

Risk Assessment Modeling for Hazardous Material Transportation: A Case of Non Uniform Population Distribution

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Introduction

Problem Statement

Material transport in urban areas is of great safety concerns.

Year	Total No. of Road Accidents (in numbers)	Total No. of Persons Killed (in numbers)	No. of Accidents per ten thousand Vehicles	No. of Persons Killed per ten thousand Vehicles
2000	391449	78911	80.12	16.15
2001	405637	80888	73.76	14.71
2002	407497	84674	69.16	14.37
2003	406726	85998	60.68	12.83

Hazardous material transport involves further greater environmental and safety issues. (e.g., in 1991 at Chennai, India, Accident involving transport of LPG caused death of 93 people)

...Introduction

Regulatory Status and Concerns

- Safety standards and codes are in place to regulate the safe transportation of of HazMat. (E.g., The Manufacture, Storage, and Import of Hazardous Rules; 1989)
- However, the elaboration of such regulations and codes do not fully warranty against such accidents.
- A ***good operations management... especially selection of routes*** can significantly minimize the associated hazards.

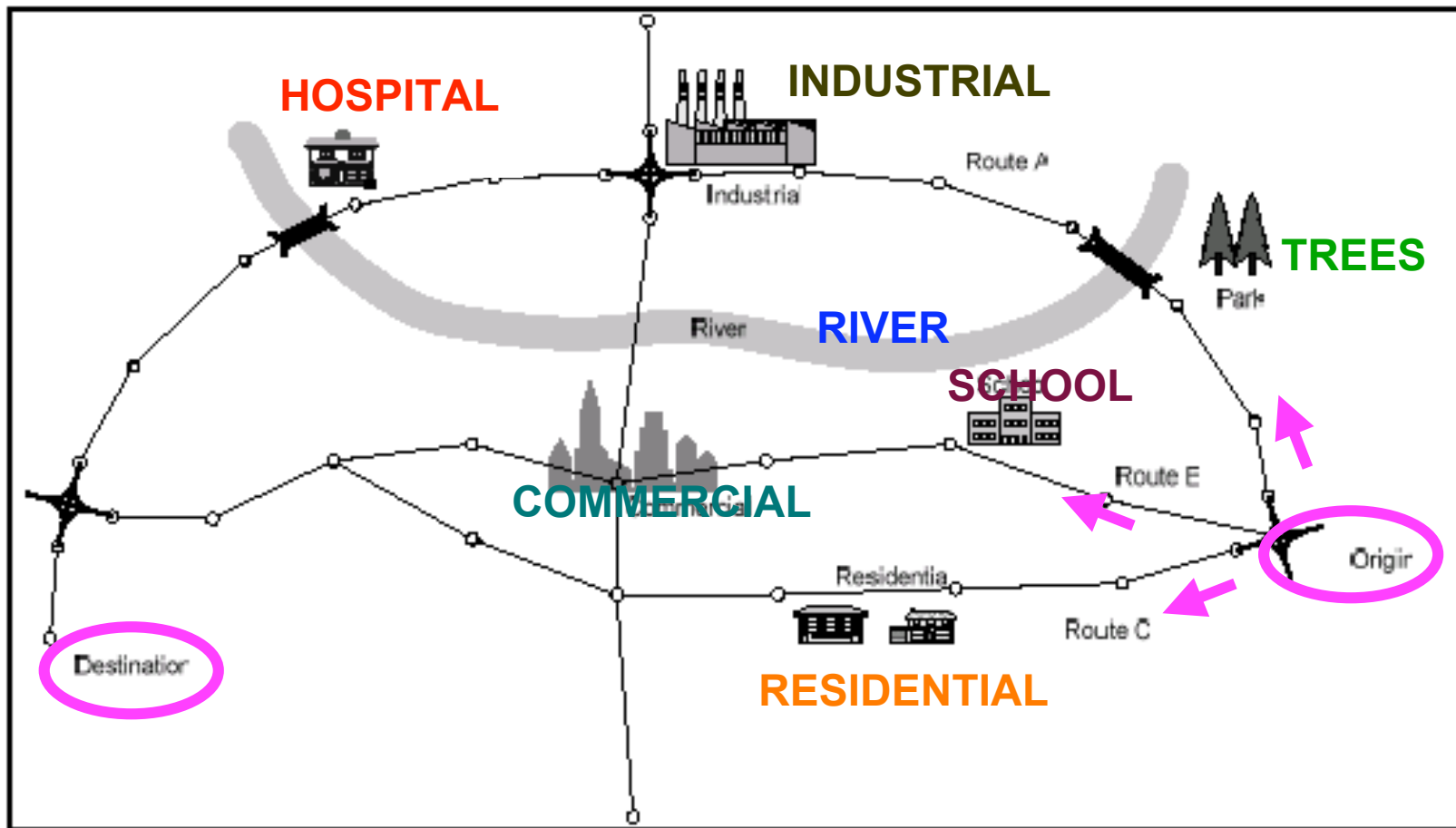
Criteria for Route Selection

1. Should we select the route, which is shortest/ offers minimum travel time?
 2. Should we select the routes for which the accident rate is lowest?
 3. Should we select the route for which the population exposed is lowest in case of possible accidents?
- How to take decisions?
 - Could we select the route, which is shortest, as well as have lowest accident rate and lowest population exposure?
 - Some more issues.....
 - How much responsibility is on the shipment company for damage, clean up cost, and even insurance premium?
 - Are the shipment companies solely responsible for accidents OR the infrastructure and other traffic issues also needs to be considered?

...Criteria for Route Selection

- Where do we go from here.....
 - Hazard materials transport is a multi-objective, and multi-stakeholders **PROBLEM**.
 - Risk assessment is a subjective discipline based on perceptions.

An example network



In the same settings different stakeholders may perceive the risk differently.....hence the decision on route selection should give due consideration to different population groups.

Risk Quantification

Conventionally Risk (R_i), for accident scenario ' i ' is a function of scenario frequency (F_i), and scenario consequence, (C_i)

$$R_i = f(F_i, C_i)$$

The minimum risk model is based upon shortest route algorithm. Minimum risk path through the network, can be computed using the recursion..

$$\bar{R}(i) = \min_j [R(i, j) + \bar{R}(j)]$$

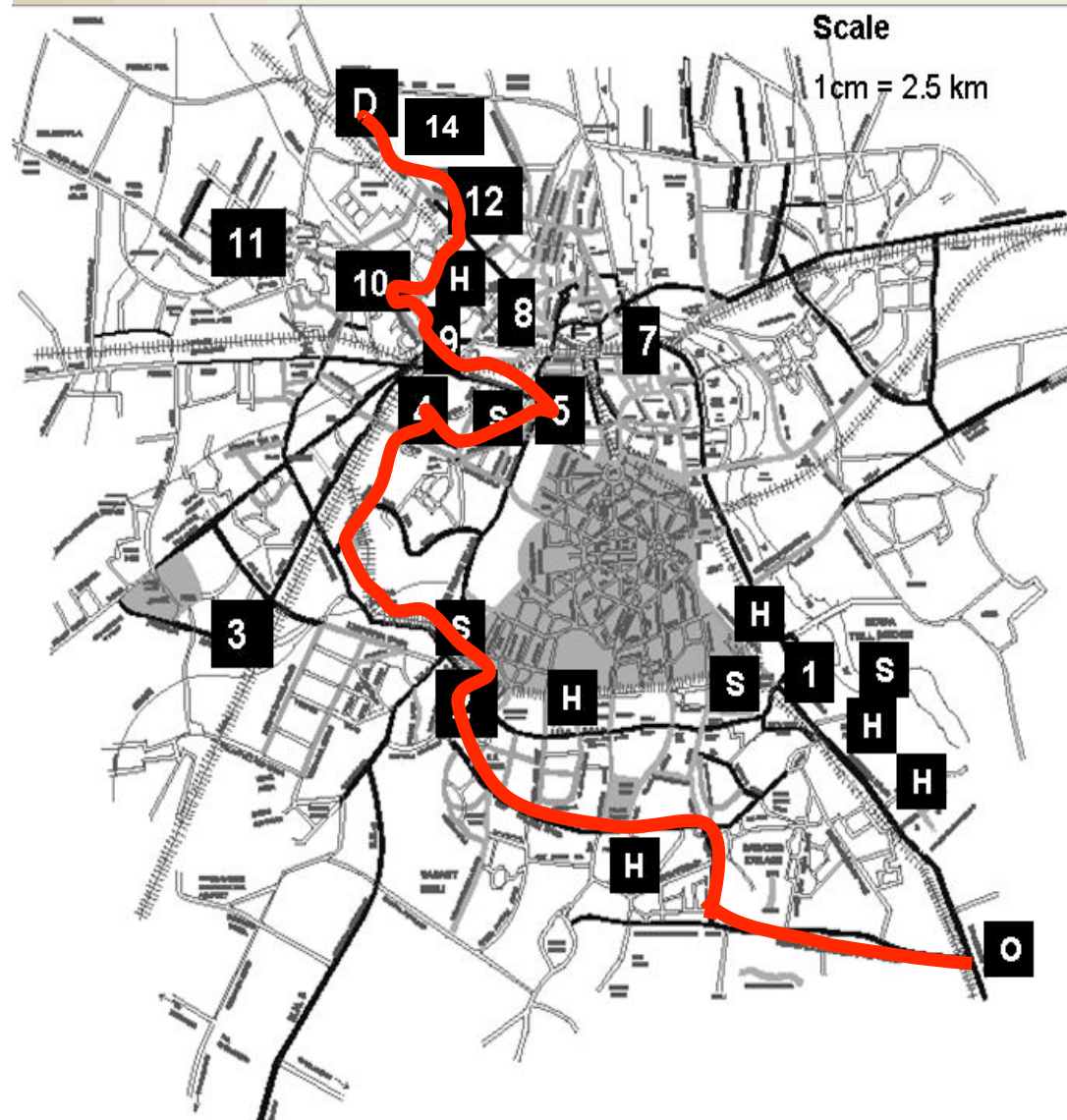
...Risk Quantification

- Accident probability from historical data of accidents
- Accident consequences depending upon population affected
 - Population groups
 - On Road Population
 - Off Road Population
 - On road population is calculated using annual average daily traffic (AADT) data.
 - Off Road population is further categorized into subgroup like hospital, schools etc.

...Risk Quantification

- Effective population is calculated by aggregation of population group by providing weightage according to their sensitivity.
- Weightage to different groups can be given subjective using Fuzzy Delphi technique involving expert opinions.

A Case of Hazmat Transport in Delhi



Legend

- O** Origin
- D** Destination
- H** Major Hospitals
- S** Schools

Minimum Risk Path

O → 2 → 3 → 4 → 5
→ 9 → 10 → 12 → 14
→ D

- Road network consists of ring road and outer ring road, two major NHs

- No. of residential areas, Schools and Hospitals are located on this network.

Conclusion

- Between same origin and destination pair different route may be selected for giving relative importance to population group.
- It is suggested to use 'equivalent population' (giving relatively more importance to the sensitive receptors) instead of population exposed will lead to improved decision making.