AN INTEGRATED INFORMATION SYSTEM FOR HAZARDOUS MATERIALS RISK MANAGEMENT

Konstantinos Zografos and George M. Vasilakis

University of Patras
Department of Operations Research and Management
Rion, Patras 26500
Greece

ABSTRACT

The production and transportation of hazardous materials is an unavoidable process in any industrial society. A number of industrial activities of vital economic importance are dependent on the uninterrupted flow of hazardous materials shipments. Advanced Transport Telematics (ATT) technologies have the potential to support strategic, tactical, and continuous monitoring functions of risk management. The objective of this paper is to systematically present the state-of-the-art and the state-of-practice of the above mentioned technological achievements and to assess their importance in hazardous materials risk management.

INTRODUCTION

The substantial amount of hazardous materials transported annually worldwide constitute a great potential danger for the society and the environment prompting public and private agencies to find efficient and effective ways and methods to eliminate risk related to hazmat incidents. Prompt and accurate detection and effective management reduces the impact of hazardous materials incidents and eliminates the potential societal and environmental risk. The rapid technological development provides new opportunities in risk reduction when hazmat are transported. In particular, ADVANCED TRANSPORT TELEMATICS technologies (ATT) promise to have dramatic impact on the way hazmat transportation functions will be performed in the near future. Advanced Transport Telematics (ATT) technologies have the potential to support strategies, tactical, and continuous monitoring functions of risk management actions related to hazardous materials transportation.

Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), Collision Avoidance System (CAS), On Board Computer (OBC) technologies coupled with integrated communications, data management and display systems, i.e. Geographic Information Systems, and Decisions Support Systems offer a wide spectrum of risk management capabilities.

The objective of this paper is to present a systematic description of the above mentioned technologies and provide a framework for the development of an Integrated Decision Support System (DSS) that manages risk by taking advantage of all features provided by the reviewed technologies.

AN OVERVIEW OF TELEMATICS IN COMMERCIAL VEHICLE MONITORING TECHNOLOGIES

Automatic vehicle identification is a system that consists of two major components: a) an on board component and b) a roadside component. The on-board component is an electronic tag that has a unique identification signature and the capability to store information describing the type of vehicle and its load. The roadside device is a "reader" that interrogates the tag and extracts the information stored in it. The information extracted from the tag can be transmitted to a computer located at a vehicle control and monitoring center. The operation of a typical AVI system is presented in Figure 1.

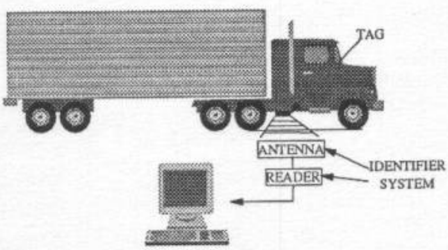

Figure 1. AVI system

AVI systems can be used to monitor and control the movement of vehicles transporting hazardous materials. This can be achieved by equipping hazmat trucks with the appropriate transmission tags and by installing "tag-readers" at crucial monitoring locations along a corridor or a network heavily traveled by trucks carrying hazmat. The AVI systems can provide essential input information for the effective management of incidents involving hazmat vehicles. In particular, the AVI system can identify truck location, and route, and display all the information at a central control center. Monitoring the truck movement in relation to a planned timetable and a predefined route can help the control center to: 1) identify deviations from a predetermined schedule and route 2) provide crucial information required for monitoring the movement of hazmat shipments, and 3) enforce hazmat routing and scheduling regulations. For instance, (Figure 2) if the control center receives a signal that the truck passed Point #1 and after a significant time period it did not pass Point #2 there is an indication that something abnormal happened (i.e. the truck is stalled, incident or the driver did not followed the redefined route).

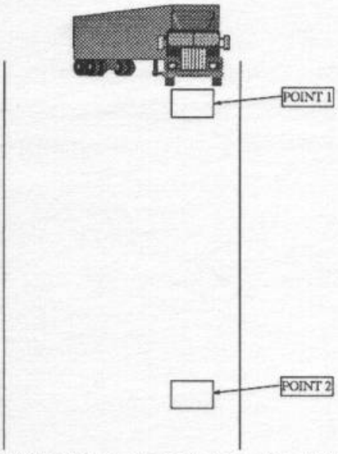

FIGURE 2. Truck monitoring using AVI technology

Alternative AVI technologies have been developed for monitoring commercial vehicle operations (Boghani, 1990); these technologies involve Low-Frequency (RF), Microwave (RF), and Optical Bar Code.

The objective of *Automatic Vehicle Location(AVL)* is to identify the current position (location) of specially equipped vehicles. AVL systems are vital for monitoring hazmat truck movements and managing hazmat incidents. Knowledge of the exact position of a vehicle transporting hazardous material can eliminate drastically the response time in case of an incident. Integrated AVL and Geographic Information Systems (GIS), provide the very interesting feature of plotting truck's path and current location on a digital map at the control center and at the truck cab, helping the operator at a control center to monitor hazmat truck movement and determine the location of an incident and provide rerouting information to the cab driver.

Vehicle location is identified by using various techniques:

- Dead-reckoning system- "inertial guidance"
- Ground Based Determination System
- Low earth orbit satellite-based system (GPS)
- Radio Determination Satellite System (RDSS)
- Proximity system-radio tags

Details about the technical and operational characteristics of the above mentioned systems can be found in references (Greenback et al, 1988), (Boghani, 1990), (Davies et al, 1991).

THE PROPOSED METHODOLOGICAL FRAMEWORK

The danger associated with accidental release of hazardous materials is substantial, therefore the development of an integrated Decision Support System aiming to reduce the risk of transporting hazmat is vital. This system must take advantage of the capabilities provided by modern technology. In the case of a hazmat incident ATT technologies provide vital information to assist incident management procedures and minimize their catastrophic societal and environmental impacts. For instance information regarding the location of a hazmat truck and monitoring of its movement, results in: a) significant reduction of incident detection, response and clearance time, b) reduction of emergency vehicle dispatching time, c) accurate and quick activation of traffic detouring and area evacuation plans, and finally, d) implementation of a plan that informs public about the situation (type of incident, severity, precautions, etc.) to prevent undesirable post-incident consequences. Therefore, ATT technologies can reduce the likelihood of severe post-incident consequences and the likelihood of incident impact.

The proposed Integrated Risk Management Information System consists of various components. At the first step spatially distributed data are collected. In particular, information regarding: the condition of a hazmat truck from On Board Computers (OBC), the location of AVL\AVI, and Traffic Management information are transmitted to a central control center and this information is combined and integrated in the computer of an Emergency Response Center. The next step, is to integrate the above information with a Geographic Information System (G.I.S) which allows the monitoring and display of the trucks transporting hazardous materials on a digital map. The operator at the central control center monitors the movement of the truck and gives on line feedback information to the driver through the communication system. In case of an hazmat incident, the second component of the Transportation Risk Management Information System is activated. This module consists of a database containing different hazmat types and appropriate response actions in case of an incident. The information from the database (i.e., incident type, response and clearance actions) and from the G.I.S. (i.e., exact location, population exposed in risk, land use, etc.) is transferred to analytical models and an expert system. The analytical models in cooperation with the expert system provide recommendations for both the operator at the central control center and the driver. The proposed system is shown in Figure 3.

CONCLUDING REMARKS

An Integrated Information System for Hazardous Materials Risk Management has been presented. The proposed system integrates available technologies for acquisition, transmission, and processing information regarding the location of hazardous materials shipments with analytical models and decision tools. The proposed system can help emergency response to reduce their response time and consequences to reduce the risk of hazardous materials transportation. Work in progress involves the detail quantification of the risk reduction benefits expected from the introduction of ATT technologies and the cost effectiveness evaluation of the proposed system.

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