

TRANSPORTATION OF DANGEROUS GOODS AND THE ENVIRONMENT: A CONCEPTUAL FRAMEWORK OF THE PLANNING FOR CLASSIFICATION PROCEDURE OF DANGEROUS GOODS

JO Oluwoye, PhD.
Reader in Transport Planning,
Research and Graduate Programs, FDAB.
PO Box 123, Broadway. Sydney.2007. Australia.

INTRODUCTION

The transportation of dangerous goods on congested urban roads is becoming an area of increasing concern for public safety and environmental awareness. The risk to population and damage to environment is a major concern to the general public and government policy makers. Several studies on the transportation of hazardous materials (HM) have been reported in the literature. They relate to aspects such as database development, selecting criteria for designating HM highway routes.

Oluwoye and Ly (1997), and Alskowitz *et al.* (1990) illustrated the use of geographic information system (GIS) in mapping HM shipments. They found that GIS is ideally suited for minimum path identification and risk computations because it allows interaction of the transportation system and environment. Pijawka *et al.* (1985) developed a model of HM risk management and proposed a risk score for individual routes which reflected the interaction of four variables: the number of hazard events on the route; HM accident probability; population at risk; a composite index called potential hazard rating (PHR); and volume of HM by class. Saccomanno *et al.* (1990) performed a study on fatality rates and hazard areas for transporting chlorine and LPG by truck. Harwood *et al.* (1990) developed truck accident rate models as a function of roadway and area type (urban or rural) from state data on highway geometrics, traffic volume, and accidents. Ashtakala (1993) developed a methodology for determining safe routes for the transportation of HM. Oluwoye and Ly (1996) also developed a methodology for sustaining transportation of HM.

Ashton (1977), Nemmers and Williams (1983), House (1978), and Wright and Glickman (1984) provide an extensive review of current experience with safe routing strategies in North America and Europe. Gopalan *et al.* (1990) focus on developing equitable routes that spread the transportation risk to ones of the network. Glickman and Sherali (1991) consider a model where the objective is to determine a route that minimizes the expected number of fatalities, given that the number of fatalities exceed a certain number. Their model reduces to a formulation identical to that in Sivahumar *et al.* (1993a), where a single route model that minimizes the risk at the occurrence of the first accident is examined.

In general, much of this current experience has been to direct hazardous movements to designated corridors, where land development is less intensive, and historical accident rates are less pronounced. The underlying basis of this approach is to project past accident trends into the future, with a minimum assessment of the contextual factors that affect accident occurrence at specific locations at different points in time. In fact, a static assessment of past accident experience may fail to identify effectively those routes that are safer under a wide-range of random environmental conditions.

What is a dangerous goods?

Oluwoye (1988) defined DG as a wide range of bulk liquid chemicals with potential for spillage, fire and toxic release, and to liquified petroleum gases with potential for fire and/or explosion. The purpose of this paper is to develop a conceptual model of the classification procedures of DG movements which can be useful for transportation (truck) planning and policy.

CONCEPTS

The total dangerous goods and spill costs to a road, and its environment are a function of the DG traffic accident and its consequences. In order to achieve cost-efficient risk exposure strategies the goal of the optimization must be the minimization of the total costs subject to technical, environmental, and capacity constraints (See Figure 1).

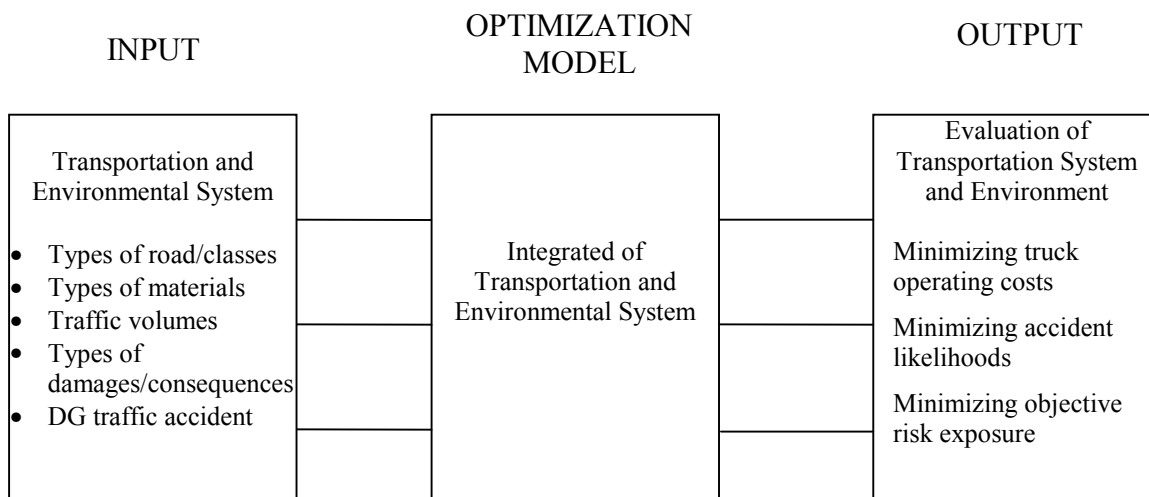


Figure 1: Structure of the integrated transportation of dangerous goods and environmental system

Furthermore, it should be noted that, in case of a traffic accident, heavy vehicles carrying DG cause damage not only on the road but also to the surrounding population and environment (Oluwoye and Ly, 1997). The consequences of DG traffic accident are shown in Figure 2. It should be noted here that the number of people affected by a DG traffic accident is confined to the resident population living around frontage / and use road section.

Similarly, a DG traffic accident causes environmental damage in the adjacent to the road section or segment. Notwithstanding, dangerous goods and materials transportation includes operation incidental to the whole course of carriage, such as loading, unloading, and storage in transit. Safety on a transportation route is defined in terms of the amount of population or environmental components at risk of 500 m distance from the centreline of each critical roads on both sides of a road section (Oluwoye and Ly 1996). A route is considered safe if it exposes least amount of population or environmental components (eg. plant and animal life, soil, water) to a DG heavy vehicle.

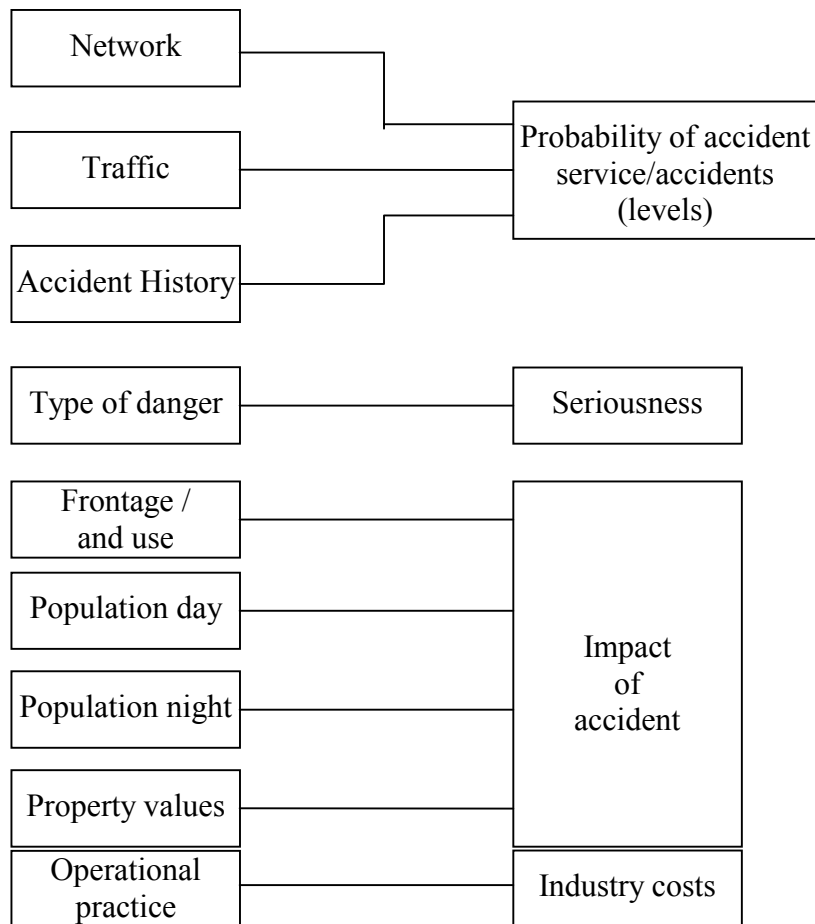


Figure 2: Basic approach of the routing of DG

METHODOLOGY

A key element in comparing the risks of alternative routes for DG transportation is to have reliable data on heavy vehicle accident rates for use in the calculation of the relative probabilities and seriousness of DG materials releases. Notwithstanding, the effect of roadway and area type on truck accident rates must be accounted for in routing studies. The methodology to determine safe routes for transporting DG is shown in flow chart, Figure 3. In the first stage of Figure 3 description of the existing situation data within the environment needed for the individual roadway segments is shown. The second step, defining classes of road environment and accident frequency for road type. In the third stage, determine road segments minimum of 500 m and for each segment: one environmental class, one accident frequency, one road type and one road length. In the stage four is to obtain data and define the percentile distribution of the traffic stream, while stage five is to use the table to calculate the probability figure and use the table to read its effects. Step six is to analyse the data and calculate the expected values. The final stage is to present the results for exploration of policy implications. However, the adverse impacts of DG movements will not be fully realised unless an accident occurs. Minimising the risk of an accident is clearly, then, an important routing consideration. The first classification procedure is by calculating road impedance values expressed as time, and were assigned by dividing the length of each road segment by its average speed,

converted into metres per minute. This gave an average time to traverse that section of road. Mathematically the operation is:

$$\text{Length of Road(metres)/Average road speed(metres per minutes)} = \text{Time to traverse roadway.}$$

Thus, the Accident frequency for each section of road is:

$$\text{Accidents frequency per year} = \text{Accidents}/(\text{Year} * \text{Traffic intensity in both directions} * \text{Road segment length in metre})$$

The annual accident frequency are dependent on class of road.

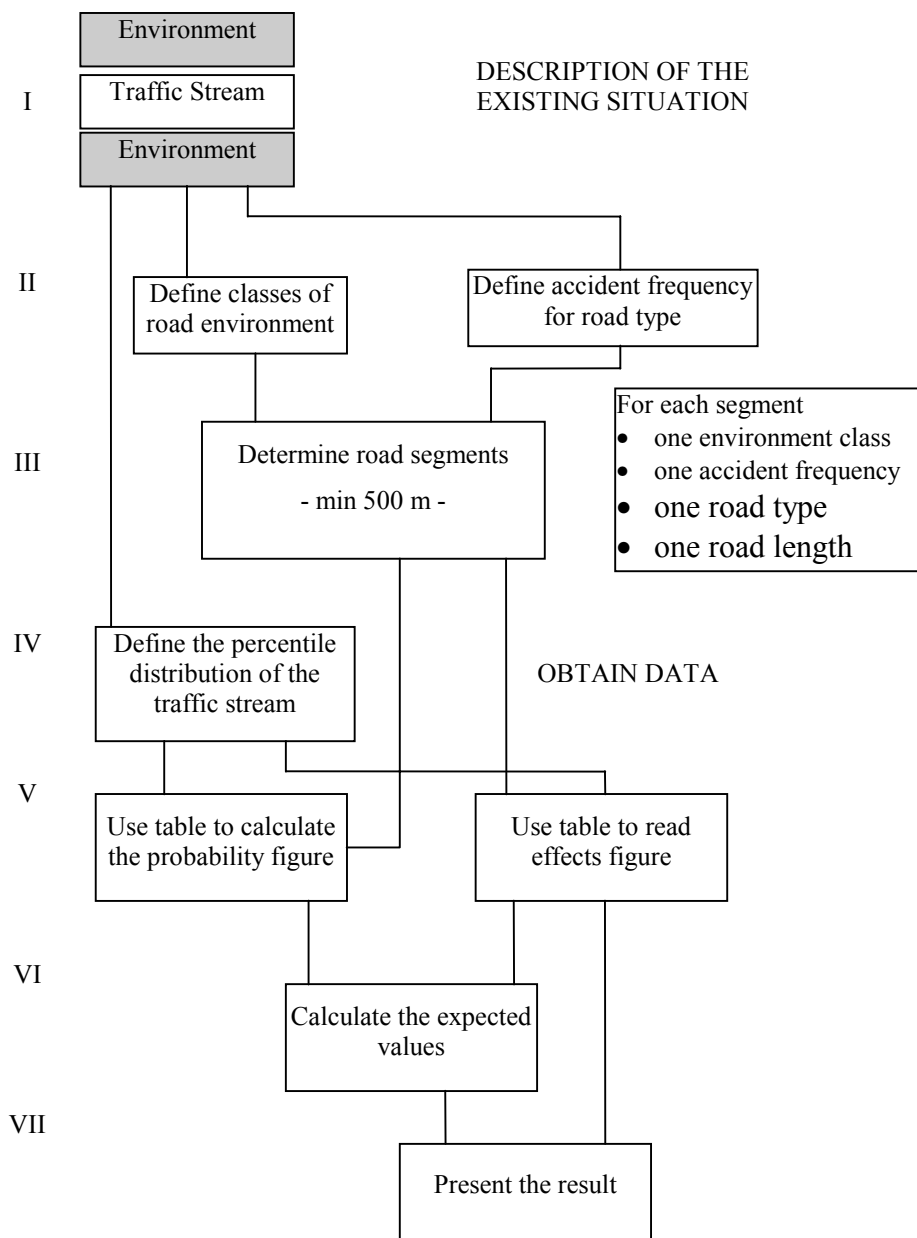


Figure 3: A flowchart of an overview of the routing of DG calculation method

The second classification procedure should be based according to the environment.

Mathematically the Population or Value density class per 1,000 m² is:

For the inner strip zone (both sides of the road) equation is:

$$\frac{\text{population or value density class per 1,000 m}^2}{\text{m}^2} = \frac{\text{number of persons or K \$}}{300 \text{ m x length segment in km}}$$

For the outer strip zone equation is:

$$\frac{\text{population or value density class per 1,000 m}^2}{\text{m}^2} = \frac{\text{number of persons or K \$}}{500 \text{ m x length segment in km}}$$

DISCUSSIONS

As can be seen from the above discussion that, within the city/town, there is a need for concern about the transportation of DG along main roads which pass through sensitive land-uses, such as residential, shopping centres, schools, frontage, etc. Furthermore, estimates of accident frequency and population or Value density are essential for conducting risk assessment in routing studies of highway transportation of DG movements.

Routes for vehicles carrying DG need to be complemented or formulated with the general aim of minimising the movements of DG through areas with high day and night populations and away from sensitive uses such as hospitals.

In the transport of dangerous goods and materials, the hazardous characteristics of these materials such as explosiveness, inflammability, chemical toxicity and corrosiveness must be taken into account. While there are DG such as poisonous gas, which are less commonly transported, there are some which are commonly transported, an example of which is petrol.

Improvement in the movement of DG from where they are manufactured or produced to where they are needed, requires careful and efficient traffic management. The hazards or the various risks associated with the transportation should be minimised, if not eliminated.

The effects/impacts of DG vehicles or land-uses along the routes used by them are those relating to all truck movements such as noise, vibration, safety, air pollution, traffic delays, and damage to pavements. The effects are related to the vehicles; these are the probability of mishap with serious consequences such as fire and explosion.

CONCLUSIONS

In conclusion, the Planner and Government efforts should be concerned with occurrence of disaster. Therefore, safety measures should establish standards, which will provide an acceptable level of control of the DG hazards to persons, property and the environment that, are associated with the transport of such goods. Thus, emphasis needs to be placed on the public

safety aspects of DG movements and transportation for explosive goods, which should be permitted only under special arrangement and using authorized vehicles.

It is important that in the transportation of DG, the concerned transport and storage personnel should receive relevant instructions about the hazards involved and the precautions to be observed. Also, in the event of accidents during the transport of DG, emergency conditions and provisions should be available and observed for protecting human health and the environment.

The methodology proposed in this paper is useful for application in transportation (truck) planning and policy.

REFERENCES

- Abkowitz, M., Cheng, P.D., and Lepofsky, M. (1990). "Use of Geographical Information Systems in managing hazardous materials shipment." *Transportation Research Record* 1261, Transp, Res, Board, Washington, D.C. pp 35-39.
- Ashtakala, B. (1993). "Methodology to determine safe routes for hazardous materials transportation," *Proc., CSCE Annu. Conf.*, vol. 3, Canadian Society for Civil Engineers (CSCE), Moutreal, Que., Canada. pp 567-575.
- Ashton, W.G., (1977). "Routing of Hazardous substances Moved by Road,". *Proceedings, Symposium on Transport of Hazardous Materials*, Institution of Civil Engineers, December, London.
- Environmental Protection Authority of NSW, (1992). "A Survey on the Transportation of Dangerous Goods in NSW by Road and Rail", Report from Dangerous Goods and Emergency Response Section.
- Harwood, D.W., Viner, J.G., and Russell, E.R. (1990). "Truck Accident Rate Model for Hazardous Materials Routing," *Transp, Res, Record*, 1264, Transp, Res, Board, Washington. D.C. pp 12-13.
- House, R.K. and Associates, (1978). "The Economics of Urban Goods Movement", *Urban Goods Movement Report Series*, Vol. 10, September.
- Glickman, T.S., and Sherali, H.S.,(1991) "Catastrophic Transportation Accidents and Hazardous Materials Routing Decisions," .*Probabilistic Safety Assessment and Management Conference*, Beverly Hills, California.
- Gopalan, R., Kolluri, K.,Batta, R., and Karwan, M.H.,(1990) "Modelling Equity of Risk in the Transportation of Hazardous Materials," *Operations Research*, 38,pp 961-973.
- Newmers, C.J. and Williams, W.L., (1983). "Guidelines for Designating Routes for Transporting Hazardous Materials", *Public Roads*, Vol. 47, No. 2. pp 61-65.
- Oluwoye, J.O. (1988). *Assessment of pedestrian crossing activity in the determinations of reducing conflict between pedestrians and vehicles along a strip of commercial streets in Nigeria Unpublished PhD Thesis*, UNSW Australia, May.
- Oluwoye, J.O. and Ly K., (1997). "Geographical Information Systems and Transportation of Hazardous Materials in NSW", *Research Report Submitted to UTS Research Office*, April.
- Oluwoye, J.O. and Ly K., (1996). "Methodology for Evaluating GIS for Sustainable Development: Road Transport of Hazardous Materials Shipment as a case study". *AURISA '96*, Vol. 1, Nov 25-29, Hobart. pp 246-251
- Pijawka, K.D., Foote, S., and Soesilo, A. (1985). "Risk Assessment of Transporting Hazardous Material: Route Analysis and Hazard Management." *Transp. Res. Rec.* 1264, Transp. Res. Board, Washington, D.C. pp 22-41.
- Saccomanno, F.F., Shortreed, J.H. and Mehta, R. (1990). "Fatality Risk Curves for Transporting Chloride and Liquefied Petroleum Gas by Truck and Rail", *Transp. Res. Rec.* 1264, Transp. Res.Board, Washington, D.C. pp 29-41.
- Sivakumar, R.A., Batta, R., and Karwan, M.H.,(1993a) "A Network-Based Model for Transporting Extremely Hazardous Materials," *Operations Research Letters*, 13. pp85-93
- Wright, M.E. and Glickman, T.S., (1978) "A survey of Foreign Hazardous Materials Transportation Safety Research since 1978". Paper presented at 1984 Transportation Research Board Annual Conference, Washington, D.C.

TRANSPORTATION OF DANGEROUS GOODS AND THE ENVIRONMENT: A CONCEPTUAL FRAMEWORK OF THE PLANNING FOR CLASSIFICATION PROCEDURE OF DANGEROUS GOODS

JO Oluwoye, PhD.
Reader in Transport Planning,
Research and Graduate Programs, FDAB.
PO Box 123, Broadway. Sydney.2007. Australia.

Author's Biographical Information

Dr.Oluwoye J.O. is a Reader in Transport Planning and Faculty Postgraduate Research Co-ordinator in the Faculty of Design,Architecture and Building at the University of Technology,Sydney, Australia.He previously lectured and practised as a Town Planner, Land Economist, Environmental Planner, and Traffic & Transportation Planner in America and Africa(Nigeria).

Dr.Oluwoye's previous publications and current research focus on the use of Quantitative and Qualitative in Environmental Design and Management.

Dr.Oluwoye has a Diploma in Cartography&Remote sensing from Briar Cliff College, NY.USA. BSc in Urban and Regional Planning with minor in Estate Management from University of Wisconsin-Madison,USA., Master in City Planning from Howard University,Washington D.C., and Ph.D.in Traffic and Transportation Planning from the University of New South Wales,Australia.

He is a Member of the Chartered Institute of Transport, the American Planning Association, the Nigeria Institute of Town Planners, the American Congress on Surveying and Mapping, the Road Engineering Association of Asia and Australasia, the Australian Institute of Traffic and Management, and also the World Congress on Transport Research.