Establishing Hazardous Materials Truck Routes for Shipments Through the Dallas-Fort Worth Area

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ABSTRACT

The transportation of hazardous materials over streets and highways in the Dallas-Fort Worth area has become a significant transportation safety concern. Recent accidents involving vehicles transporting such materials have resulted in extensive property damage, traffic congestion, serious injury, and loss of lives. The occurrence of these accidents heightened local officials' interest in addressing this problem. In response to these concerns the North Central Texas Council of Governments, working with local governments in the Dallas-Fort Worth area, completed in January 1984 a regionwide routing system for hazardous materials truck shipments traveling through the metropolitan area. This approach was based on the guidelines established by the FHWA for systematically analyzing alternative routes and selecting those with the least amount of risk. The process followed to implement the FHWA risk-assessment approach is summarized, and the results of the analysis and the steps toward implementation of the selected routes are given.

The purpose of this study is to develop a system of regional hazardous materials truck routes for shipments through the Dallas-Fort Worth area. This plan was developed in response to the need identified by local, state, and federal officials for designing a regionwide routing system based on the selection of the safest available routes coordinated among each of the various local jurisdictions.

Funding to conduct this analysis was provided by the Texas State Department of Highways and Public Transportation (SDHPT) in cooperation with FHWA. The study was conducted by the North Central Texas Council of Governments (NCTCOG), the metropolitan planning organization (MPO) for the Dallas-Fort Worth area.

BACKGROUND

In 1978, in an effort to minimize the risk associated with the shipment of hazardous materials through the city of Dallas, the Dallas City Council amended the city code to restrict such shipments through the city to designated routes. This code modification also prohibited hazardous materials carriers from using certain freeways and tunnels. The Dallas routing plan designated the outer freeway loop for hazardous materials being shipped through the area. In proximity to the Dallas central business district (CBD), the ordinance prohibits local hazardous materials vehicles from using the elevated or depressed portions of freeways and the underground delivery tunnel system. City of Dallas police and fire personnel began signing, monitoring, and enforcement of these routes in 1983.

In 1979 the city of Fort Worth amended existing city codes also to specify the loop freeway system for through shipments of hazardous materials. The routing plan has not yet been signed or implemented for enforcement.

Several studies related to the routing of hazardous materials have previously been completed by NCTCOG. A Rail Planning Program for North Central Texas was developed in 1980 (1). Although this document addressed rail transportation issues primarily, a final recommendation cited the need to address hazardous materials movements by truck in the same region. The Regional Industrial Waste Management Study, also completed in 1980 (2), documented the significant levels of hazardous industrial waste materials that are being shipped via the trucking system in the Dallas-Fort Worth area.

In the fall of 1982, NCTCOG directors held a series of meetings with local police, fire, emergency response, health, and transportation officials regarding all facets of the hazardous materials issue. Local representatives expressed a strong interest in developing a regionwide program addressing these problems, including transportation. In November a regional hazardous materials task force made up of local staff members (one member appointed from each of the 10 largest cities) was created. The purpose of this group was to assist NCTCOG in the development and implementation of a work program addressing hazardous materials management. The work program dealt with three subject areas: (a) hazardous wastes storage, treatment, and disposal; (b) hazardous materials transportation; and (c) emergency response to hazardous materials incidents.

In the area of hazardous materials transportation, a two-phase approach for addressing hazardous materials truck routing was outlined. Phase 1 of the approach was aimed at establishing a regional system of hazardous materials truck routes for through shipments of hazardous materials, such shipments being defined as those not having origin or destination points within the Dallas-Fort Worth area. Phase 2 of this approach is the development of local routes within each jurisdiction. The local routes would be designated to serve those shipments with terminal locations in each city.

In the development of the work plan for this study, local officials emphasized the immediate need to develop a regional through-routing system that would be coordinated across all local jurisdictions. City representatives indicated that once a regional routing system had been established, the local route analysis could be completed on a case-by-case basis in cooperation with local staffs. The through-region routes could then also be utilized as access and egress routes to local routes developed by each city.

DEVELOPMENT OF AN ANALYSIS METHOD

The initial task of this study was to develop an analysis method for evaluating alternative hazardous materials truck routes for shipments through the Dallas-Fort Worth area. An approach for analyzing and selecting hazardous truck routes based on a risk-assessment methodology is outlined in the FHWA publication Guidelines for Applying Criteria to Designate Routes for Transporting Hazardous Materials (hereafter referred to as the FHWA guidelines) (3). This document provided the basic framework for evaluating alternative highway routes for hazardous materials truck shipments.

Figure 1 shows the hazardous materials routing method as outlined in the FHWA guidelines. The first step in this procedure is to define study issues and responsibilities. These include the identification of participants, objectives, jurisdiction, and potential routes for the analysis. Each of these four areas was addressed in the development phase of this study along with the type of shipments to be considered and several planning assumptions.

Study Participants

NCTCOG was identified as the lead agency to conduct this analysis. Assistance was provided by the staffs of local cities in the region, SDHPT, and FHWA. In order to gain input from all levels of government and the trucking industry, a technical committee of 40 members was established to review the project at key points in the study. This committee was made up of local representatives from transportation planning and emergency response offices of major cities in the region, SDHPT, FHWA, the Dallas-Fort Worth Council of Safety Professionals, area trucking firms, trucking interest groups, and the previously established NCTCOG Hazardous Materials Task Force.

Objective

The objective of this study was to develop a system of regionally coordinated hazardous materials truck routes that would reduce the potential exposure of individuals to an accidental release of hazardous materials transported on public roadways through the Dallas-Fort Worth area.

Jurisdiction

The jurisdiction for this routing study was the Dallas-Fort Worth metropolitan area, which includes all of Dallas and Tarrant counties and a small portion of the counties immediately adjacent to Dallas and Tarrant. This area corresponds to the Intensive Study Area (ISA), a geographic area designated by the MPO and used for all regional transportation planning.

Planning Assumptions

Several assumptions were made with regard to the implementation of this risk-assessment analysis, the first being that the designation of hazardous materials truck routes for shipments through the region

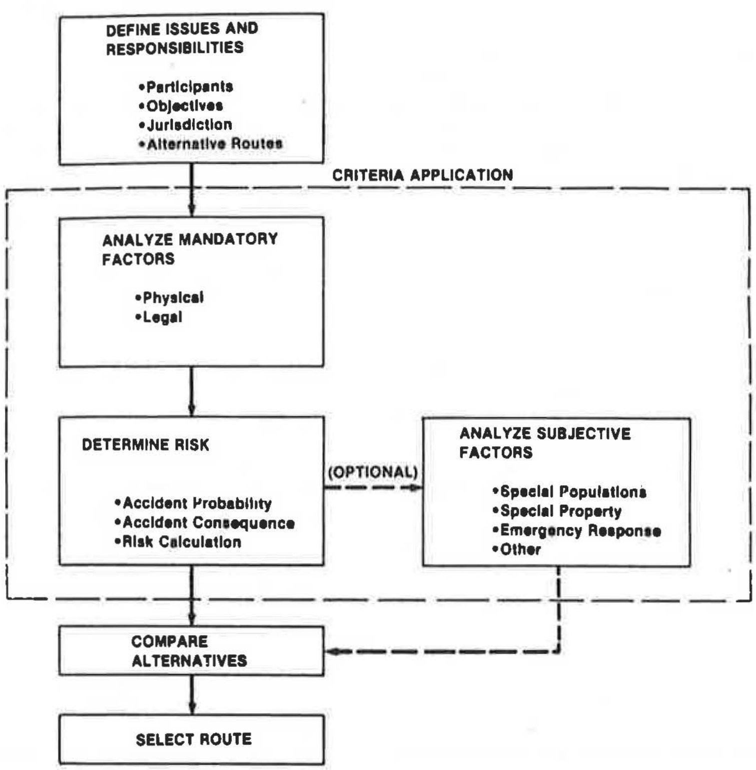

FIGURE 1 FHWA hazardous materials routing procedure *(3)*.

was a regional issue and should be addressed from a regional perspective. In doing so, the recommendations of this study must serve to enhance the safety of the entire region and not that of a single interest group or community.

Second, it was assumed that an acceptable route or set of routes for all hazardous materials being transported in conformance with federal safety regulations could be designated through the region.

Finally, it was assumed that the risk-assessment approach would identify those routes with the least amount of risk as defined by the FHWA guidelines independent of information regarding the frequency, type, or volume of hazardous materials shipments traveling through the region.

Type of Shipment Considered

Clearly various levels of risk can be associated with different quantities and types of shipments. However, in order to establish a uniform regional routing system, it was decided that any vehicle transporting hazardous materials through the Dallas-Fort Worth area in sufficient quantity to require placarding as set forth by the U.S. Department of Transportation regulations would be subject to the through-region routes. This includes, but is not limited to, those shipments identified in Table 1 of the Code of Federal Regulations (CFR 49, Section 172.504). These are Class A Explosives, Class B Explosives, Poison A, Flammable Solid, and Radioactive Materials. Also included are all other hazardous materials, found in Table 2 (CFR 49, Section 172.504), that require placarding, including those materials transported in bulk-cargo tankers with a capacity of more than 110 gal.

Alternative Routes

The identification of routes to be evaluated as alternatives in this analysis was completed in the initial phase of this study. Four criteria were established for designating this initial network:

1. All freeways (i.e., controlled-access facilities) should be considered as potential through routes,
2. Potential through routes entering and leaving the metropolitan area should serve as direct paths to other major metropolitan areas or the Interstate system and remain on controlled-access facilities wherever possible,
3. Freeway-to-freeway travel movements not served by direct ramp connections should be included, and
4. Potential through routes should not include existing tollroad facilities and noncontiguous freeway facilities.

Figure 2 shows the network examined in this analysis.

Once the preliminary network had been established, the criteria-application phase as shown in Figure 1 began. An initial screening of the network was done to eliminate alternative routes on the basis of mandatory or nonreconcilable factors, which included any physical constraints such as weight limitations on bridges, height restrictions on overpasses, inadequate shoulders for breakdowns, and extensive construction. The majority of the network used for this study included Interstate facilities or major freeway facilities built to Interstate standards. None of the preliminary network was eliminated in the initial screening process on the basis of physical constraints.

Legal constraints such as regulations regarding

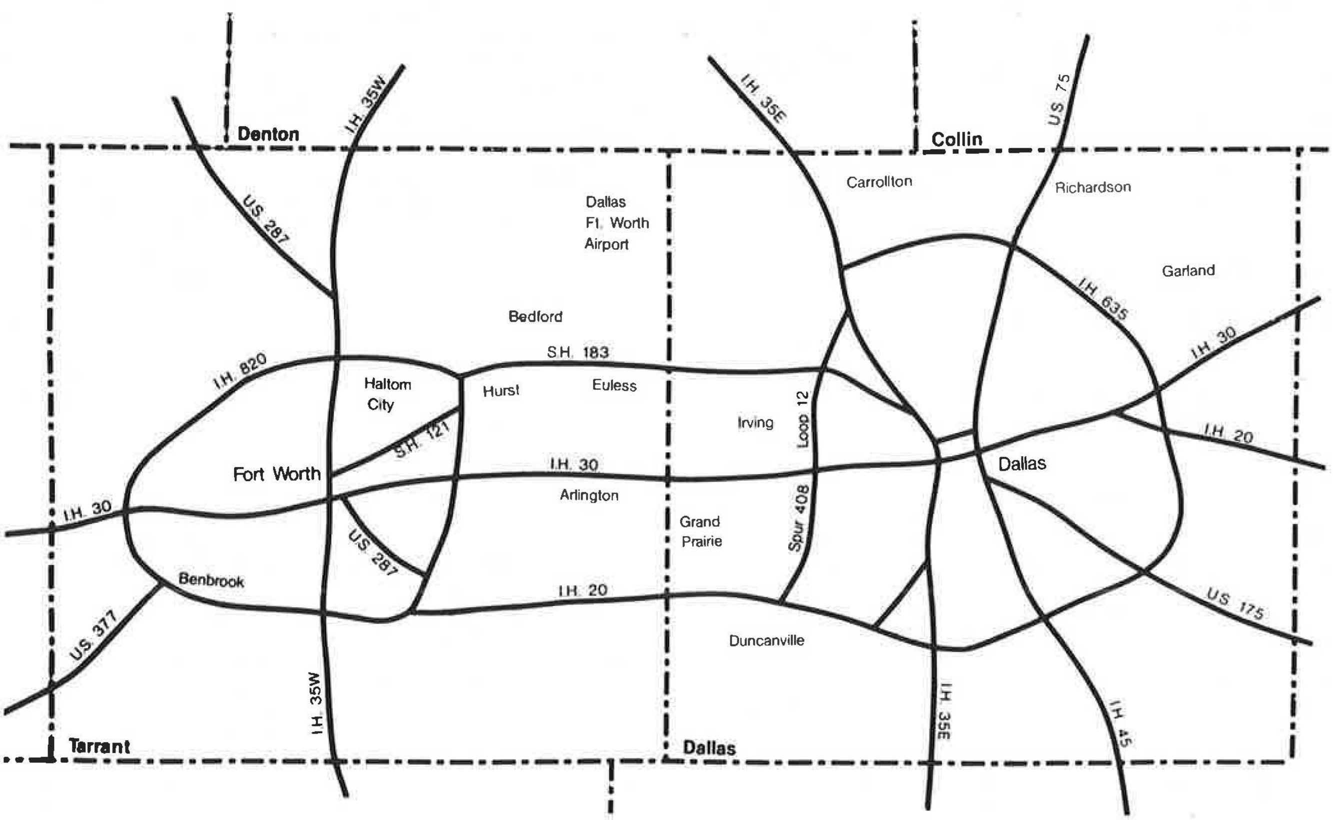

FIGURE 2 Preliminary hazardous materials route network.

bridges and tunnels were also reviewed for the network. Although both Dallas and Fort Worth had established hazardous materials truck route ordinances as previously described, these regulations were not used to eliminate potential network alternatives. No other legal constraints were identified to eliminate any of the network.

RISK-ASSESSMENT METHODOLOGY

On the basis of the FHWA guidelines, the risk associated with hazardous materials shipments on a roadway segment may be calculated by estimating the probability of an accident on that segment and the consequences of that accident should it occur. These two variables, accident probability and accident consequence, may then be combined to establish a total risk measure referred to as the "population risk." This numerical value is determined by multiplying the probability of an accident by the potential consequence of that accident for each link segment in the network. By summing these link specific risk measures along each alternative route, a total risk value can be established for each route. The route with the lowest risk value may then be determined. The FHWA guidelines suggest that this value be the primary criterion in the route-selection process. The guidelines also note that these risk values are not particularly meaningful as absolute numbers; it is the relative difference in the risk values that is used to differentiate the routes. The following discussion summarizes the accident probability, consequence, and total risk calculations used in the risk-assessment application to the Dallas-Fort Worth region.

Implementing the FHWA risk-assessment method on a regional scale for the Dallas-Fort Worth area entailed the analysis of approximately 500 mi of freeways over a $2{,}600\text{-mi}^2$ area. Although the FHWA guidelines provide the user with a set of worksheets for manually entering the data and performing the necessary calculations, it was determined at the outset of this study that manually performing this analysis on a regionwide scale would be extremely tedious and time-consuming.

In addition, much of the detailed freeway network and demographic information required to implement the FHWA risk assessment was in place and being used in the NCTCOG Multimodal Transportation Analysis Process (MTAP), a set of computer programs used for travel demand forecasting. Hence, in order to conduct this analysis on a more efficient basis and to reduce opportunities for human error in the detailed and repetitive calculations needed, the FHWA risk-assessment approach was developed into a series of computer programs compatible with the regular travel demand modeling process.

Accident Probability

The probability of a hazardous materials accident is the likelihood or chance that a vehicle carrying hazardous materials will be involved in a roadway accident. The FHWA guidelines provide a formula for calculating accident rates for all vehicles operating on a freeway on the basis of facility type and average daily traffic. A constant value to adjust the all-vehicle accident probability to equal the accident probability of a vehicle transporting hazardous materials is also provided. These equations are recommended when data to derive local estimates are not available.

In this application to the Dallas-Fort Worth area, truck accident data were provided by SDHPT for all the freeways in the region. These data consisted of the total number of tractor-semitrailer truck accidents for 1980, 1981, and 1982 summarized by 0.5-mi segments. For each study segment an annual total number of truck accidents was developed and formulated into accident rates by combining the accident data with estimates of total annual traffic volume for the corresponding segment.

The accident rates are expressed as the total number of truck accidents per million vehicles (all vehicles). According to the FHWA guidelines, the accident probability is determined by adjusting the accident rate to reflect the amount of exposure that a vehicle experiences. Hence the accident rate for each segment was adjusted by the segment length to obtain an accident probability (accidents per vehicle mile) for each segment. The accident probability formula is as follows:

Probability of an accident on Segment I = annual number of truck accidents$_I$/(annual number of vehicles$_I$ * link length$_I$).

As illustrated in the following example, a freeway segment 0.7 mi long with an annual traffic estimate of 44,200,000 vehicles (130,000 vehicles per day times an annualization factor of 340) and 26 truck accidents per year has an accident rate of 0.5 accident per million vehicles and a probability of 0.8 accident per million vehicle miles:

R_I = (26 truck accidents/44,200,000 vehicles),
$R_I = .5 \times 10^{-6}$,
P_I = 26 truck accidents/(44,200,000 vehicles x 0.7 mi),
$P_I = .8 \times 10^{-6}$ accident/vehicle mile, and
P_I = .8 accident per million vehicle miles.

The accident probability values for each of the 2,800 link segments that determined the freeway network were then posted on the NCTCOG network link file for input into the risk calculation.

The FHWA guidelines provide a factor to adjust all-vehicle accident probabilities to estimate the probability of a hazardous materials accident. This factor of 2.3×10^{-5} is based on the national ratio of hazardous materials accidents to all vehicle accidents for 1973 through 1978. This adjustment factor was not applied to the accident probabilities in the Dallas-Fort Worth study. Because the factor would have been applied uniformly across all potential routes, no additional detail would have been introduced to the study. In addition, no adjustment factor is provided by FHWA to adjust a truck accident rate. The purpose of using truck accident rates was to represent the relative risk of alternative routes based on the historical frequency of all tractor-semitrailer truck accidents.

Accident Consequence

According to the FHWA guidelines, the consequences of a hazardous materials accident or spill may be estimated for both exposure to population and property. For this application only exposure to population and employment were estimated in the consequence analysis. Data were not available on a regional scale to estimate potential property damage.

The potential impact area for a hazardous materials release will depend on the class of hazardous material that is being considered. A review of available literature regarding hazardous materials impact areas and recommended evacuation distances revealed an impact range with a radius varying from 0.25 to more than 2 mi, depending on the material, severity of spill, and atmospheric conditions present at the time of the accident. Information regarding the types and quantities of hazardous materials being transported through the Dallas-Fort Worth region was not available. An annual analysis of wind direction and speed revealed significant seasonal variations. For these reasons a worst-case exposure area was used for this analysis with an impact area radius of 2 mi. As recommended by the FHWA guidelines, this distance was held constant throughout the study.

In order to estimate the potential consequences of a hazardous materials accident on the Dallas-Fort Worth freeway system, a FORTRAN computer program was developed. The program, given the coordinates for each of the 2,800 link segments that made up the potential freeway routes, calculates the geographic impact area that falls within a 2-mi distance of each freeway segment. The program then determines the analysis zones that fall into a link impact area and sums the population and employment for those zones in the impact area of each link.

Although the concept of estimating population and employment for each link segment is outlined in the FHWA guidelines, an important change was made in this risk-assessment application regarding the calculation of the accident consequence. In order to take into account the length of each link or route segment in the estimation of the impact area, the total population and the total employment found to be within an impact area of a link were multiplied by the length of the link segment. The resultant measures are expressed as population exposure miles and employment exposure miles. This concept is similar to that used in calculating vehicle miles of travel in the accident probability equation in which the number of vehicles on a link is multiplied by the link length. The formula and computer program developed to calculate exposure miles were designed to estimate the value equally on link segments of varying length. This problem of analyzing alternative route segments of different lengths is not addressed in the FHWA guidelines.

Once the total population exposure miles and total employment exposure miles had been calculated for each link, the values were posted on the network file and used to estimate the total risk factor for each link segment.

Risk Assessment Calculation

The accident probability and the potential consequence measure for each link segment are multiplied to produce a total risk factor. Summing across all network links produces a total risk value for each alternative route. In this study the total risk factor for each route segment was defined as follows:

$$\text{Total Risk}_I = \text{accident probability}_I \times \text{sum of the population and employment exposure miles}_I.$$

The total risk factor for each link segment was calculated in a computer program and posted on the network link file.

In order to identify those routes for hazardous materials shipments through the Dallas-Fort Worth area, a minimum-risk path algorithm was developed. Twelve entry or exit points to the region were identified on Interstate or state highways as shown in Figure 3. The freeway network designated as potential through routes was then read into a minimum-risk path algorithm along with the accident probability, accident consequence, and total risk measure for each network link.

The minimum-risk path algorithm was based on the

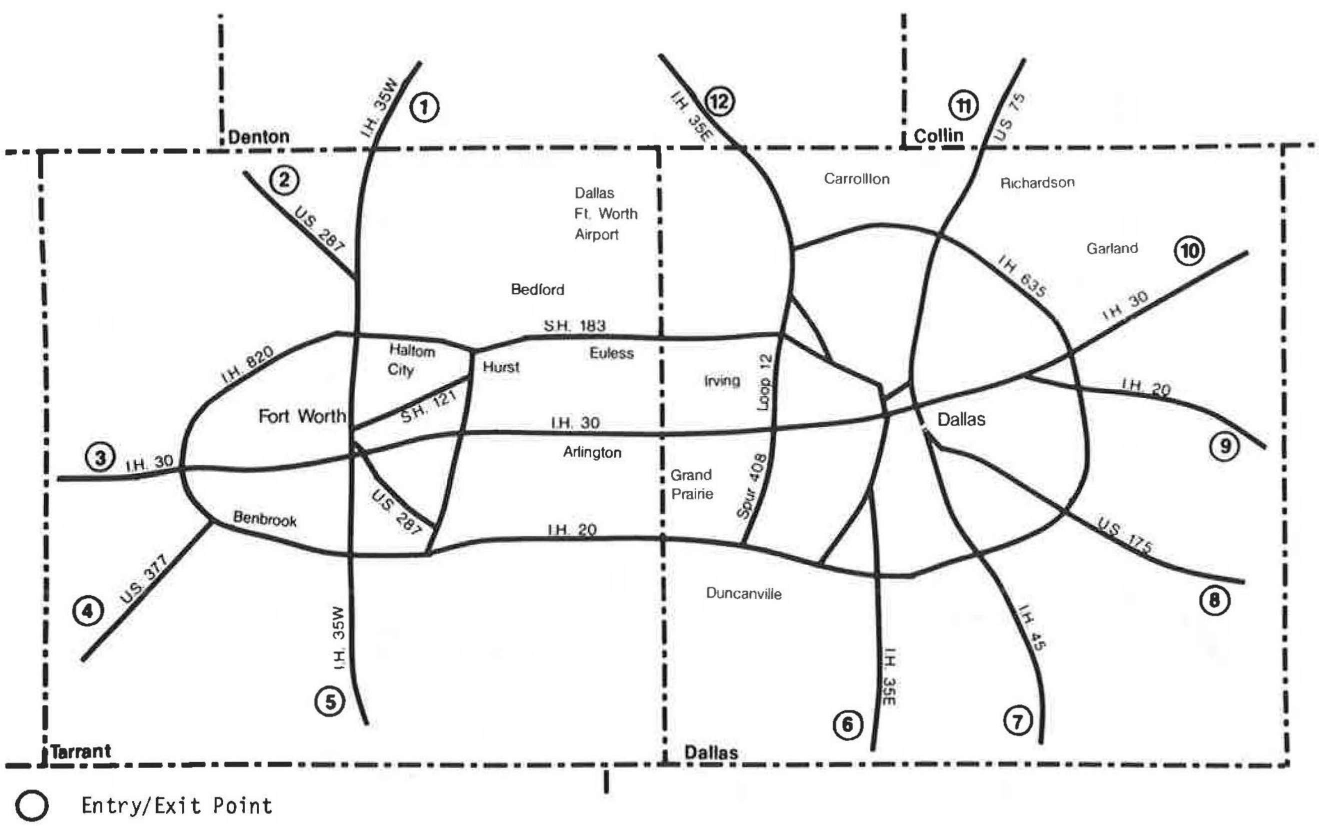

FIGURE 3 Freeway network entry or exit points.

NCTCOG-MTAP travel assignment program similar to the program UROAD in the FHWA-UMTA Urban Transportation Planning System (UTPS). This is a path-building program based on the minimum-path impedance. When it is used for travel assignment, the highway paths are selected on the basis of a combined minimum impedance of travel time, travel distance, and tolls.

In order to use the path-building approach to select the minimum-risk routes, the time distance and toll impedance on each link used for travel assignment were replaced by the total risk factor for each link. The program then calculated the least-risk paths from all entry or exit points to all other entry or exit points on the basis of minimizing the total risk.

The routes that had the highest frequency of use for travel between each of the 12 entry or exit points would then represent the least-risk paths. A significant concern of this approach was the possibility that a large variation of least-risk paths would occur on the basis of the origin entry or exit point and the destination entry or exit point. This would, in turn, make it difficult to establish a set of routes with any uniformity on the basis of this analysis.

The resulting minimum-risk paths are shown in Figure 4. Those chosen were the outer-belt loops of Interstate 635 and I-35E (Loop 12 and Spur 408) in Dallas County; the outer loop of I-820 and I-20 in Tarrant County; and I-20 providing the east-west connection between the loops. A summary of the frequency with which these routes were chosen revealed that of the possible 132 paths selected from each of the 12 exit or entry points to all other entry or exit points, the routes shown in Figure 5 were chosen on 128 occurrences. In four instances, State Highway (SH) 183 between I-35E and I-820 was chosen.

In order to establish the relative benefit of both designating the least-risk paths or not designating routes and the potential amount of circuity that a routing system would create for hazardous materials shipments as recommended by the FHWA guidelines, a set of minimum-distance routes was calculated. These routes, referred to as the base-case analysis, were chosen as a means of measuring the impact of routes currently being used by trucks under no restrictions because data were not available regarding the relative frequency of hazardous materials shipments on specific freeways through the Dallas-Fort Worth region. Using the minimum-distance routes as a comparison was based on the assumption that hazardous materials carriers would elect to minimize their travel distance when traveling through the metropolitan area. In reality, however, it is likely that shippers are more sensitive to travel time, traffic congestion, and safety as opposed to only minimizing travel distance. This would indicate a greater likelihood for hazardous materials shipments to use the Interstate loops around Dallas and Fort Worth as shown in the least-risk paths.

Figure 5 shows the minimum-distance routes. As shown, the majority of the freeways are used for minimum-distance routes between each entry and exit point. A summary of the risk-assessment process comparing minimum-risk paths with minimum-distance routes is shown in Figure 6.

RESULTS OF RISK ASSESSMENT

Table 1 provides a summary of this risk-assessment study comparing the results of the base case (minimum-distance routes) and the minimum-risk paths. As shown, the cummulative total risk of 42,884,000 experienced in the base-case analysis is reduced by 62

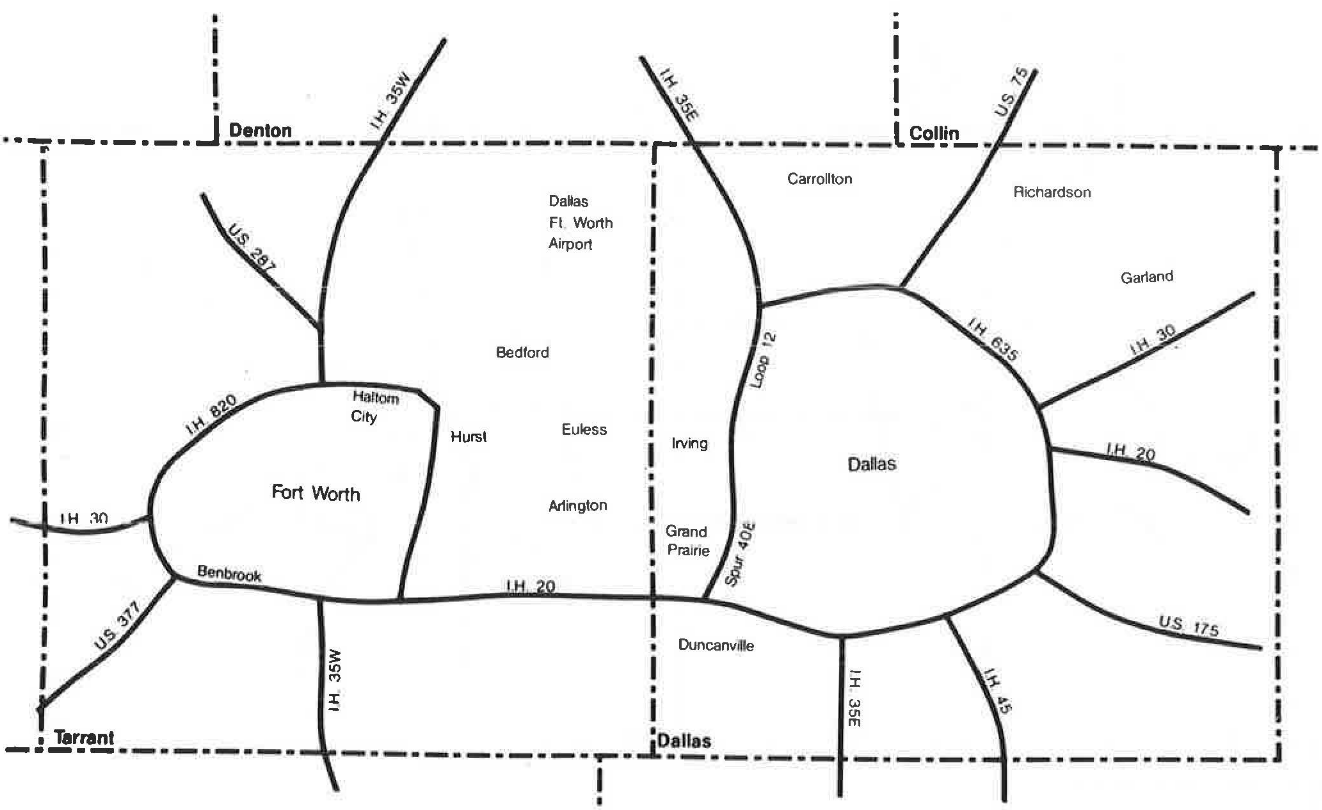

FIGURE 4 Minimum-risk paths.

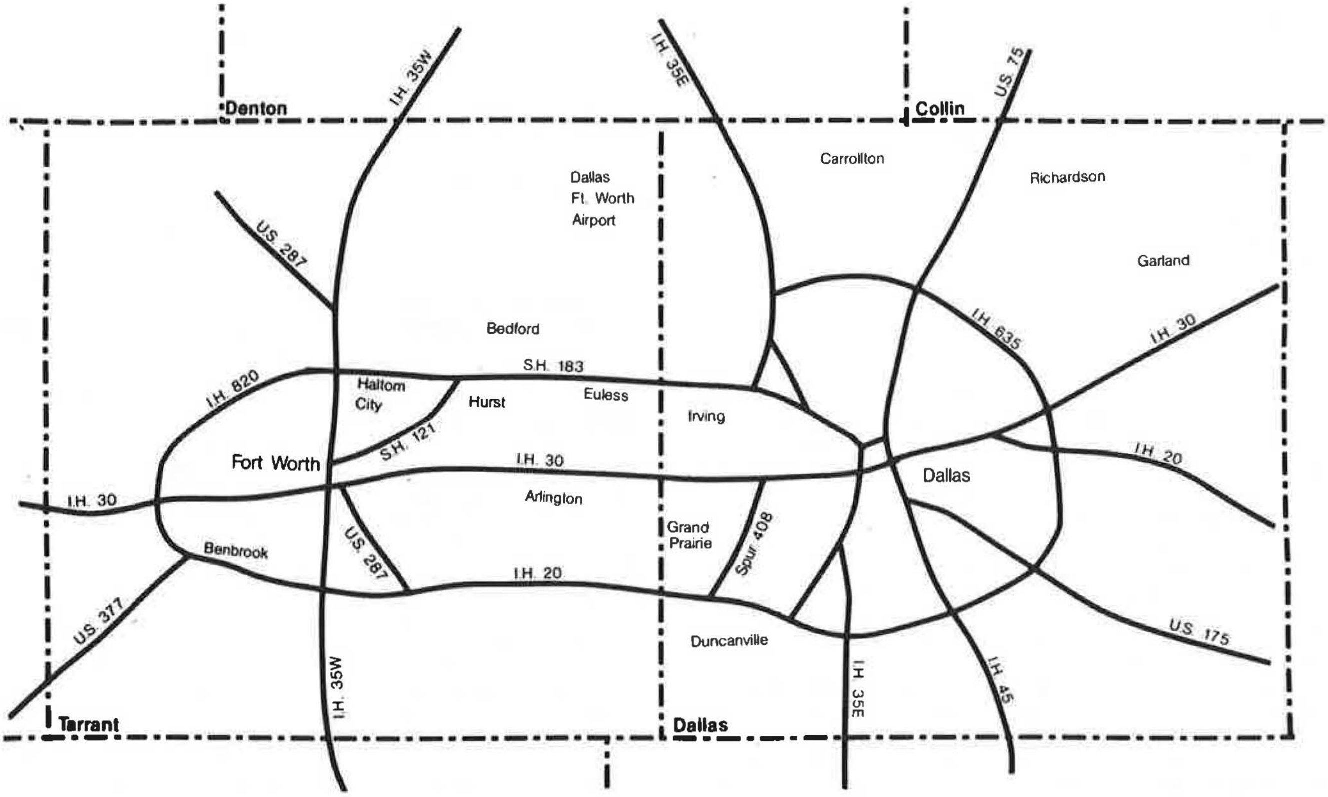

FIGURE 5 Minimum-distance routes.

percent when minimum-risk paths are used.

A second means of measuring the benefit of the minimum-risk paths was to compare the total population and employment exposed along the minimum-risk paths versus that for the base-case minimum-distance routes, as shown in Table 1. In the base case, more than 72 percent of the region's population and 86 percent of the region's employment fell into the 2-mi exposure band along the minimum-distance route. Implementing the minimum-risk paths reduces the amount of population exposed by 47 percent and employment by more than 80 percent.

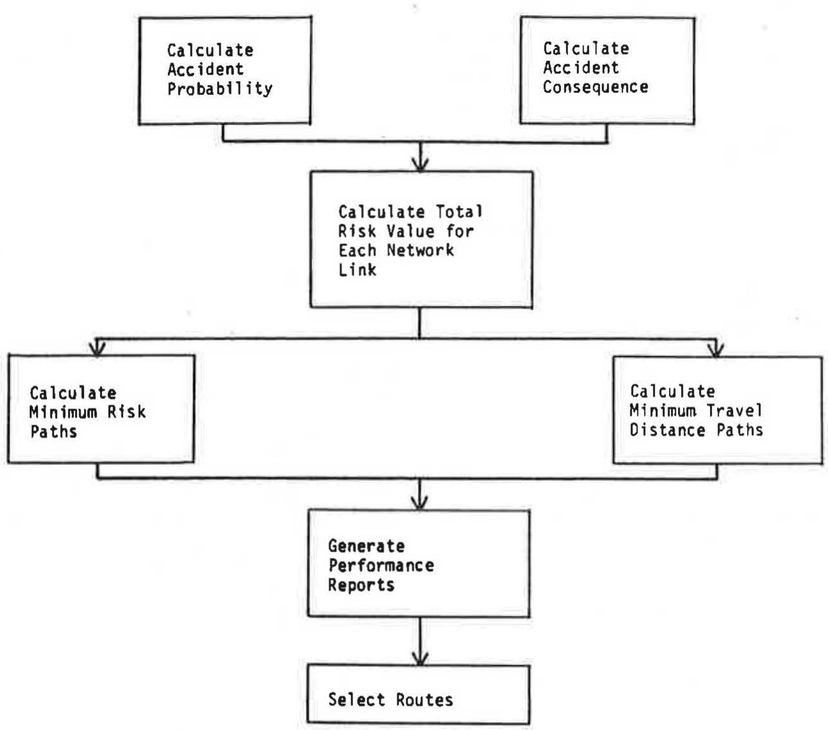

FIGURE 6 Hazardous materials routing risk-assessment methodology.

TABLE 1 Summary of Risk Assessment

Performance Measure	Base Case[a]	Minimum-Risk Paths	Percent Change
Total risk	42,884,000	16,336,000	−61.9
Total population exposed	1,931,000	1,018,000	−47.3
Metropolitan area population exposed (%)	72	38	−47.3
Total employment exposed	1,197,000	231,000	−80.7
Metropolitan area employment exposed (%)	86	17	−80.7
Circuity (vehicle miles of travel)	3,543	7,658	+116.1

[a]Minimum travel distance.

The FHWA guidelines recommend that a measure of circuity be estimated to represent a generalized measure of the added travel costs associated with selection of the minimum-risk path. Circuity is defined as the ratio of the minimum-risk path length to minimum-distance route length. For this application the sum of the minimum-risk path distance from each entry or exit point to all other entry or exit points was divided by the sum distance of the minimum-distance routes. The result, expressed in vehicle miles of travel (Table 1), indicates that utilization of minimum-risk paths would increase circuity by 116 percent, meaning that on the average shipments would be required to travel more than twice as far. As was mentioned before, however, this assumes that truck shipments today are using the minimum-distance routes as opposed to the more likely case of using outer-belt freeways to minimize travel time because of congestion effects and to avoid the higher-accident locations near the Dallas and Fort Worth CBDs.

The final measure considered in this analysis was the ratio between the change in the total risk value, 2.625 (i.e., benefit, determined by dividing total risk of minimum-distance routes by total risk of minimum-risk paths), and the change in the amount of circuity, 2.161 (i.e., cost, determined by dividing total vehicle miles of travel of minimum-risk paths by total vehicle miles of travel of minimum-distance routes), added as a result of the minimum-risk paths. These values are greater than 1.0, which implies a positive benefit as a result of the minimum-risk paths when the value of risk is assumed to be equal to that of circuity. Restating, the analysis showed that for a reduction of 2.625 units of risk, the additional amount of circuity or cost equaled 2.161 and the cost-benefit ratio was 1.21.

The ideal measure for this comparison would be a cost-benefit analysis based on dollar value. To do such an analysis, however, would require specific data regarding the frequency of hazardous materials shipments on each freeway facility. This information was not available for the study.

SUBJECTIVE CRITERIA

As shown in Figure 1, the FHWA guidelines provide for the optional application of subjective criteria to reflect those factors that are not quantified in the risk assessment. These factors may be applied to cases where no single alternative is clearly superior to the others. In this application to the Dallas-Fort Worth area, given the results of the risk assessment, there did not appear to be a need to examine subjective criteria in detail.

An initial exercise completed on the part of the technical review committee was to rate those criteria, many of which fell into the category of subjective factors, that they determined to be important in establishing hazardous materials truck routes. Those rated highly, including exposure to population and employment, were emergency vehicle access, proximity to population with special evacuation needs, and proximity to municipal water supplies. Traffic congestion, proximity to environmentally sensitive areas, and exposure to special activity centers were also rated.

Although no attempt was made to weigh or quantify these additional factors into the risk assessment, a number of overlay maps were used to examine the location of all fire stations, hospitals, schools, shopping centers, and water supply reservoirs in the region. The results of this process indicated that the majority of routes through the region fell into areas served by various municipal fire departments. Each of the alternative routes affected numerous hospitals, schools, and activity centers.

At a regional level it was therefore determined that exposure to population and employment served as the appropriate measure for these factors. However, it was noted that should a set of regional routes be established, it would be essential for local municipalities to address the need for additional emergency response capabilities and risk-prevention measures as each of these factors relate to recommended routes.

In January 1984 the results of the risk-assessment study were presented to the review committee established for this study. The technical review committee supported the use of the minimum-risk paths as the through-region routing plan. Clearly, the risk-assessment analysis supported previous actions by the cities of Dallas and Fort Worth to establish the outer freeway loops as through routes for hazardous materials shipments. The designation of I-20 connecting the two outer loops and serving as the major east-west corridor received support from the committee, not only because of its lower risk value but also because of lower traffic volumes and lack of congestion. No attempt was made to further evaluate the freeway segments outside of the Interstate loops to the boundary of the study area because these segments are needed for access to the region.

At the outset of this study considerable concern was recognized regarding the impact on the suburban communities of designating the outer freeway loops surrounding the cities of both Dallas and Fort Worth. All the suburban communities who took part in the study review process agreed with the study findings. Many of the suburban representatives commented that although they were concerned from an emergency response standpoint about the presence of the route through or adjacent to their community, they recognized that a route must be provided. Finally it was recognized that by designating the routes, a point had been reached of knowing where the shipments should be and thus the assessment of emergency response capabilities and determination of risk-reduction measures along each route could begin.

Following approval of the minimum-risk paths by the technical committee, the study results and proposed routing plan were presented to and approved by the NCTCOG Hazardous Materials Task Force, the NCTCOG Executive Board, and the Regional Transportation Council. The results of this study were submitted to SDHPT and FHWA. Once their approval has been received, implementation of the regional routing system by the local governments in cooperation with the SDHPT and FHWA is expected.

CONCLUSION

The safe transport of hazardous materials requires a coordinated approach by all levels of government--

local, state, and federal--as well as involvement on the part of shippers and transporters. In this application each of these parties was essential in formulating the risk-assessment approach and developing a regionwide routing system.

This study provided a systematic means of comparing alternative routes for hazardous shipments through the Dallas-Fort Worth area and resulted in the selection of routes on the basis of minimizing the potential risk. The FHWA guidelines provided the basic framework for completing this analysis with several modifications required for the local application.

A significant amount of effort is still needed to implement this routing plan, which will require a uniform set of guidelines for signing and enforcement. NCTCOG recently completed a hazardous materials emergency response directory that provides a summary of each local municipality's capabilities for responding to a hazardous materials incident. The individual cities and the region should examine the additional need for emergency response capabilities in light of the routing plan (4).

Finally, the interaction brought about between the various levels of government, the trucking industry, and project staff provided an open forum for discussion of many of the complicated yet related issues regarding hazardous materials transportation. Designating routes for hazardous materials shipments is only one means of reducing the potential risk. Clearly, programs involving vehicle inspection and maintenance, vehicle operator training and licensing, and upgraded emergency response capabilities should be pursued to reduce the risk and improve public safety.

ACKNOWLEDGMENT

Financial support for this project was provided by FHWA, U.S. Department of Transportation, in conjunction with the SDHPT. NCTCOG is appreciative to local, state, and gederal government officials and representatives from the trucking industry for their guidance and support in this effort.

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