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MODEL DEVELOPMENT FOR RAIL TRANSPORTATION OF HAZARDOUS MATERIALS IN GREECE

S. BASBAS[a*], C. PYRGIDIS[b]

[a] *Department of Transportation and Hydraulic Engineering, Faculty of Rural and Surveying Engineering, Aristotle University of Thessaloniki, 540 06 Thessaloniki, Greece,*
E-mail : transp@edessa.topo.auth.gr
[b] *Department of Transport and Organisation, Faculty of Civil Engineering, Aristotle University of Thessaloniki, 540 06 Thessaloniki, Greece*

Abstract. Within this paper the issue of rail transportation of hazardous materials is discussed, and emphasis is given to the existing situation in Greece. The Laboratory of Transportation Engineering of Aristotle University of Thessaloniki has carried out a research study about the rail transportation of hazardous materials in Greece and the role of Greek Railways (O.S.E.). Within the framework of this research, all dangerous materials which were transported by O.S.E. were identified, the existing situation in the country was analysed, the conditions under which O.S.E. can expand the rail transportation sector of hazardous materials were identified, forecasts were made for the future and a model for the development of this sector was proposed including all necessary actions to be taken by O.S.E. The existing situation in Greece, concerning the rail transportation of hazardous materials, was identified by using, among other techniques, a specially designed questionnaire. The proposed actions can also be considered as appropriate ones in the case of other countries facing similar problems.

Keywords: rail, environment, transportation, hazardous materials.

AIMS AND BACKGROUND

It is widely known that safe transportation of hazardous materials is an essential characteristic of our technologically complex society[1]. The term "hazardous materials" covers materials of which the transportation is permitted under certain regulations. These materials are liquid and solid fuels, liquid gas, explosives, radioactive materials, virulently and corrosively materials. Their classification is based on their physical and chemical characteristics. The hazardous materials transportation process has been considered for many years as a "strictly personal and confidential business" between the carrier and the customer. Today this process is turned to a "complex market" and consists of a number of directly or indirectly involved "actors". There are a lot of factors[2,3] which affect this market like the ones mentioned in the following paragraphs.

* For correspondence.

Concerning the existing legislation framework, international laws and agreements precisely specify the framework for the various activities (e.g. safe transportation, loading, unloading, packing, storaging) in the transport sector of hazardous materials. The rules and regulations at international or European level are[4]: A.D.R. for road transport, R.I.D. for rail transport, IMDG-CODE for sea transport and ICAO-TI IATA-DGR for air transport. The basic objective of R.I.D.[5] is the improvement of safety level in the sector of rail transportation of hazardous materials.

R.I.D. is an appendix of the C.I.M. which in turn is an appendix of the COTIF Agreement. R.I.D. is in action today in 39 countries which are members of the COTIF Agreement. Originally, R.I.D. has to do only with the cross-border transportation. Since 01.01.1997, according to the directive 96/49/EU of the European Council, R.I.D. has also covered the domestic transport of hazardous materials in these countries.

Therefore, all regulations which are different from those specified in R.I.D. and A.D.R. will be replaced in all countries in which R.I.D. and A.D.R. are into action. It is a crucial issue for all countries involved in the above process, to harmonize their national legislation framework taking into account R.I.D. and A.D.R. This harmonization is essential for each country in order to avoid "unwanted" implications. It must be mentioned at this point that similar conclusions arise for the situation in U.S.A.[6] where "... problems involving hazardous materials do arise because local jurisdictions and federal agencies other than the Department of Transportation issue regulations which conflict with or are more restrictive than those of the DOT..."

Concerning customers demand, it is estimated that chemical industries, oil companies and other major "producers" or "consumers" of hazardous materials will not face any mid-term problems. The challenge for these "producers" or "consumers" of dangerous materials has to do with the answer to the following question: "how can they bring together the increase of their production and their transport activities (and therefore, the increase of the possibility of an accident) on the one hand, and the implementation of accidents prevention measures, on the other hand".

Apart from the safety criterion, which plays an important role in the transportation process of hazardous materials, there are also other criteria like the effectiveness of the transportation process, the environmental protection issues and the transport cost, which affect the final decision of customers for the mode they are going to use. Concerning public awareness, the risk of an accident due to "technical problems" of a transport mode, has been accepted by the public with great difficulty and skepticism. It is known that people feel incapable in situations in which they are not prepared to face. Therefore, people are used to requiring an improved safety level while they travel by bus or train but they behave in a different way while they travel in their private car.

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On the other hand, all public information coming from the television, the press etc. affects public opinion in a very important way. Major environmental accidents all over the world during the past years, receive enormous publicity due to the television and press coverage. This is one of the main reasons explaining the fact, that people react with great sensitivity to news about accidents involving chemical products and radioactive materials. As a result of this reaction, "pressure" is put to all parts involved in the hazardous materials transportation process in order to improve their safety measures.

Concerning the need for environmental protection measures, after the serious accidents which took place in India (Bhopal) and in Italy (Seveso), E.U. has implemented a directive regarding the level of danger which concerns certain industrial activities. This directive is entitled "Seveso". In the "implementation area" of this directive the European Council particularly includes all companies which produce, use, or transport dangerous materials in quantities capable of causing major accidents.

Therefore, all carriers of hazardous materials, independently of the transport mode used, must cooperate with all public organizations and organize the transportation process in a proper way. They must also adopt an information and prevention system which will assist the effort to minimize the number and severity of such accidents. In Greece[7], there is a provision under law 1650/16.10.1986, articles 28 and 29, for penalties in cases of environmental pollution from dangerous materials (e.g. fine up to 100 mil. drs.)

European Rail Organizations carry over 100 mil. t of hazardous materials every year. A percentage of 95% of the above transportation activity concerns tanks belonging to private rail companies. Rail transport of hazardous materials comprises the 25% of the world transportation activities of such materials by all modes except pipelines[8]. It must be mentioned at this point that the capabilities of the rail transportation system are much bigger.

Hazardous materials transported by rail consist mainly of liquid fuels, liquid gas and chemical products. All types of trains are used in the transportation process as stated below:

a) block trains and complete trains for the transportation of chemical products and liquid gas;

b) trains exclusively scheduled (trains entiers) for the transportation of liquid fuels;

c) combined transport for chemical products in environmentally sensitive areas with strict environmental legislation framework.

The competition of rail with other transport modes (e.g. road transport, maritime transport, pipelines) is very hard and affects the market share of each mode. Rail is a safe transport mode and therefore it can be considered as the appropriate and ideal solution for the hazardous materials transportation. More specifically, the following reasons support the above statement:

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a) the system "wheel – rail", as it was originally designed, is a physical mechanism which can guide the vehicle in straight path and in curves with a minimum human involvement;

b) in case of at-level railway/road crossings when they are guarded (e.g. bars, signals), safe environment is provided due to the priority of the one of the two modes (train);

c) all personnel involved in the rail transportation process are qualified and specially trained for this purpose. There is also in many networks a continuous on-line monitoring process for all trains. This process takes advantage of modern technologies;

d) routing and scheduling procedures are not affected by weather conditions.

In case that the trains carrying hazardous materials use the same track with passenger trains, the accident risk is at a minimum level due to high level of maintenance and geometrical characteristics required for the passenger trains. In a relevant survey in Greece, rail has been considered as the safest mode for 17 of 24 types of dangerous materials examined.

When comparing the rail transport with the road transport, this must be done on an "equal basis". That means, it must be taken into account that both modes operate within the framework defined by R.I.D. and A.D.R. The most important disadvantages in the road transport process are the following:

a) the non-support of massive transportation of goods (especially in the form of liquids);

b) the relatively expensive tariffs;

c) the train has only one degree of freedom (guided system) which allows to automate many parameters of the operation (i.e signalling, braking);

d) the inefficiency in the vehicle service procedures (including tank washing);

e) the increased possibility of an accident due to heavy traffic volumes, insufficient geometrical characteristics of the road network and in some cases, bad weather conditions.

The capability of door-to-door delivery of goods (high level of flexibility) can be considered as the main advantage of road transport.

Taking into account the "pressure" from both public opinion and customers for increased safety level during the transportation process, the environmental protection issues and finally the congestion in road network, it is concluded that rail is nowadays under very favourable situation in this domain.

The total cost of rail transportation of hazardous materials consists of the following two parts:

a) the "conventional" freight transportation cost which refers to all expenses needed for the operation of a train (carrying all kinds of goods);

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b) the "additional" transportation cost exclusively dedicated to hazardous materials. This second category of cost consists of "special costs" and "extra conventional costs".

The "special costs" consists of:

a) capital cost and operation cost referring to trains and wagons (i.e special controls, wagons washing procedures);

b) additional cost due to specific "composition" of trains;

c) additional cost due to specific loading and unloading installations (i.e safety measures, fire fighting infrastructure, measures in order to avoid terrain pollution);

d) cost for personnel training;

e) cost for special marking of wagons and packaged goods;

f) cost for the operation of a system for monitoring cargos during the trip.

The "extra conventional costs"consists of:

a) cost which refers to all expenses needed for special manipulations according to R.I.D.;

b) "approach cost", which is the cost referring to all expenses for "door-to-door" collection and delivery of a product (construction and maintenance of sidetracks, operation of a special service just for collection and delivery of goods using the road network).

EXPERIMENTAL

The Laboratory of Transportation Engineering of Aristotle University of Thessaloniki has carried out a research study[9] about the rail transportation of hazardous materials in Greece and the role of Greek Railways (O.S.E.). Within the framework of this research all dangerous materials which were transported by O.S.E. were identified, the existing situation in the country was analysed, the conditions under which O.S.E. can expand the rail transportation sector of hazardous materials were identified, forecasts were made for the future and a model for the development of this sector was proposed including all necessary actions to be taken by O.S.E.

The existing situation in Greece concerning the rail transportation of hazardous materials was identified using a specially designed questionnaire. The aim of the questionnaire was to identify and record flows, quantities, origin-destination points, transportation cost, packing, infrastructure, safety issues, legislation issues and finally, comments and proposals from the producers point of view. The first step of the questionnaire survey was to contact all chambers of commerce and industry in Greece (51 chambers). 47 chambers finally participated in the survey and a total number of 290 companies from all over the country received the questionnaire. Apart from the questionnaire, interviews were made with other producers in the public and private sector.

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Table 1. SWOT analysis results for the rail transportation of hazardous materials[10]

Points of strength	Points of weakness
1. All main industrial areas of the country are located in a small distance from the railway network (also see point of weakness No 1). 2. Few accidents. High level of customers' trust on rail safety (also see opportunity No 5). 3. Rail is the ideal transport mode for massive transportation of special categories of cargos like grains, etc.	1. Few industrial zones and ports are connected with the railway network. 2. Inflexible existing system for cost evaluation and logistics. 3. High level of cost and tariffs taking into account the competition (also see point of weakness No 2). 4. Old rolling stock. 5. Maritime transport is in favourable position for special origins-destinations due to the geomorphology of the country. 6. Road transport offers low cost and flexibility. 7. Large part of the distribution work concerns small customers (work ideal for road transport).
Opportunities	**Threats**
1. The total transportation work concerning hazardous materials is large and exists on a constant basis (60-65 mil. t). 2. Greek Railways extended modernisation programme (ongoing). 3. E.U. and Balkan countries policy promote the use of rail. 4. Special consideration of hazardous goods within the new Business Plan of Greek Railways. 5. Strict implementation of hazardous materials safety regulations will be in favour of rail transport.	1. Greek transportation policy rather promote road transport. 2. Existing national and international transportation work of Greek Railways depends on a few major customers. 3. Competition from oil pipeline construction connecting Greece with other countries.

In Table 1 the "strong" and "weak" points in the process of transport of hazardous materials by rail in Greece are presented. This analysis is known as SWOT analysis from the following initials: Strengths, Weaknesses, Opportunities, Threats. Using this type of analysis the existing situation in O.S.E. and its position in the market, together with the opportunities and threats for O.S.E. in the existing environment were identified.

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RESULTS AND DISCUSSION

The volume (in tons) of hazardous materials which were transported by rail in Greece is very low compared to other European countries. According to research results[11] in the early '90s rail transport of hazardous materials represented only 6% of the total volume of hazardous materials transported by all transport modes (sea transport 36%, road transport 58%). The respective (rail) figure in U.S.A.[12] was 62%. More specifically, this volume is 1 094 790 t for 1996 while the same number for France is 18 000 000 t and for Germany is 38 000 000 t. It must be mentioned at this point that, although the volume of hazardous materials carried by O.S.E. is smaller compared to other European countries, this work is very important for O.S.E. More specifically, this work corresponds to 50% of the total work of O.S.E. which is 2 191 252 t for the year 1996.

Figure 1 presents the distribution of hazardous materials transportation work per category of transportation.

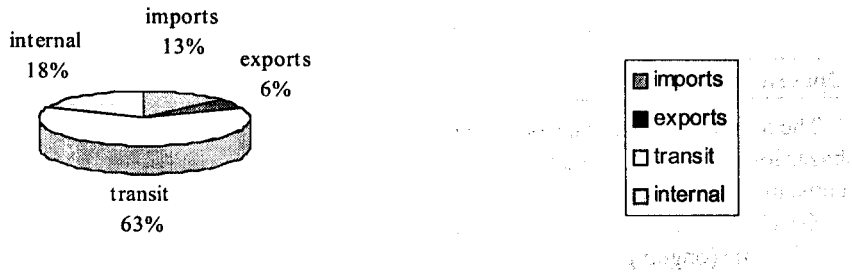

Fig.1. Distribution of hazardous materials transportation per category of transport[10]

Regarding the distribution of the amount of hazardous materials per classes (as all classes are defined in R.I.D.), class 3 (flammable liquids) covers the 80% of the total transported quantities by itself. The total quantity of hazardous materials carried every year in Greece by all modes is 60 mil. t. It must be mentioned that the 40 mil. t are fuels. O.S.E. posses the 1.66% of the total market of hazardous materials and 2% of the fuel market. The situation is worse when t/km were used taking into account that the major part of these quantities (transit and international cargos) is transported in corridors of small length. The first corridor is the Thessaloniki – Idomeni (connection with FYROM, length of 77 km, 750 000 t). The second corridor is the Thessaloniki – Promahonas (connection with Bulgaria, length of 144 km, 142 000 t). The most important corridor concerning the internal transport is the Thessaloniki – Larissa (73 000 t) and the Thessaloniki – Kozani (64 000 t). Regarding the loading and unloading stations for the internal transport, Thessaloniki covers by itself the 39.4% of the total work and at the same time all transit goes through the Thessaloniki port.

From the results of an in-depth research carried out by the Laboratory of Transportation Engineering of Aristotle University of Thessaloniki[9], it is clear that if O.S.E. follows a certain development programme in the sector of hazardous materials, the situation can be drastically improved in the near future. More specifically, O.S.E will be in the position to carry 4-4.5 mil. of hazardous materials every year within the next five years (that means four times up the today amount of work). In accordance, the O.S.E. share in this specific market will reach the 6% (from 1.66% which is today).

The above forecast was made using two different methodologies, which produced the same results at the end. The first methodology was based on a questionnaire survey (as mentioned above) including a large number of companies which play an important role in the production and distribution of hazardous materials. The second methodology was based on the utilization of data coming from the existing development plans of big industries in Greece. It is also based on data referring to existing and future needs in the market of hazardous materials transportation in the country.

According to the research results, O.S.E. has a lot of potential in order to increase its share in the hazardous materials transportation market. The model for the development of rail transport of hazardous materials proposed for O.S.E. include the following actions:

Special consideration of the transportation process of hazardous materials: a) establishment of a new Department in O.S.E., which will be responsible for the transportation of hazardous materials, b) production of a special handbook with the basic instructions for handling, transport and distribution of hazardous materials; c) revision of statistical data entry procedures; d) redesign of all necessary documents.

Safety transportation conditions. In case of a rail accident, the size of the catastrophe will be enormous compared to other transport modes due to the character of massiveness of rail transportation. Therefore accident prevention pays an important role in rail transportation. In any case[13] "...cities and local communities are currently vulnerable to multiple-fatality accidents resulting from incidents involving the transportation of hazardous materials...". Within this framework, the following measures are proposed: a) production of a table with useful information concerning all hazardous materials; b) design of a maintenance program; c) separation of repair and maintenance areas for hazardous and non-hazadrous materials; d) application of modern technology for network monitoring; e) inspection of all existing loading/unloading infrastructure; f) construction of non-level intersections where appropriate; g) improvement and renewal of infrastructure; h) construction of dedicated lines for hazardous materials in the stations; i) implementation of safety and security measures in the stations.

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It must be noted at this point that, since there is not any Information System in Greece[14] in which accident data involving road/rail transportation of hazardous materials are stored, the only available data source are the police records. The development of such an Information System is essential for monitoring this kind of accidents in the country.

Special precaution measures for environmental protection: a) construction of appropriate infrastructure for wagon cleaning; b) special construction of line infrastructure (e.g. slab track) in order to protect the subsoil.

Formation of a new legislation framework – harmonization with the European directives: a) training of the personnel; b) terminology standardization concerning the new legislation.

Ensuring of the necessary infrastructure – financing: a) systematic effort for connecting industrial zones, refineries, and other main productions and disposal centers of hazardous materials with the existing railway network; b) construction of service and loading stations for combined transport of hazardous materials in basic freight centers; c) new connections or improvements in the existing connection system of main ports with the rail network, and improvements in port infrastructure concerning combined transport; d) feasibility studies for the viability of the projects.

Design of a "realistic" market policy: a) attraction of certain categories of cargos, like transit cargos towards the rest of Balkan countries, liquid gas, explosives, fertilizers and ammonia; b) scheduling of block or exclusive trains along the main corridors; c) preference for long trains; d) increased commercial speed of trains; e) technical support of all efforts for new markets, f) new rolling stock.

Cost accounting and pricing: a) accurate calculation of the cost of the rail transportation of hazardous; b) pricing must be based on the cost evaluation but it must also provide incentives for the customers and allow for special agreements between them and O.S.E.

CONCLUSIONS

Rail transportation of hazardous materials can be in an advantageous position compared to other transport modes like road transport, especially when environmental issues are taken into account. A number of actions are considered as necessary in the case where a Rail Organization wish to increase its share in the market.

These actions include special consideration of the following issues: transportation process of hazardous materials, safety, measures for environmental protection, legislation, infrastructure and associated financing, market policy and fi-

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nally, cost accounting and pricing. The proposed model for the development of rail transport of hazardous materials in Greece can also be applied in other countries facing similar problems.

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