personnel. Guidance is also provided on how to reduce the risk in those situations where targets still remain vulnerable even after HM traffic has been diverted onto more secure routes. This Guidance Document provides a method that will enable routing officials to prescribe or restrict HM routing using a stepwise process tailored to the specific safety and security conditions a routing official might encounter. An online Routing Tool provides the routing official with a "hands on" means of assessing routes following the steps described in this Guidance Document. The Routing Tool is available at _____.

1.3 Basic Approach Used in the Document

The approach outlined in this Guidance Document considers the synergistic relationship between safety and security. The objective is to not discard any past routing analyses based on safety criteria, but rather to build off of those analyses by factoring in security considerations.

This Guidance Document proceeds in stepwise manner in order to consider the variety of situations encountered by a routing official. First, the routing official is directed to evaluate the HM routes using the current DOT standards in 49 CFR, Part 397. If a route has been previously designated using these standards, and there is no need to update it, then this activity can be skipped. The only change that needs to be made is to call the previously designated route a candidate route rather than the designated route. Using the approach developed in this document, it will remain a candidate route until all the security steps have been completed.

The examination of the routes for *through* routing of HM uses two safety criteria listed in 49 CFR, Part 397.71(b)(4), the segment length and the accident risk. Accident risk is the product of the segment length, the accident rate on the segment and the exposed population should an accident occur that results in a HM release on the segment.

Once *through* routes have been evaluated using the federal routing standards, the approach considers two new route security assessments. The first security assessment is patterned after the safety assessment methodology, replacing risk with distance traveled through urban areas for each of the routes being evaluated. The second security assessment focuses on critical infrastructure and iconic structures. Critical infrastructure refers to portions of the route where there is the presence of a major bridge or tunnel. Whenever possible, designated HM routes should not pass through critical infrastructure. Iconic structures are those facilities judged to be attractive terrorist targets. The proximity of a route to an iconic structure relative to the proximity of the structure to the nearest police station is used as the security measure of interest. The criteria for determining what constitutes an iconic structure are discussed in more detail in Section 2.2.

Where no candidate route meets the desired safety and security criteria, guidance is presented for providing security protection on a selected route by designating zones that are off limits to HM truck traffic except when a carrier is covered by special permit. These zones provide security protection from the use of HM as a weapon by limiting HM traffic in the zone. While much of

the guidance is provided for assessing the security risk of *through* routing, a third security assessment methodology is presented that considers the proximity of routes to iconic structures which could be used to evaluate the security of *local* HM transport routes.

This Guidance Document acknowledges that caution must always be used when designating routes so as not to overly burden commerce, a routing standard also listed in 49 CFR, Part 397.71(b). As prescribing or restricting HM routes or establishing restricted HM zones are elements of an overall strategy for promoting security, routing officials may determine the extent to which these policies should be part of an overall security strategy.

2.0 Unified HM Routing for Safety and Security

This section provides the background information needed to understand the proposed unified approach for designating HM routes and restricted zones based on both safety and security considerations. The security criteria are designed to augment the current approach used for designating HM routes using only safety considerations. Since the protection of critical infrastructure and iconic structures is an important security consideration, subsection 2.1 discusses the need to protect these facilities. This is followed by subsection 2.2 providing guidance on identifying iconic structures. Subsection 2.3 describes the current approach for designating HM routes based on safety considerations. Subsection 2.4 discusses some of the security benefits that are built into the current safety based hazardous material routing regulations. The final subsection, 2.5, summarizes the application of an integrated approach to enhanced safety and security of HM transport in a metropolitan area.

2.1 The Need to Protect Critical Infrastructure and Iconic Structures

Absent in the current routing guidelines for safety, the security routing method explicitly considers how to evaluate cases where hazardous material transport occurs in close proximity to critical infrastructure and iconic structures. Since the potential exists for individuals or groups to purposely use hazardous materials as a weapon, there is a need to prevent HM traffic from passing over strategically important parts of the transportation system, otherwise known as "critical infrastructure." As a general rule, critical infrastructure refers primarily to major bridges and tunnels.

On the other hand, routes may be located in close proximity to certain structures that might be attractive targets for terrorists. These potential targets are collectively referred to as "iconic structures." Iconic structures are high profile buildings that, if severely damaged or destroyed, would result in significant economic, social, psychological and/or environmental damage to society. They can include critical infrastructure that is not directly a part of the route in question.

2.2 Identifying Iconic Structures

This section provides guidance to routing officials in identifying the most important iconic structures to be considered in a security-driven HM routing evaluation. In this context, keeping HM traffic well away from all iconic structures may pose an undue burden on commerce. The guidance shown below should therefore be used to identify the most important iconic structures that represent the most realistic potential terrorist targets.

For the purposes of classifying iconic structures, they can be grouped into three general categories according to importance: (1) national, (2) regional and (3) local. Examples of national iconic structures would be the U.S. Capitol, White House, Pentagon, Golden Gate Bridge, and Statue of Liberty. Most would probably agree that major financial centers, such as the Wall Street area of New York City, would also be classified as national iconic structures because of the economic impact that might result from a successful terrorist attack. In contrast, a state capitol building, federal facilities located in major urban areas and buildings important to the history of a state or region would be classified as regional iconic structures. Generally, one

can expect that the vast majority of cities will not have an iconic structure of national importance and that cities with populations of less than a few hundred thousand people will rarely have iconic structures of regional importance.

Local iconic structures will likely be the most common. An effective way to classify these is through consultation with local officials. These officials have the greatest knowledge about the importance of local facilities. Moreover, they are also aware of the need to protect these icons.

2.2.1 Guidelines for Identifying the Most Significant Iconic Structures

The following approach is recommended for use by local officials in identifying and categorizing iconic structures which might be protected by controlling HM traffic:

1. National Iconic Structures
   a. Could the structure be attacked and damaged or destroyed using hazardous materials transported in trucks?
   b. Does the structure constitute a vital part of our nation's transportation system (i.e., key bridge or tunnel)?
   c. Is the structure important to the national economy?
   d. When a picture of the structure is shown on television, is it instantly recognized by an adult living in the U.S. and would the majority of foreign adults recognize it as a symbol of the U.S. government and way of life?
   e. Would the potential destruction or damaging of the structure aid in recruiting more individuals to the cause preached by a domestic or international terrorist group?
   f. Would the destruction or damaging of the structure result in a national call for action and a rededication to the U.S. war on terror?
   g. Would most U.S. citizens want the structure or a replica of it rebuilt, thereby restoring it to its former importance?

2. Regional Iconic Structures
   a. Could the structure be attacked and damaged or destroyed using hazardous materials transported in trucks?
   b. Does the structure constitute a vital part of the region's transportation system?
   c. Is the structure important to the regional economy?
   d. If a picture of the structure was shown on TV in the region, would most people living in the region recognize the structure, and know its purpose and something about its history?
   e. Would the potential destruction or damaging of the structure provide sustenance to either domestic or international terrorist groups?
   f. Would most citizens in the region want the structure or a replica of it rebuilt, thereby restoring it to its former importance?

3. Local Iconic Structures
   a. Could the structure be attacked and damaged or destroyed using hazardous materials transported in trucks?
   b. Does the structure constitute a vital part of the local transportation system?
   c. Is the structure important to the local economy?
   d. Does the structure exhibit symbolic value for the local area (e.g., a stadium or an arena of a team that has or is a contender for a national championship)?

e. Would the destruction or damaging of the structure result in a region wide response to join with the local officials in raising funds to replace or repair the damage to the structure?
f. Would damage or loss of the structure (bridge, tunnel, or ferry) result in a significant loss in time and money because of greater travel times for thousands of commuters?

Table 1 provides a representative list of the types of iconic structures that could be identified, along with their associated categories and relative attractiveness (weighting). These rankings will be used directly in the security route evaluation methodology.

Table 1. Representative List of Iconic Structures

Icon Level	Example of Icon	Weighting
National	National Capitol, Supreme Court Building	4
	Major monument: Statue of Liberty, Bunker Hill Monument	4
	Historic site: Mount Vernon, Monticello	4
	Iconic skyscraper: Empire State Building, Sears Tower	4
	Golden Gate Bridge, Lincoln Tunnel	4
	Corporate headquarters for an internationally recognized firm	4
Regional	State capitol	2
	Sports facility for major league football or baseball	2
	Nationally known indoor sports arena	2
	Historic site of regional importance: Presidential library, Yellowstone Lodge	2
	Federal building	2
	Bridge or tunnel of regional significance	2
Local	State office building	1
	Large structure at a major university	1
	Art, science or history museum	1
	Convention center	1
	Bridge or tunnel of local significance	1

2.3 Safety Regulations for Routing of Hazardous Materials

In the mid-1990s, DOT finalized routing regulations for trucks carrying placarded quantities of Non-Radioactive Hazardous Materials (NRHM). These regulations supplemented earlier routing regulations for shipping highway route controlled quantities (HRCQ) of radioactive materials. Both sets of regulations, found in 49 CFR, Part 397, were prepared to enhance public safety during the transport of these materials. For the transport of spent nuclear fuel, separate transport security requirements, not tied to any routing regulations, have been issued by the Nuclear Regulatory Commission (NRC) (10 CFR, Part 73.37). Spent nuclear fuel shipments, since they also exceed the threshold for being classified as HRCQ shipments, must meet the aforementioned requirements as well. For truck transport of spent nuclear fuel, the NRC

requirements specify the use of full-time escorts and that the vehicle must be equipped with communication equipment and an NRC approved immobilization device. The second driver, if armed and trained in the use of firearms, can serve the function of the escort. In highly populated areas, an additional escort in a separate vehicle is required. The NRC regulations also specify that the shipper must pre-notify the Governor or an official designated by the Governor, specifying the cargo being transported, its planned shipment schedule, and the route to be taken through the state. The only routing component of these regulations is that the routes used by the carriers must be pre-approved by NRC. The NRC regulations do, however, establish the precedence for imposing additional security requirements on routes selected to enhance public safety.

Both the HRCQ and NRHM routing regulations give routing officials the authority to designate routes. The HRCQ regulations require the use of interstate highways and, where they exist, interstate highway beltways or bypasses around urban areas. The NRHM regulations provide a set of standards to be followed for designating HM routes. While both regulations normally result in prescribing an interstate highway for the *through* routing of HM, the two regulations approach the end result in a very different manner. In the case of HRCQ designation, the official is selecting an alternative route to the one designated in the regulations, whereas for NRHM shipments, the routing official is designating the HM route. The approach described in this Guidance Document for designating routes, taking security into consideration, advises the routing official to consider use of interstate highways or roads built to interstate highway standards when prescribing NRHM routes. Like both the radioactive and NRHM safety regulations, the focus will be on all shipments, recognizing, however, that separate assessments may be required for routing *through* and *local* HM shipments. Most authorities, if they have designated routes, have made a distinction between *through* and *local* HM shipments and, in most cases, made the decision to prescribe routes only for *through* transport of NHRM.

The HRCQ regulations not only specify that interstate highways (including bypasses and beltways) are to be used to circumvent urban areas, but they also specify a process officials must follow to designate alternative routes. In the case of the NRHM routing regulations, there are no baseline requirements regarding the use of interstates (including bypasses and beltways), but instead the regulation focuses on the process and criteria a routing official should use to designate a route. The NRHM regulations can be applied to all HM shipments, both those with local origins and destinations, as well as those passing through the area. If the routing official does not formally designate a route, then there is no routing restriction for the transport of NRHM. Because of the voluntary nature of this regulation, at the beginning of calendar year 2007, only one-third of the states and a few tribes had designated routes for NRHM. In almost all cases, the designated routes have been for *through* routing of hazardous material and not for *local* routing.

While the regulations for HRCQ of radioactive material and for NRHM are markedly different, the common feature of both regulations is that only a state or tribal official can designate routing of these materials. This prevents local officials from acting on their own to restrict hazardous material transport. They must work with the designated routing official who is charged with considering the best interest of all citizens, rather than those in one community.

The regulations governing the routing of NRHM in 49 CFR, Part 397 place responsibility for carrying out the steps necessary to establish and enforce the routing regulations with the state or tribe having jurisdiction over the designated routes. The state or tribe must make a finding, supported by the record, that the routing designation enhances public safety. It is then the responsibility of the motor carrier transporting the hazardous material to comply with the routing regulation.

Within the existing NRHM routing regulations, 49 CFR, Part 397.71(b) specifies nine federal standards that must be followed by the routing official. The fourth standard states that if the:

(i) current routing presents at least 50 percent more risk to the public than the proposed routing, then the proposed routing designation may go into effect

(ii) current routing risk represents more risk but less than 50 percent more risk to the public than the proposed routing designation, then the proposed routing designation shall only go into effect if it does not force a deviation of more than 25 miles or result in an increase in trip length of more than 25 percent of the part of the trip affected by the deviation, whichever is shorter, from the most direct route through a jurisdiction.

Although only two measurable routing criteria, public safety risk and trip distance, are contained in the regulations, the regulations do list thirteen factors to consider when estimating public safety risk. Some, such as *(i) population density within the zone of potential impact, (iii) types and quantities of NRHM* and *(vi) exposure and other risk factors*, can be directly related to public risk. Others, such as *(ii) type of highway, (iv) emergency response capabilities, (vii) terrain considerations, (xi) delays in transportation, (xii) climate conditions*, and *(xiii) congestion and accident history*, are directly related to public safety risk because they affect the likelihood of an accident. While the aforementioned factors directly affect public safety risk, they can indirectly impact public security risk. For example, it is more difficult for a group of terrorists to take over a shipment on a freeway where access and egress is limited, and where traffic is moving at the posted speed limit. It is much easier if the hazardous material is traveling on local streets and traffic is congested. The remaining factors, *(v) results of consultations with others, (viii) continuity of routes, (ix) alternative routes*, and *(x) effects on commerce*, are not related to risk but are important to the process of designating alternative routes to enhance safety and/or security.

2.4 Security Benefits Associated With Safety Criteria

Because it is important for routing officials to understand the security implications built into the existing safety regulations, this subsection discusses the unintended security benefits of using the current NRHM routing regulations in 49 CFR, Part 397 Subpart C as a framework for route evaluation.

While the majority of the current standards are procedural in nature, there are three standards that are quantifiable and require specific attention. These are: (4) *through routing*, (7) *reasonable routes to terminals and other facilities*, and (9) *factors to consider.* For these, any security benefit, although unintended, should be recognized.

Under the *through routing* standard, the regulation considers risk to the public as the primary criteria and distance as the tradeoff criteria if the risk to the public for the most direct route is greater, but less than 50 percent more than the proposed routing designation. The standard recognizes that, generally, the longer the route, the greater the risk of an accident. The security risk similarly increases, as a longer route provides more opportunity to compromise the shipment. The risk to the public from a HM release (safety risk) has a component that is not related to security (accident rate) and a component that is related to security (population density). From both a public safety and security point of view, releases in a highly populated area result in greater impacts, increasing the concern about their occurrence. Transporting hazardous materials on roads through less densely populated areas results in both a safety and a security benefit. In many cases, bypasses and beltways around large urban areas, although somewhat longer, result in more travel through areas having lower population density. Thus, this federal standard is only applied to the *through routing* of hazardous materials.

The seventh standard, *reasonable routes to terminals and other facilities,* clearly has both a safety and security benefit. The ninth standard, *factors to consider,* lists 13 factors to be considered when designating a HM route. The first four, *population density, type of highway, types and quantities of HM, and emergency response capabilities,* clearly affect both safety and security. Of the remaining standards, *exposure and other risk factors, terrain considerations, continuity of routes, effects on commerce, delays in transportation, climatic conditions* and *congestion and accident history*, show a similar relationship. If one or more of these factors is judged to have no effect or makes one route safer than another, then the routing official would probably conclude that the security of the safer route was the same or better than the alternative route. That leaves two factors, *results of consultation with affected persons* and *alternative routes,* which relate more to the route identification process than to either safety or security considerations. These two factors force the routing official to evaluate routes that others might identify.

2.5 Summary of an Integrated Approach to Enhanced Safety and Security of HM Transport in a Metropolitan Area

This section summarizes the proposed approach that routing officials can use to enhance the safety and security of HM routes in their jurisdiction. This approach leverages HM routes that have already been designated using safety criteria. Although the focus will be on designating *through* routes, consideration will also be given to designating *local* HM truck routes and restricted zones. Section 4.0 describes the methodology in detail.

The proposed approach involves a series of steps as summarized in Table 2. The first step evaluates the relative safety of proposed HM *through* routes. The criteria shown in the NRHM Routing Guidebook is used for this step. Once this step is completed, some of the same information is used to perform a parallel security evaluation (see Steps 2 through 9). The *through* routes for HM transport are evaluated in Steps 2 through 4 and routes for *local* HM transport are evaluated in Steps 5 and 6. Step 7, if necessary, further restricts *through* or *local* HM routes by establishing HM free zones. Steps 8 and 9 are implementation steps; the proposed HM route designations are first discussed with local officials in Step 8, and then after

adjustments are made based on those discussions, implemented in Step 9. The implementation process will differ among states and tribes.

Table 2. Summary of Routing Methodology

Step	Description of Step	Criteria Used	Possible Outcome
1	Assess the safety related to the through routing of HM by looking at the overall distance traveled, the accident rate, and the average population density along each alternative route	For the currently designated and each alternative route, the total distance ratio (using the designated route distance as the denominator) and the accident risk ratio are calculated. A measure of the accident risk is the product of the total distance, the accident rate and the total population adjacent to the route. The route with the lower accident risk is used in the denominator of the risk ratio calculation. A candidate route is one where the accident risk ratio is greater than 1.5 or, if between 1.0 and 1.5, the overall distance ratio is less than 1.25.	If the proposed alternative route meets the safety criteria, then it is designated as a candidate route, otherwise both routes are carried into the security evaluation as candidate routes
2	Address the security related to the through routing of HM by determining the distance through urban zones and the total route length for the most direct route and for route alternatives that use bypasses built to interstate standards	The ratio of the route distance through urban zones is calculated, as is the total distance ratio. A route is considered a candidate route if its urban zone distance ratio is greater than 1.5, or if between 1.0 and 1.5, the overall distance ratio is less than 1.25.	If the proposed alternative route meets the criteria, then it is designated as a candidate route pending evaluation in subsequent steps. If neither the most direct route nor the alternative route has a significant difference, both are considered candidate routes for the subsequent steps.
3	Address the presence of critical infrastructure on the candidate route(s).	Routes having critical infrastructure are dropped as candidate routes.	Carry all candidate routes with no critical infrastructure to Step 4. If all candidate routes are eliminated at this step, go back to Step 2 and identify additional candidate routes. If no additional routes can be designated as candidate routes, retain the previous candidate routes but for those that do not pass Step 3, the decision might be made to require escorts for those classes of HM that could pose a threat to the structure

Table 2. Summary of Routing Methodology (Continued)

Step	Description of Step	Criteria Used	Possible Outcome
4	Address the proximity of iconic structures to the candidate route(s).	The three relevant measures are the closest approach distance from an exit on the candidate route to the iconic structure, (A); the importance of the iconic structure, (C), on a 1 to 4 scale, 4 being the most important; and the distance of the nearest police station to the iconic structure, (B).	Routes where A/C< B for all iconic structures along the route remain as candidate routes.
5-6	Use Steps 3 and 4 to evaluate the security aspects of local HM traffic. Address whether restricting local HM travel on selected route segments would improve the security of critical infrastructure and iconic structures	Use the same criteria as used in Steps 3 and 4 but now apply the analysis to determine the effect of restricting the local flow of HM on the selected urban route segments.	The typical outcome is to restrict local HM travel on route segments as a means of increasing the security associated with critical infrastructure and iconic structures
7	If local or through routes are too close to iconic structures, consider forming a one-quarter mile buffer around them as a HM free zone	No criteria are used. This is a feasibility assessment. If there would be too many zones or too much restriction to the normal flow of HM traffic, then such restrictions might be considered to be an excessive burden on commerce.	If it is concluded that the restrictions would be too great or such restrictions are not feasible, then the routing official would recommend to the state or tribal authorities to seek security measures other than those associated with routing
8	Discuss the results with local officials	Review criteria and data to get their agreement as to accuracy of findings	Start the process of taking the remaining candidate route and designate it as the route to be used for through HM traffic. Restrictions recommended from Steps 1, 3 and 7 would also be discussed.
9	Implement the route designations		The designated route segments become part of the state or tribal statutes and are transmitted to FMCSA in accordance with 49 CFR, Part 397.103(c)(1)

When evaluating the security aspects of *local* HM transport, an assumption is made that the preferred HM routes would be limited access roads built to interstate highway specifications and that only the existence of critical infrastructure on or iconic structures near those routes would lead to route restrictions. Thus, the evaluation of *local* HM routes would not consider the safety and security risk associated with transport *through* urban areas. When proposing such restrictions on *local* HM travel, continuity of routes must be a major consideration, as routing restrictions that become a major burden on commerce could be disallowed in any preemption challenge[1].

The current NRHM routing regulations for safety are voluntary. The regulations must be followed only when the routing official chooses to designate HM routes. It is proposed to maintain this voluntary element of the current NRHM routing safety regulations even after adding the proposed security routing requirements. The current NRHM regulations have some secondary factors that can be used in the route evaluation process. As shown in subsection 2.4, some of these secondary factors also enhance security. These secondary factors would be quantified as part of the route evaluation process and presented to the local officials as additional considerations that could be factored into the decision making process. After considering all of the factors, the voluntary nature of the regulations permits the routing official to conclude that there is sufficient justification for designating new routes or restricted zones to enhance both safety and security or, alternatively, that no designations are needed.

If the route is being assessed for specific types of HM, the routing official may decide to select different exposed population impact distances (bandwidths) when calculating if a route segment should be classified as urban. The NRHM Guidelines presents several options for selecting the bandwidth. One option is to use bandwidths equal to the evacuation distances specified in the 2004 Emergency Response Guidebook (US DOT 2004). The most common bandwidth in the book is for fires involving almost every hazardous material and in every instance the bandwidth is 800 meters (about one-half mile). The NRHM Guidelines also present several other options. One option is a table with bandwidths ranging from 300 meters (0.18 miles) for explosives, to five miles for toxic by inhalation (TIH) releases. If specific phenomena were considered, bandwidths as small as 100 meters (0.06 miles) might be used for hazardous materials with very poor dispersal characteristics, such as Class 8 corrosives with low vapor pressures. In addition, the fireball from a release involving a gasoline tanker would not be expected to have consequences beyond 100 meters. Because boiling liquid expanding vapor explosions (BLEVEs) are capable of propelling shrapnel hundreds of meters, offset distances of 800 to 1,600 meters (one-half to one mile)) might be used if these specific types of hazardous materials are being considered in the evaluation. If the routing official decided to use one bandwidth for all hazardous materials, an 800 meter bandwidth on either side of the roadway would be considered reasonable.

[1] Preemption refers to the concept that federal laws can take precedence over state laws that are inconsistent or contrary to federal laws (see http://rspa-atty.dot.gov/preempt/intro.html).

2.5.1 Developing a Balance Between Designating Routes and Controlling HM Transport Using Travel Restrictions

Routing officials are likely to encounter a variety of situations when deciding whether designating a HM route is sufficient for an urban area. The following subsections list a few frequently encountered situations and discuss how they can be addressed in a way that will enhance security

2.5.1.1 Cases where Designated HM Routes Provide Sufficient Security and No Additional Route Restrictions are Needed

In many large cities, several interstate highways traverse the urban area and the entire urban area is circumscribed by a beltway that is the designated HM *through* route based on safety considerations. If the designated route is far enough away from any iconic structures, then there is no need to identify any route restrictions for security.

2.5.1.2 Cases where Restricted HM Travel Provides Sufficient Security and No Designated Routes are Needed

In some urban areas it is easier to restrict HM access rather than designate HM routes. This has been done when a single route restriction effectively diverts HM traffic away from the very dense core of a large metropolitan area or where there is one region of concern and many alternative routes avoid the area and have favorable characteristics. For example, all HM travel is prohibited through Yellowstone and Grand Teton National Parks, but there are alternative U.S. highways that bypass the parks and a single restriction effectively eliminates the risk of HM accidents in pristine areas and locations of heavy tourist population. In other instances, routes have been restricted around hospital complexes. If routing officials had been evaluating the security aspects of routes, in all likelihood they would have also used restrictions as a way to control HM transport.

2.5.1.3 Cases where Both Designated HM Routes and Restricted HM Travel Result in a Balanced Security Program

There are a few cases where a combination of designated routes, prescribed and restricted, has been used. In most cases, the prescribed routes removed the *through* HM traffic from an urban area and the restricted routes controlled the movement of *local* HM traffic, usually to reach shipping origins and destinations within a beltway. Since damage to a central business district can result in severe economic losses, route restrictions in these areas might become more common when the security element is an added consideration.

2.5.1.4 Mandate Some Types of HM to Follow a Certain Route

In general, designating HM routes for specific classes of hazardous material occurs only when a routing official is concerned about the flow of a material that is known to have severe, acute consequences if a release occurs. For example, California routing officials have established designated routes for shipments of explosives, radioactive materials, and TIH materials to control their movement in a regional as opposed to an urban setting. Similar considerations can be made when evaluating the security aspects of routes.

2.5.1.5 Mandate that Specific Type(s) of HM Follow a Certain Route at Specific Times

Time of day restrictions are a common way to enhance public safety be prohibiting HM traffic when routes are highly congested, typically during rush hours. Traffic congestion is one of the safety criteria to be considered when establishing routing restrictions or prescribing HM routes. Such restrictions can lower accident risk and severity when considering public safety. Since the consequences would also be more harmful from a purposeful act during these periods, security risks can also be lowered by imposing time of day restrictions on travel. Thus, routing officials may decide to impose time of day restrictions when considering transport security of specific types of HM.

2.5.1.6 Restrict All HM or Some Types of HM on Specified Routes at All Times

In most cases, it is desirable to restrict HM traffic at all times. Such a restriction is much easier to regulate and recognizes that the threat to iconic structures is present at all times.

2.5.1.7 Restrict All HM or Some Types of HM on Specified Routes at Specified Times

Restrictions to specific times are almost always imposed on *local* rather than *through* HM transport. Time of day restrictions are imposed when it has been determined that a complete ban is likely to be an impediment to commerce. For example, a total ban on explosive shipments across the Golden Gate Bridge in California would certainly be desirable in protecting the infrastructure and minimizing disruption to daily commuter travel. However, since a complete ban might be deemed to be an unreasonable impediment to commerce, explosives could be escorted across the bridge at certain times, such as between 9:00 a.m. and 6:00 p.m. Alternatively, certain types of HM might be permitted during nighttime hours. For example, all HM transport on Manhattan Island in New York City must occur between the hours of 1:00 a.m. and 5:00 a.m. Just as these restrictions lower safety risk, they would also lower security risk because fewer people would be exposed should a purposeful hazardous material release occur.

2.5.1.8 Establish Restricted Zones where HM Transport is Controlled by a Permit or a Security Plan System

A permitting system is almost always used to control *local* HM travel. For example, in Yellowstone and Grand Teton National Parks, while prohibiting all through HM transport is feasible because there are reasonable alternative routes, there is also a need to supply gasoline and fuel oil to service centers located inside park boundaries. In addition, there is the occasional need for explosives for a construction project. In these two national parks, the permits also specify refueling the service areas when the general public is not present, during the late evening and night time hours. The permitting system enables park management to control both the routes to be used and the time of day that necessary HM shipments will be made. It is anticipated that the same logic would be used when evaluating HM security.

3.0 Detailed Methodology for Designating Routes or Restricting Travel Based on Security Criteria

This section describes a methodology that is proposed to control the movement of trucks carrying hazardous materials in a manner that would enhance the security of these shipments. The methodology has been designed to supplement any methodology that routing officials may be using to enhance the safety of these shipments through compliance with the hazardous material routing regulations in 49 CFR, Part 397. A routing official may decide to use the safety methodology, the security methodology, or both of them. Upon applying the methodologies, a routing official may decide, after consultation with key stakeholders, to adopt all, some or none of the results. This methodology does not attempt to provide officials with a means of conducting a more detailed vulnerability analysis that would assess specific threats to specified targets (critical infrastructure and iconic structures) in an area. Guidance for officials who would like to conduct a more detailed vulnerability assessment is presented in Appendix A.

3.1 Description of the Methodology to Enhance Route Safety and Security

Separate approaches have been developed for *through* routes and *local* routes, as follows.

1. *Urban and regional through routes*. This assessment of *through* routes establishes candidate routes for hazardous materials traversing an urban area or a region containing several urban areas (e.g., urban clusters). Three analyses of *through* routes are performed. The first analysis uses the safety criteria and the second analysis uses the security criteria. The third analysis examines, for candidate routes, their proximity to iconic structures to determine if additional route restrictions are warranted to enhance security. At each analysis stage, the desire is to develop candidate routes to carry into the next stage. If a route remains a candidate route after all the analysis stages have been completed, then the routing official may, after consulting with local officials, make a route designation. If the results are inconclusive, the routing official may decide to not designate any HM routes or may, after consultation with local officials, decide to use other types of HM route restrictions (e.g., use of escorts or imposing time of day restrictions for all HM or specific classes of HM). Any restrictions must be shown to not impose an undue burden on commerce.

   The urban component of *through* routing would be applied primarily to area metropolitan area having more than 150,000 inhabitants. Cities with populations of larger than 150,000 people include over one hundred of the largest cities in the country. Smaller cities, such as Great Falls, MT, Augusta, ME, or Savannah, GA, typically have no limited access highways going through the heart of the city, but do have bypasses built to interstate highway specifications. For cities of more than 150,000 inhabitants, a truck driver probably has the option of using limited access highways built to interstate highway specifications to transport hazardous material on the most direct route through the urban area, or to transport the material on bypasses or beltways around the urban area. In such cases, because the carrier has the option of driving through or around the urban area, it is reasonable for a routing official to consider establishing a designated route to improve security. While the assumption is made that most of the designated routes would be expressways built to interstate highway specifications that go around the urban area, the

methodology could be applied to other types of roadways. Limited access highways are the focus of route selection because travel on such highways is safer and usually more secure.

The regional component of the methodology recognizes that routing officials will occasionally encounter a situation where, because of the close proximity of populated areas, designating a route to avoid one urban area will direct the HM through another area. When this occurs, it is appropriate for the routing official to consider the entire region rather than independently assess each urban area. The regional analysis is best suited for a densely populated area of the country, such as parts of California and New Jersey. It could also be applied to urban clusters, such as the Baltimore–Washington corridor. In such settings, regional planning, as opposed to urban planning, becomes an important consideration when addressing both HM route safety and security.

2. *Local movements for pickups and deliveries*. The *through* routing standard – 49 CFR, Part 397.71(b)(4) – isnot easily applied to *local* pickups and deliveries. Accordingly, this methodology is for *local* movements to enable pickup and delivery. In such instances, one may designate *local* HM routes or establish HM restricted zones to provide enhanced security for iconic structures. The proposed methodology to provide enhanced security for iconic structures for *through* routing of hazardous materials is instead applied to local movements. This methodology is primarily for use within urban areas but could also be applicable for smaller cities. It is assumed that if a routing official evaluated the safety of local HM movements, the official would instruct motor carriers to use the roads built to interstate highway specifications where feasible but would not formally designate routes for local HM movements. As this recommendation would also promote security, this methodology proposes to enhance the level of safety and security by evaluating the relative proximity of the iconic structures to these interstate highways and to the nearest police stations. Since these roads are likely to be closer to iconic structures than beltways or bypasses more often prescribed for *through* routing of HM traffic, it is likely that the portion of the methodology that evaluates the need to restrict travel on *local* roads and/or to establish HM-free security zones will be applied more often if *local* HM movements are included in the assessments. It also follows that if *local* HM movements are evaluated, the proposed restrictions might be found to unduly limit commerce, resulting in a scale back of the HM transport restrictions.

As is the case in presenting the methodology for assessing safety risk in the NRHM Guidelines, a major section is devoted herein to describe overall planning that would be performed before beginning the process of considering designated routes and HM restricted zones. Part of the planning effort would include an assessment of the need to apply security criteria to existing routes that have been designated using the safety based routing regulations, or to select new candidate routes based on security considerations. Such a planning step would apply to both *through* and *local* routing situations. For both *through* and *local* routes, the types of questions that would be asked are:

- Does an existing or potential credible terrorist threat exist that could result in HM cargo being used as a weapon to damage or destroy critical infrastructure or nationally, regionally or locally recognized iconic structures?

- Do current designated HM routes protect these iconic structures by ensuring that HM shipments travel at sufficient distance from the potential targets?
- Have measures already been taken to protect potential targets using methods such as constructing barriers and stationing police close to the iconic structure?

After this assessment, the routing official may conclude that the decision to apply security criteria to either existing designated routes or new routes may or may not be justified. This conclusion would be discussed with local officials and then documented.

Assuming that the routing official did decide to evaluate both the safety and security of HM transport in a specific urban area or region, Figures 1 through 5 provide flow charts showing a logical sequence of steps for identifying the most effective set of routing designations and restricted HM zones. Figure 1 is the master chart that directs the routing official to the subsequent figures as the analysis proceeds.

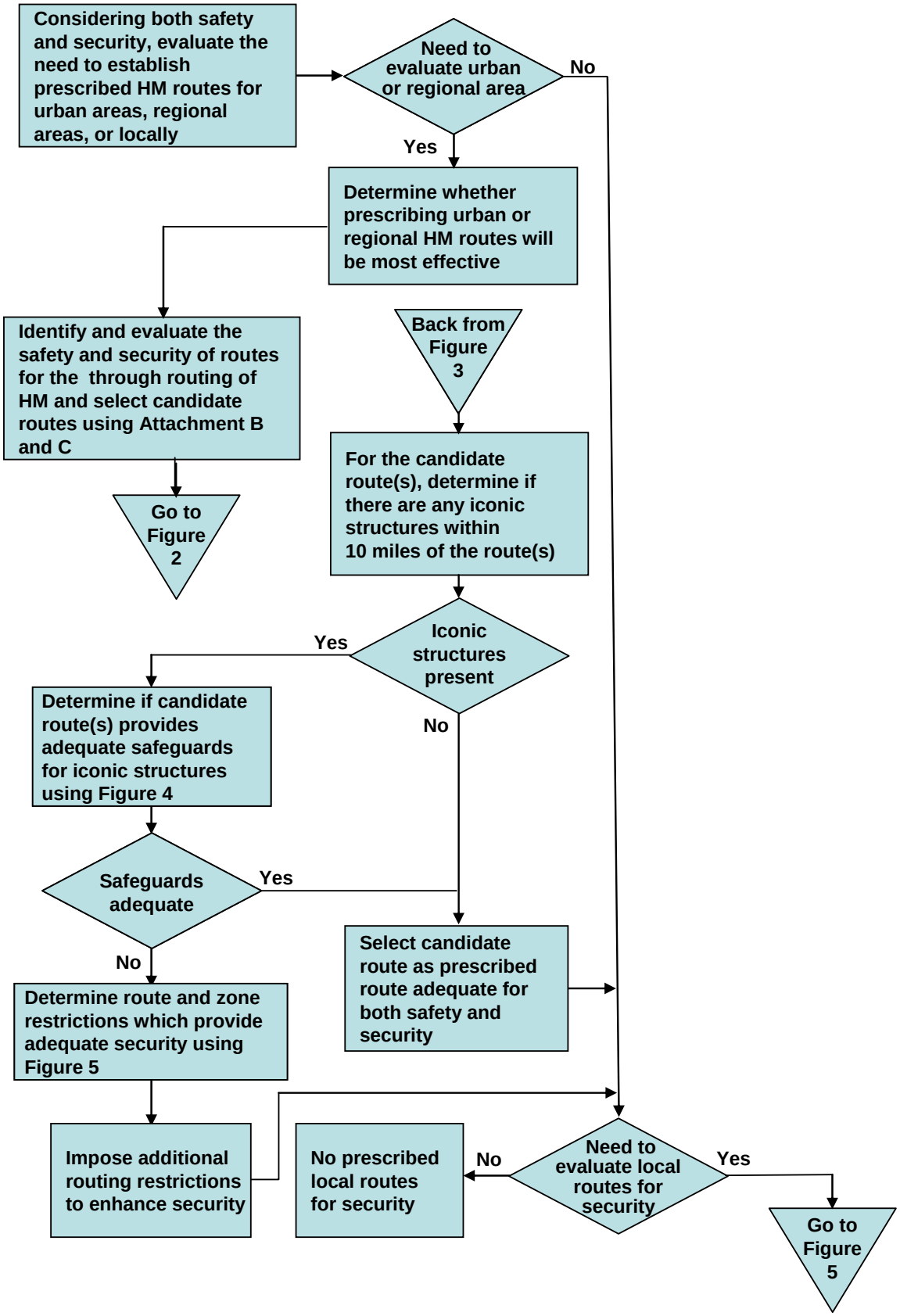

Figure 1. Overall Methodology for Designating HM Routes

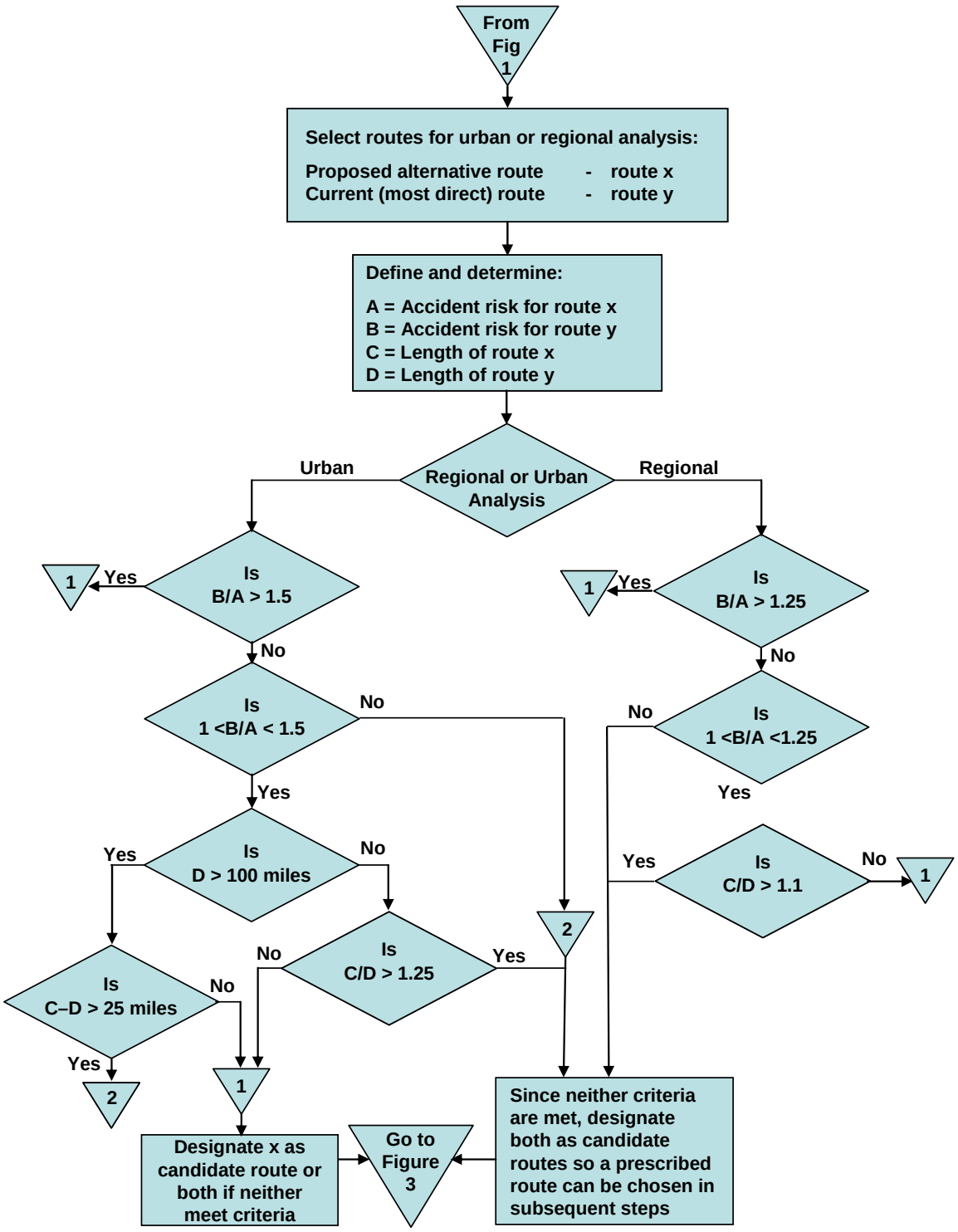

Figure 2. Designation of HM Routes for Urban and Regional Areas Using Safety Criteria

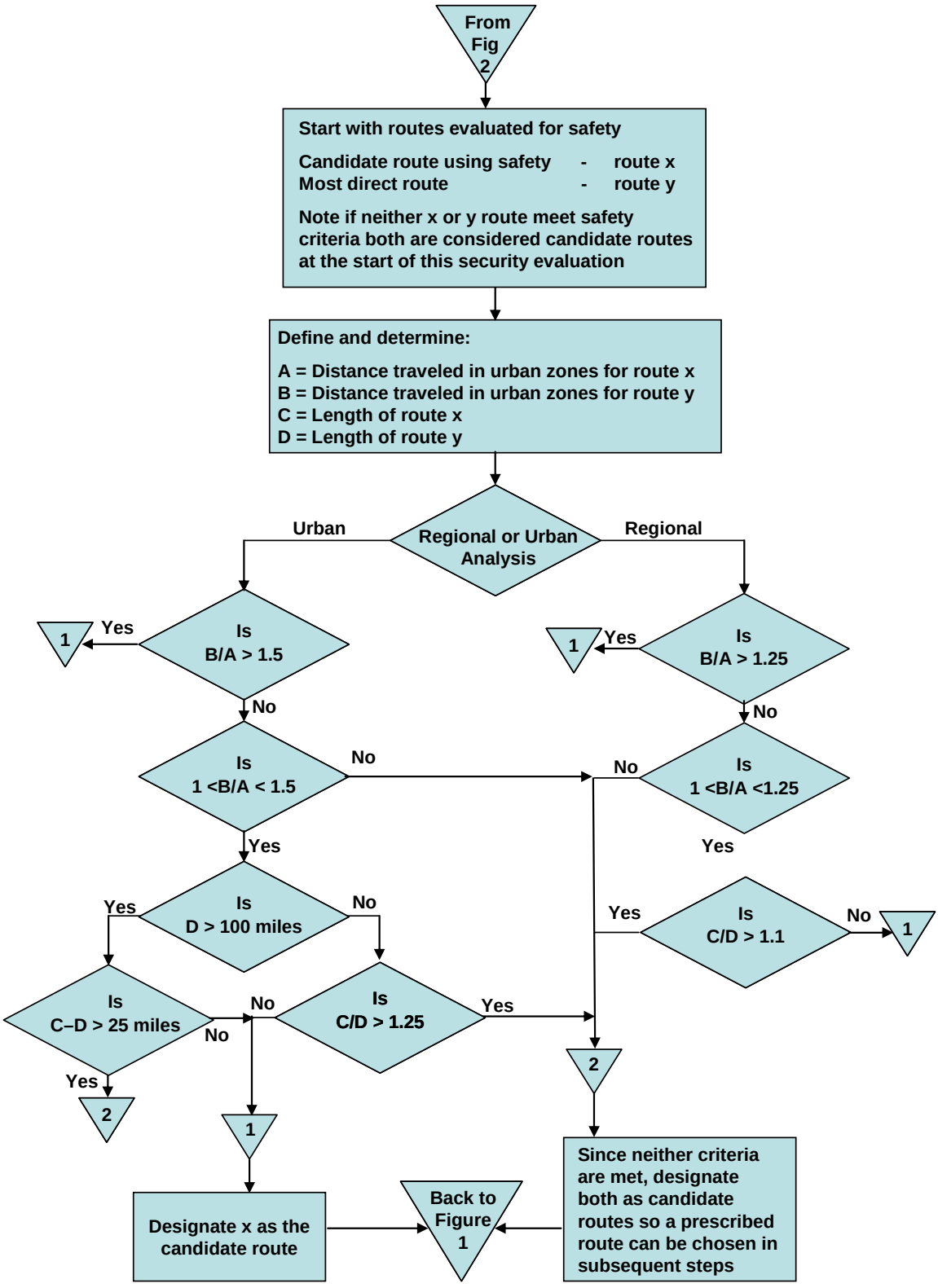

Figure 3. Designation of HM Routes for Urban and Regional Areas Using Security Criteria

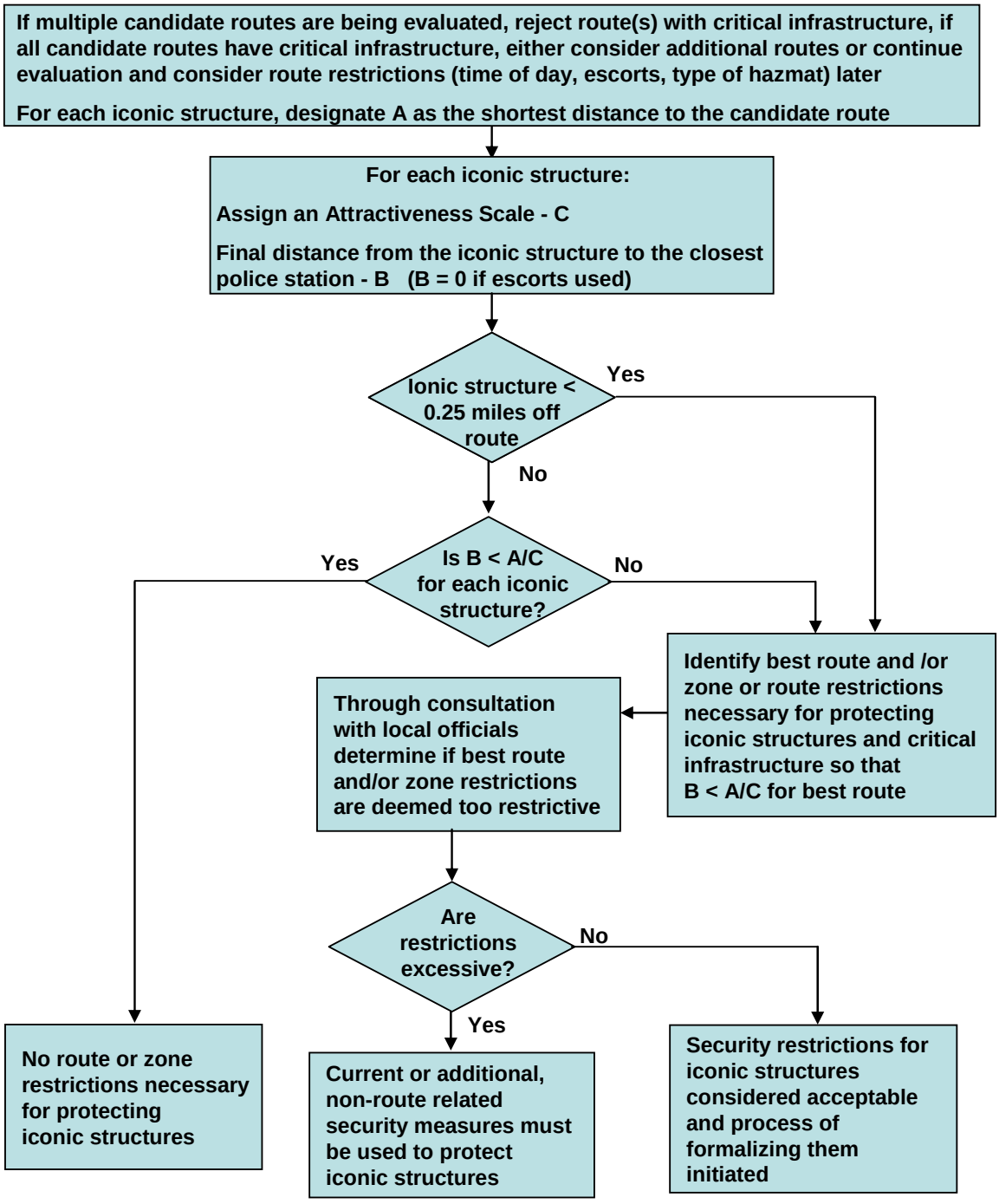

Figure 4. Identification of Restricted Routes and Zones

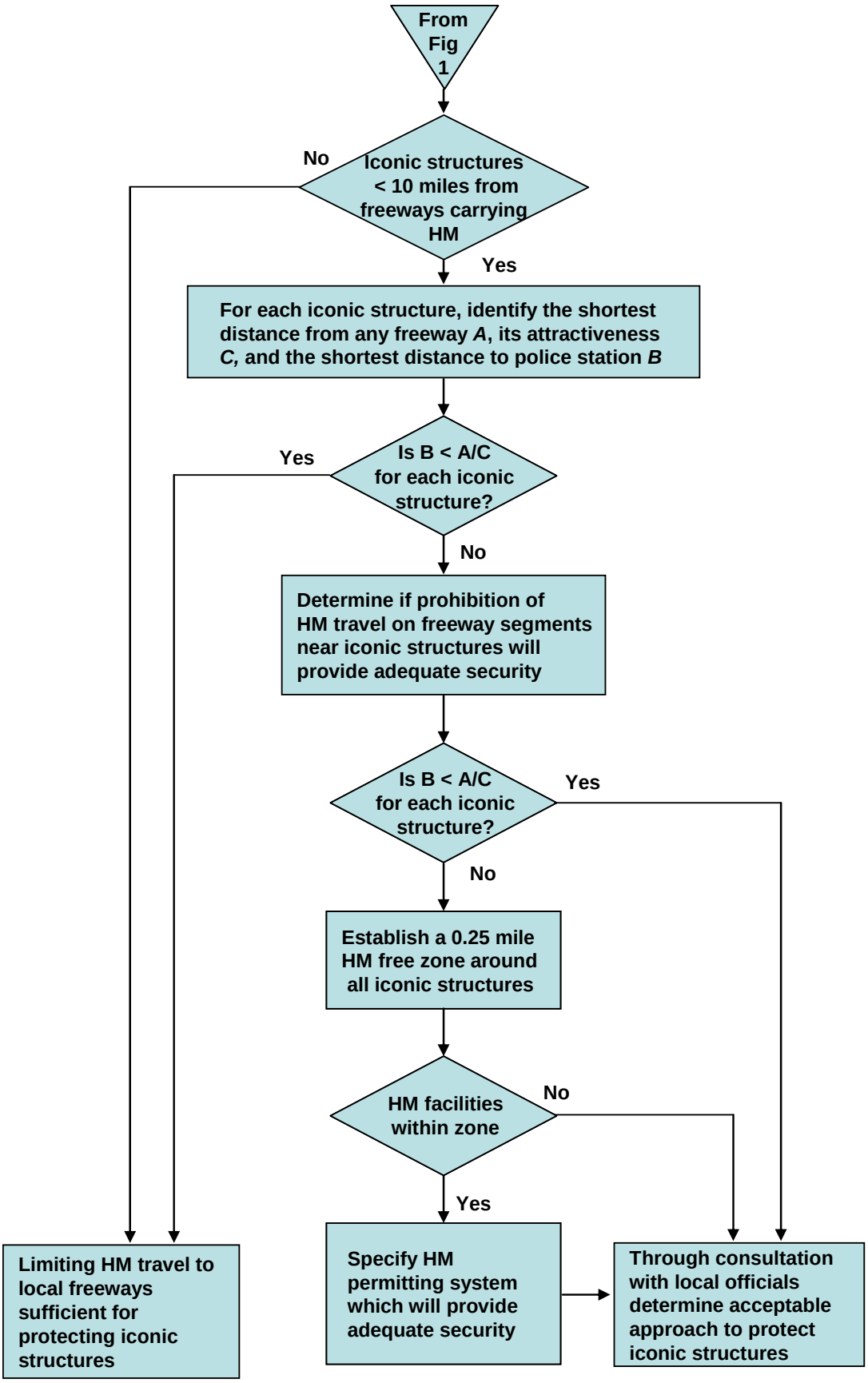

Figure 5. Designation of Local Routes

3.2 Detailed Discussion: For an Urban or Regional Setting

The first assessment step is shown in Figure 2. Both an urban and regional analysis are shown. For the urban analysis, the safety based assessment applies the fourth federal standard in 49 CFR Part 397.71(b)(4). The two performance measures are safety risk and segment length. If the risk of the current route is 50 percent more than the proposed alternative route, then the alternative route is designated as the candidate route. If the safety risk of the current route is greater but not more than 50 percent higher than the proposed alternative route, then the alternative route is designated as a candidate route if the alternative route is not 25 miles longer or 25 percent longer, whichever is less. If neither distance criteria is met, then both are retained as candidate routes. The rationale for designating both as candidate routes is so that subsequent analyses might identify a characteristic of one of the routes that will enable it to be the preferred route to be carried forward in the analysis.

The NRHM routing regulation would use the same criteria for both an urban or regional analyses. However, it is believed that it would be more difficult for a route to be selected as a candidate for regional routing if the performance measures were not decreased. Accordingly, in a regional assessment, the risk difference is reduced from 50 to 25 percent and the distance performance measure from 25 to 10 percent.

The second assessment step, shown in Figure 3, performs a security analysis. The performance measures used are the distance traveled through urban areas and the overall route distance for each alternative being considered. Continuity of routes must be maintained for a comparative analysis to be meaningful. This means that the possible routes being evaluated must have the same beginning and ending points. This screening methodology is similar to the one used to evaluate safety, the difference being that accident risk is replaced by population density. This reflects a major difference between evaluating security and safety risk. With security, the focus is on incident consequence, whereas with safety there is a focus on both likelihood and consequence. The proposed population density measure is the distance traveled through an urban zone, an area defined as having a population density of more than 3,000 persons per square mile. All urban areas in the United States have many route segments with population densities greater than 3,000 persons per square mile, while smaller cities and suburban areas have few or no route segments with population densities greater than this threshold. In order to calculate a density, both the length of the route segment and the distance (bandwidth) from the roadway must be specified. As discussed earlier, the bandwidth from the roadway used to determine if the population adjacent to the road is urban could be made a function of the type of hazardous material being transported. For discussion purposes, a distance of 800 meters, about one-half mile, on either side of the route is considered. After calculating the ratio of distance traveled in urban zones and the overall distance ratio and applying the criteria shown in Figure 3, the outcome is the preliminary designation of a one or more candidate routes.

The detailed assessment steps in this stage are:

1. For the area being studied, consider whether an urban or regional *through* analysis is being performed.
2. Identify the routes to be compared. The less direct route is termed the alternative route. The less direct route would typically be a beltway or bypass, selected because it likely travels through areas having lower population.
    a. Perform the assessment using the risk and distance criteria specified in the fourth federal standard, 49 CFR, Part 397.71(b)(4). If the routing authority has identified a designated route based on safety considerations, there may be no need to re-evaluate these findings.
    b. If a security assessment is to be performed, the previously designated route will be re-defined as a candidate route to be carried into the security analyses.
    c. If the safety of the routes has not previously been identified, use the fourth federal standard and if the alternative route meets the safety criteria, it becomes a candidate route. Alternatively, both routes become candidate routes to be carried into the security analysis.
3. Initiate the security screening process. Note that one or more candidate routes might be carried into this step depending on the outcome of the route safety evaluation. Note that as was the case for safety, the most logical alternative to direct routing through the urban area is a bypass or beltway that would promote security.
    a. Determine the distance and population density distribution along each candidate route.
    b. Use Figure 3 to determine which alternative route satisfies the population security criteria and select that route as the candidate route to be carried into the next step in the assessment process. For the alternative route to be selected over the most direct route, it must have significantly less travel through urban zones (an urban zone has a population density greater than 3,000 people per square mile – when evaluating routes for all HM transport, the distance through urban zones is estimated by considering the population within a 0.5-mile band on either side of the route). If the alternative route does not have significantly less travel through urban zones, then both routes are selected as candidate routes and the decision to designate one of the routes is made in subsequent screening steps.
    c. A route is selected for designation as a candidate HM route when the total length of all the urban route segments is a factor of 1.5 smaller than the total length of urban route segments for the other route. These factors were set based on the transportation risk numbers used in the NRHM Guidelines Document and were checked for reasonableness by comparing through and beltway routes for several urban areas. A factor of 1.25 is used if a regional (rather than an urban) analysis is being performed. By using a ratio of 1.25 for the regional analysis, a route that does have significantly lower travel through urban zones can be identified and selected as the candidate route.

d. A route would also be selected if the total length of the urban route segments is a factor of 1.0 to 1.5 larger than the length of the urban segments for the other route, provided that the overall distance traveled is not either 25 miles or 25 percent longer, whichever is less. For a regional analysis, the route would be selected if the distance traveled through urban areas is between a factor of 1.0 and 1.5 larger than the most direct route through the region and the overall distance traveled is not more than 10 percent longer.

e. If the ratio is less than one (this frequently occurs when evaluating regional routes or urban routes that are entirely within an urban area), select both routes as candidate routes. This enables both routes to be evaluated to determine the route that provides enhanced security for iconic structures.

f. If neither route meets the selection criteria, the routing official may either search for a different alternative route and determine if this new route satisfies the candidate route selection criteria, or designate both routes as candidate routes to be carried into the next step of the analysis.

4. Based on these results, identify the candidate route(s) for *through* transport of hazardous material in an urban area or region.

5. Determine if critical infrastructure or iconic structures exist along and within ten miles of the candidate route(s), respectively, using the criteria presented in Section 2.2.1.

6. While a definition of what constitutes an iconic structure is described in Section 2.2.1 of this Guidance Document, state and tribal routing officials, in consultation with local officials and the general public, have ultimate authority to designate such structures. Because of the possible effect on commerce, particularly when considering route restrictions for *local* as opposed to *through* HM transport, the designation process for iconic structures should be conducted carefully and with restraint.

    a. If there are no iconic structures, routing officials may either decide to:

        i. not select a designated route for security because of the absence of iconic structures,

        ii. select the candidate route as the designated route for security based on the application of population density and distance criteria in Figure 3, or

        iii. select the same route for security that was designated for safety.

    b. If in the planning stage, the routing official decides to not consider local HM traffic, then consultation with local officials will complete the security evaluation.

    c. If iconic structures will be considered as part of the security evaluation, continue with Step 7.

7. Determine the location and type of critical infrastructure and iconic structures relative to HM routes. If these structures are located on or close to the route selected, then an evaluation would be performed to investigate if restricting HM travel along certain routes or within certain zones would provide adequate safeguards.

    a. Following the logic in Figure 4, determine if a candidate route contains critical infrastructure elements. If it does, and two candidate routes are being considered,

then the one containing critical infrastructure elements should be eliminated as a candidate route. If only one candidate route is being evaluated, then the analysis can proceed but in a subsequent step, route restrictions must be considered as a way of minimizing the threat to the critical infrastructure component of the designated route.

b. Identify any iconic structures within 10 miles of the candidate *through* HM transport route.

c. Classify iconic structures into categories of relative importance (i.e., hierarchy based on national, regional or local significance)

d. Assign an importance weight to each iconic structure of 4 for national, 2 for regional and 1 for local significance.

8. Identify police stations located within 10 miles of the candidate routes.

9. Evaluate the potential for police to prevent *through* HM shipments from being used as a weapon against iconic structures. Assume that all *through* HM traffic moves on the candidate routes identified in Figure 4.

    a. Determine the distance, A, of each iconic structure to the closest access point to/from the candidate route identified in Figure 4. Note that if a bypass or beltway has been designated as the candidate route in Figure 3, then the distance to most iconic structures is probably farther than it would have been if the shortest route through the urban area had been used in this step. In many cases, this distance will be large enough to conclude that the route specified in Step 4 provides adequate security for the iconic structures and no additional routing considerations are necessary.

    b. Calculate the mileage to each iconic structure from the closest police station, defined as C in Figure 4.

    c. Divide the distance from the freeway access point to the iconic structure by the attractiveness of the iconic structure, defined as B in Figure 4.

    d. Determine if the closest police station is within acceptable interdiction distance.

10. Consider the safeguards for the iconic structures as adequate if all have police presence within the acceptable interdiction distance.

11. Select the candidate route as the designated *through* route for HM traffic. If two routes were identified as candidate routes, the one that provides the greatest separation from iconic structures should become the designated route.

12. For those iconic structures for which this distance is not deemed adequate or where the candidate route contains a critical infrastructure component, consider additional route restrictions that might be imposed on *through* HM transport or, for iconic structures, consider establishing a HM zone which restricts or controls all HM traffic within 0.25 miles of the structure. The former approach is preferred if feasible route restrictions can be specified.

13. After establishing restricted zones or routes around iconic structures, determine the need to establish a permitting system for HM transport within the zone. Such a permitting system would be proposed if there is no police presence deemed to be adequate within or near the HM-free zone.
14. Discuss the proposed routing requirements with local officials to determine if they agree with the need to impose security routing restrictions or if they are able to identify alternative methods of providing adequate security in the urban area. Note that methods such as the placement of physical barriers surrounding an iconic structure may be considered in lieu of designating routes or imposing restricted HM zones.
15. If it is decided that the HM route and/or zone restrictions for security are feasible, then the routing official would initiate the process of codifying the restrictions into the appropriate regulations. The exact process to be followed would be expected to vary among states and tribes depending on how HM truck transport is regulated in each respective jurisdiction.
16. If it is decided that the restrictions on HM travel are too cumbersome, then the discussions with local officials would turn into an evaluation of the current level of security without any routing or zone restrictions. Two outcomes are envisioned. In some cases, it may be decided that the current level of security for all the iconic structures is acceptable. Alternatively, some augmentation of security using measures not related to route or zone restrictions might be implemented. Typically these security measures would be implemented locally and not at a higher government level.

3.3 Detailed Discussion: For Local HM

The methodology for designating routes and/or restricted zones for *local* HM traffic focuses only on the security of iconic structures. The methodology is similar to that proposed for assessing the need to restrict *through* HM traffic if the route is too close to an iconic structure. As in the *through* transport analysis, HM traffic would maximize the use of limited access highways, but selecting beltways or bypass highways would not be possible. The detailed parts of the proposed analysis methodology are shown in Figure 5. When considering *local* HM transport, while routes might be designated, it is also likely that there will be routing restrictions on roads in the vicinity of the iconic structures. Since these restrictions could have a significant impact on commerce, care must be taken not to overly limit local HM transport.

Consistent with the *through* routing criteria, because travel on roads designed to interstate highway specifications are typically safer and also provide a security benefit from limitations on access, if any route designations are made, they would be implemented to maximize travel on roads designed to interstate highway specifications wherever possible. To determine if transport of all HM or only specific types of HM should be restricted, at all times or for specific times of the day, the following assessment steps should be followed:

1. Check to see if there are any iconic structures present in the urban area or critical infrastructure elements on potential HM routes.
2. For each iconic structure, calculate the distance from the nearest freeway (A) and the distance from the nearest police station (B).
3. Use the attractiveness scale for each iconic structure (C) as described in the analysis of *through* HM traffic.
4. Determine if B < A/C for each iconic structure.
5. For each iconic structure where B > A/C:
    a. Consider prohibiting HM traffic on highway segments that provide the closest access to the iconic structures and see if restricting travel enables the criterion B < A/C to be met.
    b. Continue blocking highway access points to see of it is possible to obtain a condition where B < A/C for all iconic structures.
    c. If it is possible to meet the B < A/C criteria by restricting HM traffic on nearby highway segments, then go to Step 7.
6. Consider establishing a 0.25 mile buffer around those iconic structures where it is not possible in Step 5 to obtain a situation where B < A/C. Note that during consultation with local officials, they may want to establish a larger buffer around some of the iconic structures.
7. Determine if there is a need to move HM within the restricted zone developed in Step 6. If some HM traffic must be allowed, consider the types of HM that might damage the iconic structures for which the restrictions were developed and determine if it is feasible to limit some types of HM in the restricted zone.
8. Determine the need to establish a HM permitting system within the restricted zone. This system may involve pre-notification, special vehicle equipment, a security plan, one-time permits or some combination of these safeguards. Such a system would be required if there is a need to occasionally transport hazardous materials within the zone and these materials could be used to damage the iconic structure being protected.
9. Discuss the results with local officials to determine if the proposed restrictions are feasible.
10. If it is decided that the HM route and/or zone restrictions for security are feasible, then the routing official would initiate the process of codifying the restrictions into the appropriate regulations. The exact process to be followed would be expected to vary among states and tribes depending on how HM truck transport is regulated in each respective jurisdiction.
11. If it is decided that the restrictions on HM travel are too cumbersome, then the discussions with local officials would turn into an evaluation of the current level of security without any routing or zone restrictions. Two outcomes are envisioned. In some cases, it may be decided that the current level of security for all the iconic structures is acceptable. Alternatively, some augmentation of security using measures not related to

route or zone restrictions might be implemented. Typically these security measures would be implemented locally and not at a higher government level.

When applying either the *local* or *through* route evaluation methodology, routing officials must be aware that route designations for security should be considered as one element of an integrated security program for safeguarding iconic structures. Routing officials might find that some of the law enforcement capabilities are limited for certain iconic structures and conclude that other security measures, perhaps already in place such as the use of barriers and gates, provide effective security, negating the need for establishing restricted routes or zones for security purposes. The routing authority might also choose to restrict travel on routes for specific types of HM and/or during specific periods of the day rather than designating a HM route for all classes/divisions of HM. Many of these considerations are best handled through consultation with local officials.

3.4 Selecting the Appropriate Buffer

The purpose of a buffer is to keep truck shipments of hazardous material far enough away from any iconic structure so that it would be impossible to damage the structure without entering the buffer zone. If signage and public awareness enables the buffer zone to be well identified, then any member of the general public as well as law enforcement personnel could take actions that would potentially prevent a truck carrying hazardous material from proceeding very far into the buffer zone.

No criteria have been established regarding what constitutes an adequate buffer. While the size of the buffer zone should be established to enable an effective response of law enforcement personnel to any intrusion, the size of the zone might be better established using the characteristics of the area surrounding the iconic structure. For example, if the iconic structure is in the central core of an urban area and there is an inner beltway encircling the inner core, establishing a HM-free zone within the inner beltway might be easier to sign and enforce than a smaller zone made up of several streets surrounding the iconic structure. Using the characteristics of the area might not be feasible if there is a large facility within the zone that receives or ships many truckloads of hazardous material daily. If there are only a few gasoline stations within the buffer zone or a few buildings that require periodic deliveries of home heating oil, then such deliveries could easily be planned for a time that enables police to closely monitor the activities associated with these deliveries. Some cities, New York City being a good example, require all HM deliveries to occur between 1:00 a.m. and 5:00 a.m. In the absence of a buffer established by the characteristics of the area surrounding the iconic structure, it is proposed to establish a buffer zone no smaller than 0.25 miles in every direction from the iconic structure. Given the iconic structure is probably near the center of an urban area with traffic lights at almost every street intersection, a quarter-mile buffer area might afford a warning time of 30 seconds and perhaps longer. This gives some time for a planned response, typically by patrol cars normally in the vicinity of the iconic structure. If the structure has its own security force, which is likely for highly valued iconic structures, then this warning gives them a limited time to initiate a planned response.

3.5 Establishing Designated Routes or Restricted Zones for Specific Classes of HM

One of the important parameters that can be considered when designating a hazardous material route or determining the extent of a restricted zone is the amount of damage that would result should the hazardous material be suddenly released during an incident. This damage zone or distance from the highway within which population could be affected by a HM release is an important parameter to consider when evaluating proposed hazardous material routes. When evaluating buffer zones, if the buffer zone is too small, then a release of the hazardous material could affect the iconic structure being protected by the buffer zone.

The distance from the road or iconic structure which should be used when evaluating routes or buffer zones is a function of the hazardous material being transported. The materials that pose a risk at the greatest distance are TIH or radioactive material releases. The former releases a toxic plume and the latter respirable radioactive particulates. Although health effects are usually limited to short distances from the release point (e.g., a few hundred meters), it is not uncommon to model the release of a TIH material for 5 kilometers and a radioactive release for 80 kilometers. The release models for radioactive releases extend out to 80 kilometers because of the dose-response curve that is unique to radioactive material releases. An exposure of one person to one unit of radiation, a Sievert is a common radiation unit, results in the same number of health effects and the exposure of a million people to one millionth of a Sievert. Extending the calculations out to 80 kilometers exposes more people to the release and therefore increases the number of health effects, if any, that might be experienced as a result of the release. However, it is not feasible to establish an 80 kilometer buffer around each iconic structure nor is it feasible to evaluate two routes and get any difference in characteristics if an 80 kilometer distance on each side of the roadway was used in the analysis. As a result, since most of the exposure occurs close to the release point, the population adjacent to the route within 800 meters on either side of the route is usually used to characterize the number of people potentially exposed to a radioactive material release.

Whereas TIH and radioactive material releases frequently characterize the population adjacent to the route for sizable distances, some classes of hazardous material require very limited impact distances. The spill of a corrosive with a very low vapor pressure, or even gasoline if it does not ignite, is quite small, on the order of tens of meters. As long as a person is not trapped in their vehicle, the heat from a pool fire following the release of gasoline, diesel, or jet fuel would not cause serious damage 50 meters from the fire assuming the individual moved back within a few minutes. The radius affected by a release of material in a BLEVE might be of concern if the individual was within 200 meters of the fireball. A greater concern from the BLEVE is the shrapnel caused by the rupturing vessel. This shrapnel has been found more than 1.1 kilometers from such explosions. A similar shrapnel risk exists for sensitive explosives or reactive solids that can also explode when heated.

For routes that might carry all classes of HM, it is not feasible to evaluate them using different offset distances, nor is it feasible to have the size of the buffer zone vary with the type of hazardous material. Use of different zone sizes is feasible only if one class/type of hazardous is likely to be encountered in the region.

3.6 Potential Hierarchy of Hazardous Materials

There are many ways to establish a hierarchy of hazardous materials. The hierarchy that will be used here is based on the distance beyond which it is unlikely that an individual will experience irreversible health effects as a consequence of a release. Classic explosion curves are used to estimate the size of the potential damage zone as a result of explosions and BLEVEs (Lee, 1990), and ALOHA, a vapor dispersion model developed by NOAA, was used to estimate the consequences of gas releases.

3.6.1 Sensitive Explosives

The damage radius should a truckload of sensitive explosives be involved in an incident and subsequently explode is a function of the quantity being transported and the characteristics of the terrain surrounding the incident scene. The type of consequences being considered also affects the damage radius. Close to the blast, direct effects of the shock wave and the flying shrapnel from the explosion are the primary risk. Farther out, the shock wave can break glass and the flying glass can result in injury to exposed individuals. For a truckload containing 10,000 pounds of explosives, ear drum rupture could occur for anybody within 1,000 meters of the blast and injuries from broken glass could extend as far as 3,000 meters.

3.6.2 TIH Group A and B

The distance from the release point where potentially life threatening consequences might be realized is a function of the rate of release, the total quantity released, and atmospheric conditions at the time of the release. For TIH materials, this distance can be significant. For example, a release of 10,000 pounds of chlorine over an hour under stable atmospheric conditions can result in exceeding the ERPG-2 concentration at distances of 5 kilometers. The ERPG-2 concentration is defined as “the maximum airborne concentration below which it is believed that nearly all individuals could be exposed for up to 1 hour without experiencing or developing irreversible or other serious heath effects or symptoms which could impair all individuals’ ability to take protective action.”

3.6.3 Flammable Gases

The danger from flammable gases is the possible fireball that people could be engulfed in when the flammable gas cloud is ignited. Depending on the flammability range of the gas and its release characteristics, the radius can easily be several hundred meters. The distance becomes even greater if the gas is released as a dense gas. Such a release tends to collect in low lying regions and is slower to disperse. Even gases with molecular weights that are less than air can behave as a dense gas if they are shipped as a compressed liquid. For a release of 10,000 pounds of propane over 30 minutes, if the vapor cloud is ignited, an individual closer than 100 meters from the release point could be directly exposed in a flame pocket.

The containers can also BLEVE if they are exposed to a flame from another source. While rare, BLEVEs have a damage zone that is about 2/3 the damage zone for the same quantity of explosives. Thus the damage zone for broken glass could be 2,000 meters and for ear drum rupture about 600 meters.

3.6.4 Flammable Liquids

The danger from flammable liquids is that they will form a pool and ignite or that the residual liquid in the cargo tank will form a fireball. Because the cargo tank fails at a low pressure, BLEVEs that occur with compressed liquefied flammable gases will not occur with flammable liquids. The damage zone from flammable liquids pool fires or fireballs is almost always less than 50 meters.

3.6.5 Other Placarded Hazardous Materials

Other hazardous materials have poor dispersal characteristics when released so the only hazard is from direct contact. The damage zone seldom exceeds 50 meters.

3.7 Application of the Routing Methodology

To describe the analysis process and to illustrate the application of the routing methodology, Columbus, OH, has been selected as an example. Columbus already has a designated *through* HM route, which is the I-270 beltway that completely encircles the city. This application will focus on the southern portion of the I-270 beltway as the designated through route. The designated route and the most direct route (I-70 through Columbus) are shown in Figure 6. The most direct through route is at the top of the figure and the beltway is the longer route that loops to the south. Respective population densities along each route are also displayed. Even though the I-270 beltway has been designated as the prescribed HM truck route based on the safety criteria in the DOT regulations, the safety risk will be evaluated for this application just to demonstrate how the security steps can be integrated with the safety risk.

The safety risk is considered to be proportional to the product of the truck accident rate and the total population along the route. To estimate the accident rate, the number of serious truck accidents reported to MCMIS during the years 2001 through 2004 is used as the numerator in the accident rate equation and the product of the average annual daily truck traffic (AADTT) count and the segment distance is used as a surrogate for the truck miles traveled. These calculations are performed for both I-70 through Columbus (the most direct route) and for I-270, the currently designated HM truck route. Table 3 shows the parameter values and the calculation sequence used to estimate the relative safety risk of the two routes.

Table 3. Calculation of Relative Route Safety Risk

Route	AADTT	Distance (miles)	Total Serious Accidents (4 Years)	Relative Accident Rate	Total Population Within 1/2 Mile	Product of Rate Times Population	Ratio
I-270S	12,334	55	102	0.00015	34301	5.16	
I-70	14,498	15	104	0.000478	58601	28.02	5.43

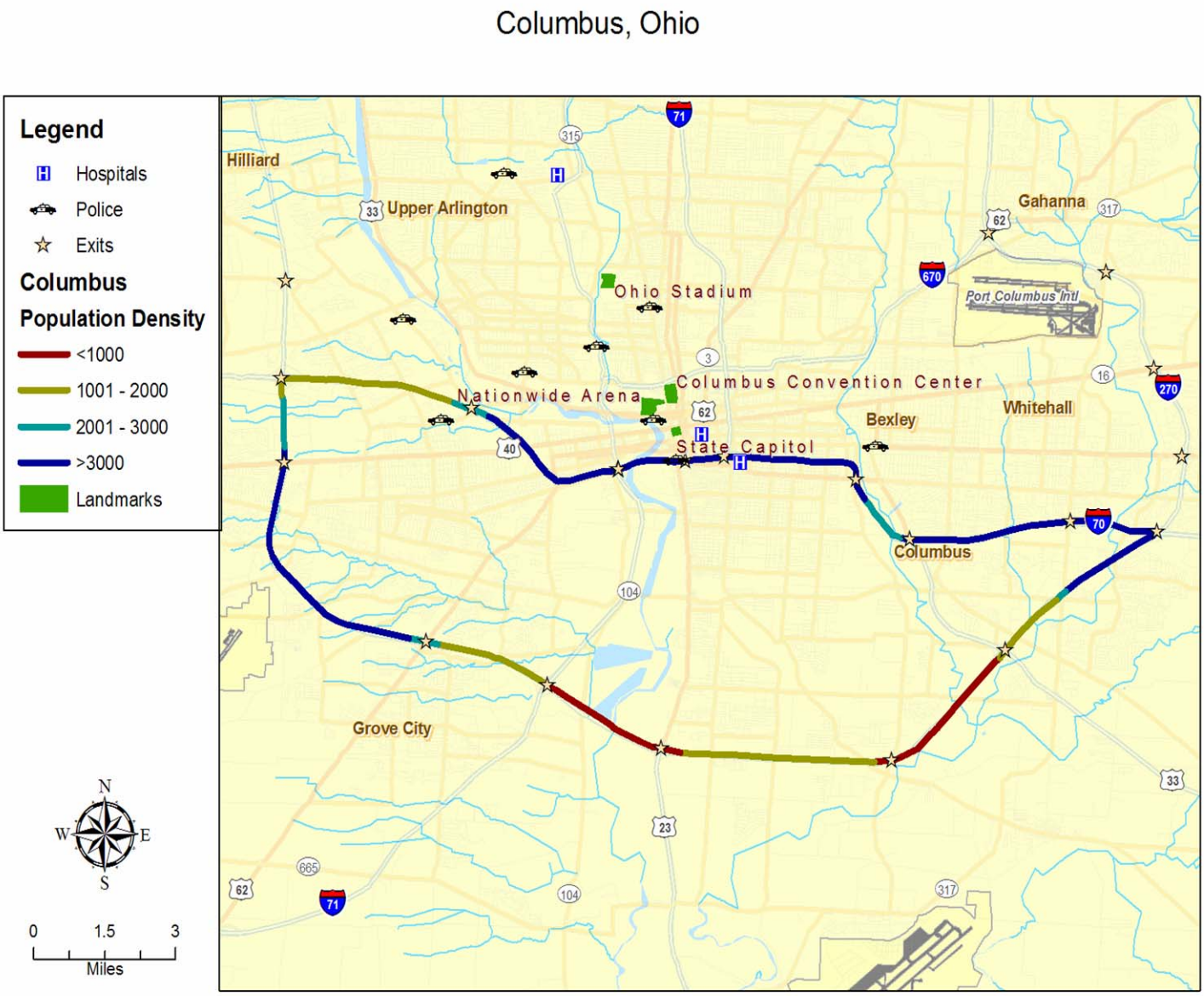

Figure 6. Through and Prescribed Bypass Route for Columbus, Ohio

In the above table, the total serious accidents divided by the product of the distance times the AADTT is proportional to the accident rate and is shown in Table 3 in the Relative Accident Rate column. The consequences of a release are assumed to be proportional to the total number of people located within one-half mile each route. Since the ratio, shown in the last column of Table 3 is well above 1.5, the risk criteria standard, I-270S, the southern beltway, is considered a candidate route for HM truck transport. Note that this calculation shows that the state routing official had a good technical basis for directing HM traffic onto the beltway rather than going directly through Columbus on I-70.

The next step is to evaluate this candidate route using the security criteria.

3.7.1 Relative Distance Through Urban Areas

The first step in the security assessment methodology is to examine the relative distances through urban areas, defined as having a population density of greater than 3,000 people per square mile. These are shown in Table 4.

Table 4. Relative Mileages for Columbus, Ohio

Columbus Routes	Relative Mileages	
	Total Route	Urban Areas
x (I-270)	20.6 (C)	6.5 (A)
y (I-70)	15.3 (D)	11.1 (B)
Ratios	C/D = 1.4	B/A = 1.7

Based on the ratios, since B/A is greater than 1.5, the beltway is designated as the candidate route using the *security* criteria, consistent with the finding based on *safety* criteria. Note that if the ratio had been between 1.0 and 1.5, then the total route mileage would have been used to determine if the I-270 route should be considered as a candidate security route. Since the total route distance is 1.4 and exceeds 1.25, the bypass would not have been selected. The candidate route selection logic would then have recommended that both be considered candidate routes and carried into the subsequent assessment steps.

No critical infrastructure elements have been identified on the interstate highways in Columbus, Ohio. However, iconic structures have been identified in Columbus. The State Capitol and the Nationwide Arena are considered to be regional icons and the Convention Center is considered to be a local icon (see Figure 6). Although not shown in the figure, the Columbus Central Police Station is located equidistant from all three iconic structures, approximately 0.5 miles away. All three structures are located far enough away from I-270 such that any security concerns related to *through* HM transport are easily met. However, *local* HM routing would take the HM vehicles much closer to all three iconic structures. Table 5 shows the results of the calculation for *local* HM transport on I-70.

It can be seen that the closest weighted distance (A/C) from I-70 to each of the iconic structures is greater than the distance from the nearest police station for all but the State Capitol. To meet this distance criterion for *local* HM traffic, HM shipments would have to be restricted on I-70 between its east and west interchanges with I-71. The alternative would be to establish a HM-free zone around the Capitol as shown in the next subsection.

Table 5. Security Evaluation of Iconic Structures for Local HM Transport

Icons	Symbol	State Capitol *Regional*	Nationwide Arena *Regional*	Convention Center *Local*
Distance from Prescribed Route (mi)	A	0.64	1.36	5
Icon Weight (C)	C	2	2	1
Weighted Distance	A/C	0.32	0.68	5
Distance from Police Station (mi)	B	0.47	0.25	0.55
Response Effective?	B < A/C	No	Yes	Yes

3.8 Description of How a HM Restricted Zone Would Be Selected

If a one-quarter mile HM-free zone was established around the Capitol, it would be approximately bounded on the north by Spring Street, on the west by the Scioto River, on the south by Main Street, and on the east by Grant Street. Within that zone, all HM travel would be restricted and any required HM transport would be by permit only.

3.9 Description of Process of Selecting Routes Leading to or From Origin and Destination Points to Through Routes

If a HM-free zone was established around the State Capitol in Columbus, an analysis would be required to identify businesses in the zone that supply or use hazardous materials. Within one-quarter mile of the Capitol, there is only one gas station and there are no industries utilizing hazardous materials. It is not known how many buildings within the area are fueled by oil-fired boilers, but it is believed that most use gas heating. Thus, the number of permits that would have to be issued is likely to be very small. The one service station is quite close to Main Street, with easy access to the freeway, so a permit might be issued to allow the tank truck to fuel the station by approaching the station from the south, thereby keeping the route taken by the tank truck well away from the Capitol. The permit required to refuel this service station might be quite informal. A blanket permit might be issued providing the pre-approved route to and from the station is followed. The permit conditions could be graded. For some iconic structures, in addition to the permit, appropriate pre-notification of the approximate delivery time could be given to local police. In the most restrictive case, all the permitted shipments would receive police escorts.

4.0 Conclusions

The material presented in this Guidance Document provides routing officials with background information, specific direction and a method for designating HM routes and restricted zones that considers both safety and security criteria without overly restricting commerce. The method provides an easy-to-use, stepwise process for routing officials to designate HM *through* and/or *local* routing. Routing officials also receive guidance on reducing risk where targets remain vulnerable even after HM traffic has been diverted onto more secure routes. The approach is designed primarily to use information and data sources that are compiled and maintained by federal agencies and, to a limited extent, using data identified through Internet searches. While it is impossible to anticipate every circumstance a routing official might encounter, the design is flexible enough to take advantage of the varying circumstances without being overly complex.

This Guidance Document is supplemented by the Safety and Security Routing Tool, a Web-based system which guides the routing official through a logical sequence of data collection and evaluation steps. The Routing Tool is intended as a decision aid and not to replace the judgment of the routing official who must balance the overall needs of the region with the need to provide safe and secure hazardous material transport. The Routing Tool can be located at _____.

4.1 Practical Considerations

Although specific guidance is presented regarding the identification of critical infrastructure and iconic structures, and the assessment of route proximity to both iconic structures and law enforcement, it is important to recognize that routing officials are the local experts. They possess the knowledge needed to make the ultimate decisions for how/whether to designate HM routes or restricted zones. Their judgment must be used to confirm that such decisions provide a practical solution for enhancing both safety and security. In some cases, routing officials may decide to override a preferred route based on applying the methodology. For example, if the method recommends that a particular alternative route be eliminated because it is too long relative to the most direct route, the routing official may decide to retain that route as a viable routing option based on knowledge of certain local factors that have not been included in the routing methodology.

Any routing decision to enhance hazardous material transport safety and security must be part of an overall HM risk management strategy and there will be cases where other measures will be more effective than designating hazardous material routes or restricted zones. Finally, in accordance with the current regulations, 49 CFR, Parts 397.71(b)(5) and 397.71(b)(9)(x), routing officials must consider the impact that HM route designation or zonal restriction will have on commerce. Particularly in the security area, other non-route related security measures can be adopted if the effect on commerce of the proposed HM routing recommendation is judged to be overly burdensome.

5.0 References

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Appendix A: Security Vulnerability Analysis of HM Routes

A.1 Background

Risk analysis is the evaluation of the likelihood and the consequence of an undesirable event, and risk is generally expressed as the product of these terms. Likelihood is quantified as (1) a frequency that events occur (e.g., events/year, accidents/mile) or (2) a probability that an event will occur (i.e., a number between zero and one). Consequence is usually expressed as fatalities, economic loss, or area impacted by a HM release. Security vulnerability analysis is a type of risk analysis in which the likelihood term is the product of the probability of a threat and the vulnerability of the target.

The following discussion focuses on the application of security vulnerability analysis to the selection of routes. It is intended to provide routing officials with guidance that will enable them, where warranted, to conduct vulnerability assessments that may assist in the classification of iconic structures with respect to the establishment of designated HM routes or restricted areas.

A.2 Security Vulnerability Analysis Framework

Security vulnerability analysis, like the more general risk analysis, is tailored to fit the specific needs of the project. The overall steps in a security vulnerability analysis are:

1. Perform a criticality assessment to identify potential targets.
2. Conduct a threat assessment to define credible attack scenarios.
3. Conduct vulnerability assessments for each target/scenario combination
4. Conduct consequence assessments for each target/scenario combination
5. Prioritize target/scenario combinations to determine those for which mitigation strategies need to be considered. In a routing context, mitigation is primarily route avoidance.

For this discussion, the HM vehicle is considered the weapon to be used against the target. The HM vehicle can be directly attacked with bombs or other ordnance, or it can be diverted and moved to the target before the HM is released/dispersed/initiated. Bombs and standoff ordnance that could be used to disperse the HM are considered as attack modes. HM security vulnerabilities are being addressed with planning, training, routing, and implementation of technological solutions, such as were demonstrated in the 2004 HM Safety & Security Field Operational Test. Note that routing, the focus of this discussion, must be distinguished from procedural and technological improvements that are considered characteristics of the shipment itself (e.g., locks/seals, disabling systems, escorts, etc.). These characteristics are not addressed in this discussion.

A.2.1 Criticality Assessment

The criticality assessment identifies and screens potential targets. In a HM routing context, a HM release is the objective, and the HM is the weapon that is intended for the target. The targets to consider are high-density population areas, critical infrastructure and iconic structures. Table A-1 lists examples of such targets. A criticality score is traditionally assigned to help the decision maker determine the targets of most interest for analysis and to help make cost-benefit

decisions for mitigation. For routing analysis purposes, however, it is assumed that targets can be easily identified and screened (i.e., considered or not in subsequent analysis steps) by the routing official.

Table A-1. Examples of Targets

High-density population areas
Groupings of medical and/or educational facilities
Groupings of office buildings
Passengers in terminals (bus, train, ferry)
Tunnels and bridges
Roads on dams
Communication facilities
Drinking water supplies
Chemical/petroleum storage and/or production facilities
Major utility facilities including transmission lines

The population targets for vulnerability analyses are essentially the same ones that the routing officials have addressed before for HM routing using safety analyses. The other targets are security-specific considerations. In either case, the routing official must be familiar with route features important to safety and vulnerability analyses.

The Transportation Research Board's National Cooperative Highway Research Program has developed guidance for state DOTs for assessing vulnerabilities of highway physical assets for the purpose of developing countermeasures (typically physical or procedural barriers) for critical assets. The highway asset criticality assessment involves developing a score for each of numerous highway physical assets, a potentially exhausting exercise whose purpose is to prioritize the list of highway physical assets. This project does not overlap traditional highway asset vulnerability analysis.

A.2.2 Threat Assessment

A threat can be defined as the probability that a specific target is attacked in a specific way during a specified time period. For a routing analysis, however, it is sufficient to avoid quantifying the probability and focus on attack scenarios. For HM routing analyses, the release of the HM is the objective. The attack scenario can involve taking control of the HM vehicle and moving it to a target or directly attacking the HM vehicle at the desired point of release on the normal route. Table A-2 lists the two scenarios of interest for transporting HM.

Table A-2. HM Transportation Threat Scenarios

Scenario Beginning	Scenario Completion
Take control of the HM vehicle, move it to a target, and …	Open valves to release HM Release HM with explosives Crash HM vehicle into the target
Directly attack the HM vehicle by …	Launching/shooting ordnance from a distance at the HM and/or driver Ramming with another vehicle Exploding bomb in adjacent vehicle Exploding roadside bomb Detonating a device attached to the shipment

For routing purposes, the two threat scenarios differ only in whether the HM is released/ dispersed/initiated on the route or whether the HM is taken control of and diverted off-route before it is released/dispersed/initiated.

A.2.3 Target Vulnerability Assessment

The target vulnerability is the probability that consequences occur, given a specific attack on a specific target; the probability is usually qualitatively evaluated. The vulnerability assessment addresses the characteristics (e.g., physical, technical, administrative, procedural) of each target in each scenario that make the target easy or difficult to successfully attack. Security vulnerability attributes to be considered for HM transport are listed in Table A-3. Further description and scoring values for the HM transportation vulnerability attributes appear in Table A-4. The attributes are not necessarily independent; for example, the control attribute may be dependent on the security attribute.

Table A-3. Vulnerability Attributes for HM Transport

Vulnerability Attribute	Attribute Description
Accessibility	Physical and geographical barriers that deter the threat
Effort/Hardness	Required sophistication and equipment to overcome the HM vehicle's and/or the target's physical resistance
Control	Degree of control the attacker has over the outcome
Security	Ability of security personnel to mitigate the attack

The vulnerability attributes in Tables A-3 and A-4 are considered either route or shipment attributes, as follows:

- Accessibility is a routing attribute where criteria for easy route accessibility would be a function of:
    1. length of roadways with frequent stoplights
    2. length of other than high-speed highways
    3. remoteness of the route
    4. lack of rest stops that are well lighted and staffed with alert personnel.
- The effort/hardness attribute is a characteristic of the shipment container (e.g., strength, ability to disable the vehicle, locks on valves, etc.) and is not considered a routing attribute.
- The control attribute has route-dependent aspects that are addressed by the accessibility attribute and other aspects that are addressed by the security attribute. Additional aspects may depend on the hazardous material or its packaging (e.g., reliability of dispersion mechanism), and the unique aspects of this attribute are considered shipment characteristics.
- Security is largely dependent on procedures (e.g., escorts) or technology (e.g., communication) associated with the shipment. Response capabilities are route dependent, but are best addressed qualitatively rather than quantitatively (NRC 2006).

While more complex routing analyses can address additional attributes, only the accessibility attribute will apply to the vast majority of quantitative routing analyses.

Table A-4. Vulnerability Score

Scoring Range	Accessibility	Effort/Hardness	Control	Security
7 – 9	HM vehicle easily approached for hijacking or employment of explosives	Release of HM easily accomplished	High probability that HM is released and delivered to intended target	No guard force, no detection or communication capability, untimely response capability
4 – 6	Vehicle access available with moderate difficulty	HM vehicle of simple, but strong construction	50 – 50 probability that substantial HM released and delivered to intended target	Limited armed guard force, limited detection and communication capability, slow outside response capability
1 – 3	Access limited to vehicle moving at limited-access highway speeds	HM vehicle has complex design and substantial construction	Very little control over amount of HM released and delivered to intended target	Significant armed guard force, sophisticated detection and communication capability, rapid outside response capability

A.2.4 Consequence Assessment

The consequences of HM release/dispersion/initiation are largely dependent on the material and the amount released. HM routing analyses are generally for all HM classes, but in some cases, they may be class specific. It is assumed at this level of discussion that the routing analysis is not based on a specific hazardous material or even a specific HM class. Potential consequences include fatalities, injuries, property damage, loss of service or supply (e.g., drinking water), economic impact, environmental impact, national defense impact, and symbolic effect. A key consideration is the distance from the HM vehicle that consequences are experienced. For most HM routing analyses, a fixed, conservative distance is suggested for all analyses. In a few cases, a routing official may want to use a distance that is more characteristic of either a specific dispersion situation and/or a specific HM that is most prevalent along a route. Except in unusual climatic and/or terrain conditions, the typical safety routing approach is to base consequences on a fixed impact distance from the route. The same approach would work well for vulnerability analysis of population targets.

A supplemental quantitative approach is to consider the consequences of iconic structure losses in economic and environmental terms. Table A-5 contains a proposed iconic structure scoring matrix. The first column contains a qualitative description and a proposed scoring value. The second column shows how the iconic structure score relates to a representative value placed on the destruction of the facility.

Table A-5. Iconic Structure Consequence Score

Consequence Score	Representative Cost of Attack*	Iconic Value	Environmental
High (National Importance) (Score of 5000)	$40 Billion	Similar to Statue of Liberty	Long-term damage to a major ecosystem
Medium (Regional Importance) (Score of 500)	$10 Billion	Similar to a State Capitol Building	Long-term damage to a portion of an ecosystem
Low (Local Importance) (Score of 50)	$1 Billion	Similar to a park building (e.g., Yellowstone Lodge) or a stadium	Localized or short-term damage to an ecosystem

*Includes representative costs for fatalities, injuries, economic, and environmental damage.

A.3 Vulnerability Scoring

The first two columns of Table A-4 provide a scoring procedure that will permit alternative routes to be compared on a relative basis. A vulnerability score is computed for the accessibility attribute for each route segment. The route segment accessibility scores have a value between 1 and 9 and are a multiplier to the sum of the population and iconic structure scores as shown in Section A-4. The segment scores are summed to obtain the route vulnerability score.

A.4 Illustration of Vulnerability Analysis

This subsection illustrates the application of a vulnerability analysis in a routing context. The example looks at a single route alternative (Alternative 1) and is for illustration purposes only. Table A-6 provides additional data needed for the vulnerability analysis and Table A-7 presents the vulnerability analysis results.

Table A.6. Additional Data for Alternative 1

Data Type	Segment 1-A	Segment 1-B	Segment 1-C
Population	No additional data	An ethylene plant is located very close to the roadway with a normal operating staff of 75 people	No additional data
Economic	No additional data	The replacement value of the plant is $750,000,000	No additional data
Environmental	The segment crosses a river, and only short-term damage is estimated	No additional data	The segment crosses a river, and only short-term damage is estimated

Table A.7. Security Vulnerability Analysis

Accessibility Characteristic	Accessibility Score	Population	Economic Score	Environmental Score	Security Vulnerability Score	
Rural Two-lane Roadway (1-A)	5	616	0	50	5 (616 + 50) = 3,330	
Urban Two-lane Roadway (1-B)	7	765	50	0	7 (765 + 50) = 5,705	
Rural Freeway (1-C)	3	300	0	50	3 (300 + 50) = 1,050	
Total Route Vulnerability Score						10,085

A.5 Conclusion

The primary emphasis of a routing vulnerability analysis is the evaluation of targets (iconic structures) based solely on accessibility. The presence of targets is relatively easy to identify and to quantify as to their number and importance. Due to their compatibility, a routing vulnerability analysis can be integrated into a safety routing analysis or it can be performed separately.