Workshop on Risk Assessment

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ISSUE 1: THE MEANING OF RISK ASSESSMENT REQUIRES CLARIFICATION

Recommendation

It is recommended that risk assessment, when applied to materials transportation problems, be regarded as the quantitative analysis of the safety performance of the system in question under the conditions of interest. Due consideration has to be given to non-statistical approaches and to accounting for non-quantifiable factors. The objective of risk assessment is to provide better information to the responsible decisionmakers, and this purpose is best served when a systems approach is taken. A professional society concerned with risk assessment should pursue the clarification issue.

Discussion

The discussion of the need for clarification of the meaning of risk assessment began with the question of whether risk assessment was indeed worthwhile, given its shortcomings and past failures in studies about hazardous materials transportation. This proposed indictment interpreted risk assessment strictly as the application of statistical estimation techniques to safety problems in which mathematical models are used to estimate the probabilities of undesired events, i.e., accidents. Doubt was expressed about the value of spending considerable resources on the computation of probability levels that are often questionable in their accuracy and difficult to interpret, especially when they are on the order of one in a million or less. The implication was raised that such figures are not useful because they rarely, if ever, influence the judgment of the parties responsible for making decisions about actions to mitigate risk. The futility of such "overqualification" in place of sound, subjective judgment becomes even more apparent, it was argued, when the typical deficiencies of the data used are taken into account. In summary, there was vocal support given to the proposition that the power of risk assessment has been vastly overstated.

In response to this position, it was stated first of all that risk assessment ought to be construed more broadly, as the application of any systematic method to the analysis of alternatives within a decisionmaking framework in which the concern is to identify the best alternative for mitigating risks. That is, risk assessment is by nature concerned with the objective evaluation of safety problems, and in common with other scientific approaches to problem-solving uses numerical data and forms of expression. However, it is not limited to statistical methods and does not deny the value of subjective inputs. Risk assessment is but one of the tools available to decisionmakers for obtaining information. It is important that the party using the results of a risk assessment--whether obtained statistically or otherwise--be instructed about the limitations of the inputs, methodology, and outputs.

A case in point was described that concerned recent experience with railroad tank car protection, in which the narrower interpretation of risk assessment proved inadequate. Experiments were performed to analyze the sequence of events leading to violent ruptures of tank cars, and accident frequencies were computed and compared to see which vehicles would benefit most from head shields and shelf couplers. An attempt to use fault-tree analysis was thwarted by data limitations in this particular application.

Further discussion led to the consensus that risk assessment proves to be most beneficial when the objectives and the audience have been clearly targeted at the onset. The approach must then be defined to match these targets and consideration given to (a) identification of the hazards of interest, (b) estimation of the associated risks, (c) evaluation of the situations where the hazards appear, and (d) comparison of alternatives for risk mitigation. Field investigation, full-scale testing, engineering analyses, and tracking of pilot programs were all suggested as different possible aspects of the approach, to be used in addition to, or perhaps instead of, data base analysis and statistical modeling.

The observation was made that risk assessment in hazardous materials transportation has not always lived up to its expectations in the sense of producing answers. One discussant suggested that such failures are cause for pessimism; another claimed that such failures are typical of many research efforts and that a good deal of understanding is gained just by the rigorous structuring of complex hazardous materials transportation safety problems by using risk assessment.

ISSUE 2: THE FEDERAL GOVERNMENT NEEDS TO FOCUS ITS RISK ASSESSMENT ACTIVITIES

Recommendation

It is recommended that an investigation be conducted into current and potential problems in the regulation of hazardous materials transportation, that requirements for risk assessment be addressed, and that priorities be established for specific applications of risk assessment where the need is critical and the expected payoff is high. This investigation should be undertaken by an autonomous committee representing all concerned parties.

Discussion

The discussion of the need to focus federal risk assessment activities began with the observation that the current field of concern is too large; it simultaneously covers all modes of transportation and all types of hazardous materials. In addition, there is no expressed intent of concentrating on the mitigation of risk via reducing the frequency of accident occurrences, on the one hand, versus reducing the severity of accidents that do occur, on the other.

One constructive suggestion to focus efforts was that more thought be given to the motivations for performing the risk assessment in the first place. This entails cognizance of whom the study is for, why the study is being performed, which activities ought to be considered for study, and to what degree the study can be expected to be successful in view of probable limitations of data, time, budget, and methods.

The recommendation was then made that an attempt be made to identify the present and potential users of risk assessment, their applications of interest, the record of risk assessment in such situations, and the directions that could be taken to improve the record. A structure offered in response to this was to classify users as belonging basically to four groups: (a) "initiators" of hazardous material transportation activity (shippers, carriers, receivers, and their insurers and associations); (b) "responders" to hazardous material transportation accidents (fire and police departments, on-scene ex-

perts, medical and other emergency personnel); (c) "protectors" of the public interest in safety (legislators, regulators, citizen groups); and (d) "reviewers" of activities and accidents (the courts, the press). A number of general needs among these users were mentioned, including the evaluation of exemptions to federal regulations, the identification of high-risk situations, the allocation of limited resources for enforcement and emergency response, the evaluation of proposed rules, the provision of objective and informative data to the public, the development of improved industry standards, and a variety of planning information regarding research and training programs.

Some specific instances of focused non-federal risk assessment activities are the following. It was related that several large chemical manufacturers are undertaking evaluations of the historical safety records of railroads, with the intent of demanding better performance. Where the opportunity exists, other manufacturers who at one plant produce hazardous commodities that are inputs to processes at another plant are giving consideration to relocating the production of the inputs to avoid shipping risks altogether. A recent action in Canada that will require specific risk assessments to be performed and that would have repercussions on U.S. companies doing business there is a judge's recommendation that every hazardous materials shipper have an adequate plan for controlling the escape of product in accidental releases.

The remaining discussion dealt more specifically with the issue of focusing the considerable resources available for risk assessment at the federal level, where most public safety policies are established and implemented. There was general agreement that risk assessment has a contribution to make to the process of regulating hazardous materials transportation (including operations at the points of origin and destination such as loading, unloading, and temporary storage). However, it was stressed that risk assessment be used with discretion, given that (a) results need to be reported with sufficient caveats and advice as to their applicability and (b) risk assessment is simply one aspect of decisionmaking in the regulatory process. The principal advantage of risk assessment, broadly speaking, was felt to be the support of prioritization and resource allocation decisions within regulatory programs, especially the evaluation of proposed federal actions.

Some skepticism was then expressed about the realism of this position, given that experience has shown that such decisions in the past have been based almost exclusively on expert intuition and political influences alone. In response, it was stated that risk assessment has had a demonstrated and significant role in the regulatory process in England (as evidenced by the Canvey Island investigation) and the Netherlands. Furthermore, the MTB has made a commitment to employing risk assessment in regulatory planning, and it is currently developing a more structured framework for decision analysis.

The discussion then led to the subject of conditions that would be conducive to the focusing of federal risk assessment activities. It was observed that there is currently no specific legal mandate for risk assessment in the regulatory process and that, naturally, the occasion of such a mandate in the future would force the issue. In any case, the successful employment of risk assessment depends on a genuine commitment by the responsible program manager, accompanied by an ability and willingess to act on the results. Availability and quality of data (discussed elsewhere as a separate issue) were viewed somewhat as a two-way street: Improvements in the data situation would improve risk assessment and, in turn, a better resolution of the specific problems to be addressed would motivate data improvements. Another related suggestion was that if risk assessment were reoriented to be more concerned with the downstream effects of critical accident conditions or events over time, then more effective treatment of specific problems would be possible.

There was a lack of agreement on whether risk assessment should be required in the permit and exemption process. One side argued that risk assessment would enhance efficiency and consistency in the evaluation process and that standardized guidelines should be followed for the approach used and/or the supporting data. The other side argued that the current mode of evaluation is functioning successfully, that the door is open for risk assessment to be used if desired, and that most often the case for a permit or exemption can be made more simply and clearly without the benefit of a risk assessment.

ISSUE 3: RISK ASSESSMENT METHODS AND/OR RESULTS NEED TO BE MADE MORE ACCESSIBLE TO INDUSTRY AND LOCAL AGENCIES

Recommendation

It is recommended that an appropriate forum be arranged among interested representatives of different levels of government, shippers, carriers, and the research community to identify areas of mutual and individual concern about risk assessment. As a result, a mechanism would be established, with federal funding if necessary, to develop and disseminate useful risk assessment methods and/or results.

Discussion

Many of the concerns expressed in the course of the discussion about the users of risk assessment and their needs were related more to industry and local agencies than to the federal government. The observation was made that coordination among industry and local governments is necessary and that there is a federal responsibility to coordinate these concerns and to ensure that important public needs are met. A systems safety approach needs to be taken in the resolution of complex risk mitigation problems within companies and local agencies involved with hazardous materials transportation, and their diverse requirements need to be recognized, rationalized, and satisfied.

One case in point was offered by a trucking firm official, who stated that training policies for his vehicle operators could be improved if the operating aspects of their trips were better understood from an accident factor point of view. He felt that identification of the relative risks of these different aspects would help to determine the firm's overall training budget and priorities within the budget. Another case was related by a local fire official concerned with response planning and the execution of such plans, who felt that too often decisions had to be made on the basis of limited information and limited experience. He advocated the development of simplified risk assessment methods that could be applied by locals having only minimal sophistication with the use of such tools. Other participants cited public relations and the settling of legal claims as areas of high potential benefit for the application of risk assessment to issues of industrial or local concern.

The fear was expressed that an increasing number of important decisions are being made at the local government level based almost exclusively on polit-

ical grounds without the benefit of the objectivity imposed by the use of risk assessment. Those prohibitions or restrictions that have already been promulgated locally appear to be subjectively based, most likely because most local staffs do not have the technical sophistication required for risk assessment. The problem is of continuing concern, since increased public awareness and pressure for protection from risk suggest that more such actions to limit the activities of hazardous materials shippers and carriers are likely. There are, however, some positive signs of more informed approaches to local issues, such as in Pennsylvania, where a board has been established to assist in local hazardous materials shipment routing decisions using as inputs data about accident statistics, emergency response capabilities, and traffic characteristics on primary and alternate routes along with diverse expert judgments. The Central Puget Sound Regional Study, sponsored by MTB, is another encouraging effort, where a comprehensive risk assessment is under way.

The decentralized and diverse nature of hazardous materials transportation was discussed as an impediment to progress in the widespread application of risk assessment. This poses a host of challenges, ranging from the development of feasible general methodologies, the means for disseminating findings effectively, and the setting of priorities as to which specific or generic situations should be considered most important. Accessibility of risk assessment techniques and/or established findings to those companies and communities who are not in a position to develop their own was viewed as being an important federal responsibility. Perspective needs to be maintained, however, on exactly what factors are to be accounted for in the analysis, whether adequate information exists or can be generated, and how such information would be employed. References were made to a number of relevant efforts that have already been undertaken for local planning use, including a DOT University Research Contract on small community preparedness (Kansas State University), an FHWA study on the designation of routes for hazardous materials truck shipments (Peat, Marwick, and Mitchell), and a recent Canadian book on dangerous goods transportation (Zujic and Zimmerman).

Some specific recommendations for risk assessment priorities were offered. One was that since so many of the casualties due to hazardous materials transportation accidents involve response personnel, special attention should be paid to detecting the sources of risk to such parties and to developing means for risk avoidance. Another recommendation concerned ranking the hazards of shipping the various commodities by the various modes, under the various conditions which exist, and planning risk assessment needs accordingly.

ISSUE 4: IMPROVEMENTS IN RISK ASSESSMENT METHODS ARE NEEDED TO BETTER IDENTIFY AND EVALUATE CRITICAL SITUATIONS

Recommendation

It is recommended that methodologies be directed more toward the goal of detecting the causes of hazardous materials transportation accidents and the factors that contribute to them. An improved understanding of the dynamics of accident processes (especially in the case of catastrophic accidents) will require interdisciplinary approaches, with consideration given to experimentation, statistical analysis, and subjective expert judgment. Directors of ongoing and planned research programs should carry out this recommendation.

Discussion

This discussion commenced with a review of the methods that are usually used under the aegis of risk assessment and the principal phases of the risk assessment process. Typically, one or more of the following techniques are used: (a) statistical inference of accident rates and event probabilities, based on historical data; (b) fault trees that decompose an accident process and the influences on that process into more elementary, interrelated events; (c) analytical and simulation models, expressing mathematically the relationships between significant controllable and exogenous variables in the system under study, in order to gain insight into reducing risk by influencing the system's performance; and (d) more subjective yet systematic approaches for taking advantage of experience and insights that may not be readily quantifiable.

The phases of risk assessment ordinarily include estimation of (a) initiating event probabilities, (b) container failure probabilities, (c) accident consequences, and (d) costs and benefits associated with variations in operating policy and practices that are intended to mitigate risk. The decisionmaker then has to balance the results with judgments as to the realism of the analysis once institutional factors are taken into account, and with consideration to the acceptability of risk (and the difficult trade-offs and ethical aspects of such considerations).

Among the difficulties that were pointed out about generalizing on risk assessment in this manner are the differences in terminology used in this field and the degree of diversity in the applications and in the users of risk assessment. There appears to be no universally accepted body of safety analysis technology. A variety of approaches from other fields has been adapted as necessary in an ad hoc fashion with varying degrees of success, it was claimed, and there has been no purposeful weeding-out of cohesive development of unified or original methodologies. Inconsistencies in the availability of data have contributed to this problem.

One discussant observed that regardless of whether safety is being sought through government regulations, industry standards and procedures, or some other means, the fundamental goal is process control. The best way to accomplish that, it was argued, is to relate estimates of probabilities and consequences to the specific events that can be influenced within the process of interest and to the dynamics of the relationships between those events as they occur over time. Furthermore, any predictive risk estimates obtained should be shown to be consistent with experience and to be commensurate with observations that are made in accident reports and investigations. The National Transportation Safety Board is reportedly concentrating its risk assessment efforts more and more on the identification of critical events and their evolution over time during an accident.

A related point of discussion dealt with catastrophic events. The issue raised was the need to better understand the factors that contribute to these relatively rare but severe types of accidents, while recognizing that our perception of risks is not distorted by generalizing from occasional, unusual happenings. One of the most significant basic research needs in risk assessment, it was observed, is for advances in explaining and evaluating the events that occur in the "tail of the distribution". This is where the public concern really lies, given that hazardous materials transportation accidents are usually not severe, but that the potential certainly exists--and has been demon-

strated--for many lives to be taken in a single occurrence. Assessing the risks of serious accidents is difficult, however, because of the relative rarity of such accidents. Problems of sparse data and limited experience also make it difficult to differentiate between situations that may and may not occur frequently in the future.

One suggestion for overcoming the dilemma of catastrophic assessment was to approach such problems by experimentation and field testing, perhaps with voluntary industry cooperation under a nationally coordinated plan. Another contribution would come from improved accident reporting systems, which would record information specifically intended to enhance our understanding of what did or did not happen to keep an accident from assuming extreme proportions in its impacts. Consideration of "near misses" would enrich such data bases, as would attention to surrogate data about relatively common events that could be used to make inferences about similar, uncommon use.

ISSUE 5: IMPROVEMENTS IN THE REPORTING OF RISK ASSESSMENT RESULTS ARE NEEDED TO PROVIDE BETTER INFORMATION TO DECISIONMAKERS AND TO THE PARTIES AFFECTED BY THEIR DECISIONS

Recommendation

It is recommended that a survey be made to determine the range of requirements and preferences concerning hazardous materials transportation risk information. Survey results would be used to influence practical developments with regard to such concepts as societal costs, risk acceptability, and public perceptions. The validation of results is a related issue requiring resolution by the academic and professional research community.

Discussion

The discussion of the need for better reporting of risk assessment results was stimulated by a number of comments regarding the desire of various concerned parties that have more and better specific information about the potential hazards they face, the corresponding likelihoods, and some objective evaluations of the cost-effectiveness of alternatives for risk mitigation. The consensus was developed that there may be results either already available or readily attainable from risk assessment that would be beneficial if they were generated in a form that could be easily interpreted and applied by the different users. Significant inroads could be made by proper presentation and by attention to individual differences in requirements for risk assessment results.

Some time was devoted to the discussion of employing risk assessment results in a decisionmaking framework, where ultimate responsibility for selecting trade-offs must be assumed by the individual formulating the policy for allocation of resources to achieve risk mitigation. A number of different issues were raised, one of which was the choice of an acceptable level of risk. That is, on what basis and to what degree is the company or community in question, as represented by this decisionmaker, willing to provide protection against the undesirable effects (life, health, damage, etc.) of hazardous materials transportation accidents, given that it may not be possible or in any sense practical to totally eliminate risks? This was acknowledged to be an important question, fraught with ethical and technical difficulties that have already been the subject of much unresolved debate in the literature. One participant expressed doubt as to whether a single, simplistic solution would ever be possible. As a practical matter, it was observed that in many situations, the available set of resources (in terms of budget, staff, and time) has already been determined by a higher authority on grounds that may or may not have explicitly considered the question of risk acceptability. In these cases, the risk acceptability problem is thus settled conceptually by minimizing the risk within the resource constraints that have already been established; whatever level of risk then results has to be acceptable unless the resources are expanded.

In accordance with the discussion group's previous consensus that a proper risk assessment and a system safety study are essentially synonomous, attention then turned to the problems of evaluating benefits and costs. Benefits are measured by reduction in risks of various kinds. The corresponding costs are measured by the dislocations--monetary or otherwise--required to achieve those benefits. One immediate difficulty mentioned was the existence of multiple and even conflicting objectives on both the benefit and cost sides; for example, the shipping of heavy metals is a significant environmental problem, but it does not pose a threat to personal safety from the possibility of a violent release. Other examples abound with regard to which aspects of safety should be improved and who should bear the burden of providing the desired changes. The means for measuring improvements and their costs is in itself a sticky problem, as exemplified by the procedural and philosophical difficulties of calculating the value of human life.

Other aspects of the definition and quantification of measures of effectiveness in risk assessment were raised as areas where technical progress is needed. One of these is the necessary distinction between perceived and actual risks, and the lack of agreement about which is the real concern when deciding questions of public interest, especially when society may choose to emphasize certain risks to a greater extent than the weight shown by a detached mathematical analysis. Another area is the definitive characterization of release behavior and consequences, which depend on the material, the circumstances under which it was released, and the surrounding conditions. It was intended that this work should not be started anew but should take advantage of the multitude of preceding developments performed by the U.S. Coast Guard and others.

Accounting for societal costs was another measurement issue discussed at great length. The difficulties inherent in this area were agreed to be formidable but conceptually manageable and definitely in need of resolution. It was stated that experience has shown that depending on the range of societal costs included, the results of a given cost-benefit analysis of a risk mitigation strategy may lead to diametrically opposite conclusions. This is inevitable, it was said, when opposing sides such as government and industry have the opportunity to influence their research conclusions by designing the scope of their studies as they wish. Obviously, more consistency is necessary, and it was recommended that guidelines be established by an appropriate and universally agreeable means to determine which societal costs can and should be accounted for in any risk assessment intended for use by either side in deliberations about rules, regulations, or standards for safe hazardous materials transportation. A candidate for an important societal cost, which to date has reportedly been largely disregarded, was suggested by one of the federal participants: the displacement of members of the general public by hazardous materials transportation accidents, including but not limited to parties who are

evacuated. It was agreed that every risk assessment should acknowledge all potentially relevant societal costs and, at least, should discuss the impacts of those that may be significant but not measurable.

Some of the pitfalls experienced in the reporting of risk assessment results were then related, along with suggestions for avoiding them in the future. This discussion centered on improving the reliability of, and the confidence in, the numbers produced in the course of such a study. The validation of statistical estimates, especially those that could lead to costly changes in business operations based on alleged improvements in accident rates and impacts, is obviously a desirable goal. However, validation may be difficult, if not impossible, when dealing with events where there is little or no actual experience. Partial validation of those aspects of the process under assessment where there has been experience would help. The performance of several independent risk assessments either by different researchers or by different approaches would lend credence to results that are found to agree.

It was suggested that true resolution of the validation issue may be beyond the limits of knowledge; at the very worst it brings into question whether anything that cannot be validated is worth doing. On the other hand, the opportunity for validation depends on the approach taken and basic research in this spirit should be performed to identify such approaches. Moreover, it was observed that risk assessment is worthwhile even when complete validation is impossible because the study process itself is worthwhile and provides insight into final answers. The postimplementation tracking or risk assessment findings are another viable alternative to validation; this has been done in the case of the performance of tank cars that have been retrofitted with head shields and shelf couplers.

ISSUE 6: ACCIDENT REPORTING AND OTHER DATA COLLECTION FOR RISK ASSESSMENT NEED TO BE DESIGNED AND CONDUCTED MORE EFFECTIVELY

Recommendation

It is recommended that a thorough characterization be made of the types of data immediately or imminently required for risk assessment of hazardous materials transportation. Where public data are available, due attention should be paid to reliability and accessibility. Otherwise, the cooperation of industry and local agencies should be solicited to provide access to existing data or to cooperate in gathering new data.

Discussion

The availability and quality of the data used in risk assessment were recognized as being fundamental elements of the successful analysis of hazardous materials transportation safety problems. Throughout this discussion concern was expressed about (a) properly specifying data requirements, (b) making the best use of available data, (c) improving procedures in data collection, and (d) dealing with data deficiencies.

Although there was agreement that those who conduct risk assessments need to better articulate what kind of data is required and how much detail is adequate, opinions differed as to the best way to achieve this goal. One side argued that information should be obtained and organized in a piecemeal, problem-oriented fashion, thereby reducing the possibility that more effort will be expended than is required for the immediate application. The other side argued that a more global approach, in which information needs are anticipated by developing well-planned, large data bases, would be more efficient in terms of avoiding duplication of effort and having data ready and waiting for application.

It was agreed that, in either approach, attention has to be given to gathering only as much information as is needed. Sensitivity analyses can be used to help determine when refinements in the precision of inputs of a risk assessment will not pay off in terms of significantly better risk estimates. When data are employed that are known to be less than totally reliable, the onus is on the risk assessment analyst to acknowledge--and measure to the degree possible--the biases and their effects on the outputs.

Data requirements follow directly from conclusions about risk assessment priorities. Hence the strategy recommendations made in the discussion of other issues about setting priorities in risk assessment studies based on hazard rankings, on industrial concerns for accident avoidance, and on local concerns for emergency preparedness, all bear directly on the questions of which data are needed most and how much are needed. This relationship between decisionmaking objectives and the pursuit of supporting data was reiterated in the discussion of the present issue--with emphasis on economy in data collection--in terms of such questions as, Have all sources of existing data been tapped? How can existing data similar to what is needed be creatively adapted? Where are new data needed most? and How can the collection be performed most effectively?

In the case of information pertaining to accident occurrences, a number of concrete, constructive recommendations were made for improving both the nature of the data collected and the collection procedures. An expert consensus needs to be solicited on the focusing of federal accident reports to require facts on only the essential aspects of the most critical types of occurrences in terms of the conditions in which the accident happened, the events that transpired, and the impacts that resulted. The level of detail reported would depend on predetermined criteria about the significance of the accident. A suggestion was also made that consideration be given to nonpunitive reporting, as is being done in Canada, in an attempt to encourage full and factual disclosure about accidents where significant risk information might not otherwise be forthcoming because of the fear of legal action. Another suggestion was made that more attention be paid to the reporting of trucking accidents involving rollover, which is recognized as a problem requiring fuller risk assessment. This points out the desirability of more flexible reporting systems, where more details would be required on specific situations as they are deemed critical. The need to have current reports focus more on large bulk shipments of particular dangerous materials, to record the evolution of events over time during the course of an accident, and to track the performance of newly institutional mitigation procedures, were all reemphasized. A federal representative stated that the Hazardous Materials Information Reporting System is currently undergoing review and will be revised. One final observation was made that avenues should be explored to determine whether industrial records are available that would help to evaluate accident likelihoods, e.g., carrier repair records that reflect the frequency of failures of equipment employed in hazardous materials transportation.

The remainder of the discussion addressed problems and proposed improvements in the collection of data about exposure to risk stemming from the movements of various hazardous materials by the various

modes. The consensus eventually reached was that such data are best obtained at the local level, where access is likely to be best, but that precautions are needed to assure that complete and consistent measurements are taken. Specific reference was made to rail transportation, regarding the possibility that a full record of hazardous materials waybills will replace the current 1-percent sample. A reference to truck transportation was also made, indicating that there are extensive records of hazardous materials volumes (but not necessarily routings) kept by truck companies, which could be made accessible for risk assessment under an appropriate arrangement. The degree to which rail, truck, and other carriers will all be willing to share information remains to be determined. It was stated that there needs to be more mutual thought and understanding about exposure data needed, how much effort is required to operate them, and how they will be used. The State of Virginia and the Puget Sound Region have had relevant experience in flow estimation. It was suggested that federal guidelines for regional mapping of hazardous material flows be established and a university consortium be organized to carry out this process.

Workshop on Technology Development and Innovation

William A. Brobst

The federal government has had a substantial influence on technical research and development (R&D) activity since World War II. Although its direct involvement has been concentrated in the defense and health sectors, the government has impacted research in all segments of industry and society, including hazardous materials transportation. For the most part, the federal R&D programs have avoided the support or conduct of R&D to develop new private-market products or services. Even so, the overall role of the government has been questioned in light of allegations of waste and mismanagement of some research programs. One argument for reduced government involvement in R&D is based on the premise that government, in general, will be less efficient than private industry in directing R&D activities.

On the other hand, there appears to be a near consensus among economic and business analysts that the national investment in R&D needs to be increased from current levels if future gains in productivity and the standard of living are to be ensured. Given some uncertainty over the private market's willingness to significantly increase R&D investment, especially in areas such as hazardous materials transportation safety, the government may be the only meaningful source of much of the needed additional funds. These funds could be either diverted from existing programs or provided from new funding. Government funding of R&D is justified in order to correct for private-market underfunding of R&D caused by lack of private economic incentive and uncertainty of payoff in R&D and nonoptional regulation. The private economy has a natural incentive to invest in the generation of goods that produce business profit. However, safety and environmental protection cannot be owned and sold by firms that contribute to their production. Accordingly, private investment in those areas will generally be less than socially desirable.

Certain private technological investments will be underfunded, not because there is a lack of economic incentive or an excessive economic risk, but because government actions have tended to inhibit innovation. Since regulation of private activity is accomplished by specifying a limited number of conforming designs or processes, there is considerable economic pressure to continue use of the technology embedded in those designs or processes.

The government must be very careful in devising strategies and plans for intervention in the technological R&D process. As a general rule, it should only intervene in areas where there is a clear societal benefit (using the cost-risk-benefit approach) and should favor methods of intervention that cause the least disruption of the economic process.

A critical need for technological innovation arises from a pressing need for solution to important problems. In the safe transportation of hazardous materials and wastes, several factors combine to lessen the critical nature of needs for technological innovation. First, the past safety record in hazardous materials transportation has been excellent, despite the media emphasis on accidents and the public perception of problems. Because of this, the benefit of R&D often becomes clouded; handy and popular solutions often go looking for problems to solve. A wide range of safety improvements could be implemented that require only political decisions, not technological developments. The implication is not that there will be insignificant payoff from application of technological developments in hazardous materials transportation, but that the areas where technological R&D investments should be made may be difficult to identify.

GENERAL SCOPE

The Workshop on Technological Development and Innovation concentrated first on identifying and discussing those problems and issues relating to transportation of hazardous materials and wastes that require, or closely interface with, the development of new technology or innovations in order to bring about a solution. Conversely, many interesting issues were identified that did not involve technological development or innovation and were discussed only to the extent that the workshop members could determine that nothing new was needed. The mere need for application of existing technology to the solution of an issue was not enough to keep the issue on the workshop agenda.

Sixteen issues were discussed at some length, nine of which were considered relevant to technology development and innovation and within the scope of the workshop. Th group defined those nine problems, discussed the options for problem solution, made specific recommendations, and identified the responsible agencies or industry that should be responsible for the implementation of the recommendation. This last step represents the strategy of problem solution.

The group prioritized the nine recommendations, and also selected those that were of the very highest priority (the first four). These recommendations, listed in order, are noted below.

The group also discussed (briefly) the role of the government versus that of industry in technology development and innovation, particularly with respect to hardware design and competition with private industry. The conclusions of that discussion are presented prior to the discussion of the issues and recommendations.