

# SELECTING THE MINIMUM RISK ROUTE IN THE TRANSPORTATION OF HAZARDOUS MATERIALS

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## ABSTRACT

The transportation of hazardous materials is a broad and complex topic. The number of accidents involving vehicles carrying hazardous goods is increasing. Modern computer based information systems are frequently utilized for materials management. This paper presents an interactive software system for the minimum risk route selection based on the PC ARC/INFO Geographic Information System. The model computes optimal paths based on road network geometry and technical characteristics (road width, radius, and slope), class of hazardous materials, and environmental sensitivity. Hazardous materials are classified into categories according to their impact on different environmental elements. Regulatory requirements of the Hazardous Materials Transportation Act are also presented in detail in order to provide a broader understanding of the complexity of hazardous material transport.

## GENERAL

Federal laws impose comprehensive requirements on the transportation of both hazardous materials and hazardous wastes. Primary responsibility is assigned to the United States Department of Transportation (USDOT), which administers the Hazardous Materials Transportation Act (HMTA). HMTA was initially adopted in 1974, replacing earlier legislation and expanding upon USDOT's general responsibility to ensure the safe transport of goods in interstate commerce. HMTA applies to most forms of transportation including rail, motor vehicles, aircraft, and vessels. Pipeline transportation is regulated separately under the Natural Gas Pipeline Safety Act. HMTA was most recently amended in 1990 by the Hazardous Materials Transportation Uniform Safety Act of 1990.

USDOT has assigned the responsibility for promulgating HMTA rules to its Research and Special Programs Administration (RSPA). In recent years USDOT has been revising many HMTA regulations to make them clearer and more consistent and to increase the uniformity between domestic requirements and those imposed on international shipments by countries that follow the United Nations Recommendations on the Transport of Dangerous Goods (UN Recommendations). These revisions are being created through a number of related rulemakings.

Although HMTA applies to hazardous materials and hazardous wastes, the United States Environmental Protection Agency (USEPA) also regulates hazardous wastes transport as part of the USEPA's administration of the Resource Conservation and Recovery Act (RCRA). RCRA authorizes the USEPA to issue additional requirements to meet the special risks associated with hazardous waste transport. USEPA, however, must ensure that its regulations are consistent with those published by the USDOT.

HMTA generally provides that federal requirements preempt inconsistent state standards. This provision is intended to ensure that interstate transportation and commerce are not disrupted by state and local variations. States can adopt provisions that are "substantially the same" as federal standards. USDOT has the authority to issue a determination of consistency allowing the state and local governments to enforce existing requirements.

## HAZARDOUS MATERIALS TRANSPORTATION ACT

USDOT regulations are organized in two overlapping ways. They address both the range of activities involving hazardous materials and the individuals and corporate "persons" who actually undertake these activities. Current USDOT regulations cover the following activities:

- the manufacture of packaging and transport containers;
- labeling, marking, or placarding of containers and vehicles;
- handling (including packing and unpacking, loading and unloading, and procedures during transport);
- training of transport personnel;
- registration of highly hazardous materials transport;
- restriction or designation of hazardous materials transport routes (by state and local agencies, following federal standards);
- spill reporting implemented by USDOT along with EPA and the Federal Emergency Management Agency (FEMA); and
- the demonstration of financial responsibility.

## Defining Hazardous Materials

HMTA defines hazardous materials as those designated materials that might create an "unreasonable" risk to health and safety or property when being transported. Regulated materials designated by USDOT include any of the hazardous materials listed in USDOT regulations (49 Code of Federal Regulations sections 172, 101, 172, 102) and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA) hazardous substances listed in the Appendix to section 172. The USDOT list also incorporates by reference hazardous wastes subject to EPA "manifest" requirements.

Generally, HMTA regulations cover the "transportation in commerce" of any amount of a designated hazardous material. However, the degree to which regulations are applied to a given shipment depends on the hazard class of the material, the quantity of material being shipped, the type of carrier, and the type of contained holding the hazardous

Although the packaging and labeling requirements are intended to reduce the likelihood and harm of spills and other transportation emergencies, HMTA imposes additional requirements specifically to facilitate a quick response in case of an emergency. USDOT expanded the emergency response duties of shippers of hazardous materials effective December 31, 1990. First, these regulations require that each shipment be accompanied by emergency response information useful in mitigating a spill, including the following for each hazardous material transported:

- a description and the technical name of the hazardous material, as required on the shipping papers;
- immediate hazards to health;
- risks of fire or explosion;
- immediate precautions to take in response to an accident;
- immediate methods for handling fires;
- initial methods for handling spills that do not involve a fire or explosion;
- preliminary first aid measures.

This information must be available on the transport vehicle, away from the materials themselves and immediately accessible to the transporter and agency personnel (e.g., in the truck cab) for use by emergency response personnel.

In addition to taking these precautions involving the transport vehicle, each "person who offers a hazardous material for transportation" must provide a 24-hour emergency response telephone number monitored by personnel able to provide callers with additional information regarding the hazardous materials being transported, and proper emergency response procedures. USDOT's regulations provide that this number need only be monitored while materials are actually being transported. (Many shippers contract with third-party chemical information services to meet this requirement.)

Entities involved in hazardous materials transport are usually required by other laws to prepare for emergencies and emergency response. Examples include RCRA contingency plans and Clean Water Act (CWA) requirements for spill prevention control and countermeasure (SPCC) plans, and Facility and Vessel Emergency Response Plans.

#### Reporting Transportation Incidents

Carriers must notify appropriate agencies of transportation incidents. Generally, immediate notification is required if an incident causes death or serious injury, more than \$50,000 in damage, public evacuation, or the release of radioactive materials or etiologic agents. An immediate telephone call must be made to the National Response Center and to the Department of Community Affairs, Division of Emergency Management. Detailed written reports of all incidents and spills must be made to USDOT within 30 days (on USDOT Form F5800.1). These reporting requirements are in addition to similar EPA-administered requirements under RCRA and Superfund.

#### Driver and Vehicle Standards

USDOT regulates hazardous materials carriers as an extension of its regulation of motor vehicles. USDOT regulations also include technical requirements for the construction of transport containers, equipments, and vehicles for each mode of transportation--highway, rail, air, and water. Vehicles must also meet minimum safety requirements for lights, brakes, and other operating equipment in addition to following a proper maintenance schedule. The regulations also outline loading, unloading, and general handling procedures for each mode.

HMTA regulations address drivers' qualifications based on a physical examination, driving record, and written and driving tests. States generally adopt these standards, although some impose additional training or experience requirements.

#### Training "Hazmat Employees"

The 1990 amendments direct USDOT to expand training required for personnel involved in loading, unloading, handling, storing, and transporting hazardous materials as well as emergency preparedness for responding to accidents involved hazardous materials--the law refers to these employees as hazmat employees. The 1990 amendments provide that this training should not conflict with any training required by the US Occupational Safety and Health Administration (OSHA; see A2) or EPA. USDOT initially issued these "HM-126F" training rules on May 15, 1992 and then deferred their implementation (58 Federal Register 5850, January 22, 1993).

Employers must certify that employees have been trained and tested in any of the following areas applicable to their jobs:

- recognition and understanding of USDOT's hazardous materials classification system;
- use and limitations of the USDOT hazardous materials placarding, labeling, and marking systems;
- general handling procedures, loading and unloading techniques, and strategies to reduce the probability of damage or release during transportation;
- health, safety, and risk factors associated with hazardous materials and their transportation;
- emergency response and communication procedures for transport accidents;
- use of USDOT's Emergency Response Guidebook;
- hazardous materials transportation regulations;
- personal protection techniques;
- preparation of shipping documents.

Hazmat employees working as of July 2, 1993, must receive their initial training by October 1, 1993; employees hired after July 2, 1993, must receive their training within 90 days of employment. (USDOT's initial HM-126F rules made November 15, 1992, the effective date; USDOT deferred implementation in response to a number of petitions to have implementation dates for training requirements coincide with the deadline for the new labeling standards described above.) Employees who change job functions must receive any training required for their new job functions within 90 days. New or transferred employees must remain under the supervision of a trained employee or until they complete their own training.

- at the destination, the transporter ensures that the receiving entity signs for the waste, then keeps one copy and gives the other two copies to the destination facility.

A transporter must retain the transporter's copy of each manifest for a minimum of three years calculated from the date the waste is first accepted by the initial transporter.

Third, RCRA requires that transporters take certain actions in response to hazardous waste discharges during transport. They must inform appropriate federal, state and local agencies of the spill, and are also responsible for immediate containment actions (e.g., diking a spill area), although emergency response agencies typically assume site command once they reach the scene of the spill. Transporters retain legal and financial responsibility for cleanup. Transporters of hazardous waste must prepare contingency plans and train personnel in spill response procedures.

RCRA's general inspection, record-keeping, and enforcement provisions apply to transporters; thus, a violation of a legal requirement may result in criminal and/or civil penalties.

#### AN AUTOMATED APPROACH

The number and gravity of accidents involving vehicles transporting hazardous materials is increasing. As previously noted, extensive regulations are in place to comprehensively address hazardous material transport. In order to further protect the health, safety and welfare of the public as well as the environment, additional safeguards must be taken. For this reason, support from a modern computer-based information system is necessary. In conjunction with regulations for the transportation, personnel, and packaging dealing with hazardous materials, the selection of an optimal transportation route can assist in improving transportation safety. A minimum risk route selection application can be developed as part of more complete spatial information systems.

#### Data Model

The following databases must be developed as part of the overall system development:

- hazardous materials database,
- road network database, and
- environmental impact database.

An area's environmental sensitivity differs according to the category of hazardous material. This model utilizes the same categories developed by USDOT based on international standards. The model considers environmental sensitivity of water resources, air resources, human population, cultural resources, and land (upland/wetland) resources. Information regarding hazardous materials must include at a minimum, USDOT category, chemical name, and international codes.

#### Road Network Database

The extent of a local road network enables transport of hazardous materials. The condition of the road network and associated network geometry determines the relative safety of

transportation operations. Primary and secondary roads are necessary to develop the network database. Graphically, this information may be derived from digitization of street centerlines. The following road data is necessary for transportation optimization:

- horizontal curvature,
- vertical alignment,
- width, and
- construction.

Local conditions may dictate parameters by which certain roads may be eliminated from consideration in the transportation network.

#### Environmental Areas Database

While exposure to hazardous materials poses a risk to the general population and environment, there are certain elements of the human and natural environment that we may want to specifically protect due to rarity or other status. Environmentally sensitive areas may be mapped from local, regional, and state mapping sources.

#### Environmental Sensitivity Model

In many areas, different elements of environmental sensitivity may occur. For example, major groundwater supplies may be located in an area of threatened and endangered species or sensitive wetland habitat. Such areas where several elements are allocated must be modeled to reflect the confluence of several elements. GIS technology allows for the consideration of multiple databases. Utilizing topological overlay, multiple elements may be evaluated. Local conditions will determine the weights assigned to sensitive elements.

#### Optimal Path Selection

In the case that the transportation of hazardous materials cannot be avoided and alternative transportation routes cannot be avoided, an optimal path, which represents the minimum risk to sensitive elements, must be determined. This determination is possible by combining the road network database and environmental model database. Each section in the road network contains information regarding operating speed and the length of the section. The optimal path between an origin and destination is the route that has the minimum cumulative value of expression where:  $\text{impedance} = \text{length}/\text{operating speed} \times \text{vulnerability}$ . Vulnerability depends on the class of the dangerous material.

GIS enables the determination of hazardous material class based on international code and chemical name and the selection of the appropriate road network based on vehicle type. The GIS database can also contain the origin and destination points based on address range information.

#### CONCLUSION

The transportation of hazardous materials represents a major threat to the environment. With the aid of GIS for decision support in transportation, this risk may be minimized. Additional databases may be developed to allow for a more comprehensive evaluation of risk.