267

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RECOMMENDATIONS FOR HAZARDOUS MATERIALS TRANSPORTATION RESEARCH AND DEVELOPMENT PROJECTS

modes
1 highway transportation
3 rail transportation
4 air transportation
5 other

subject area
51 transportation safety

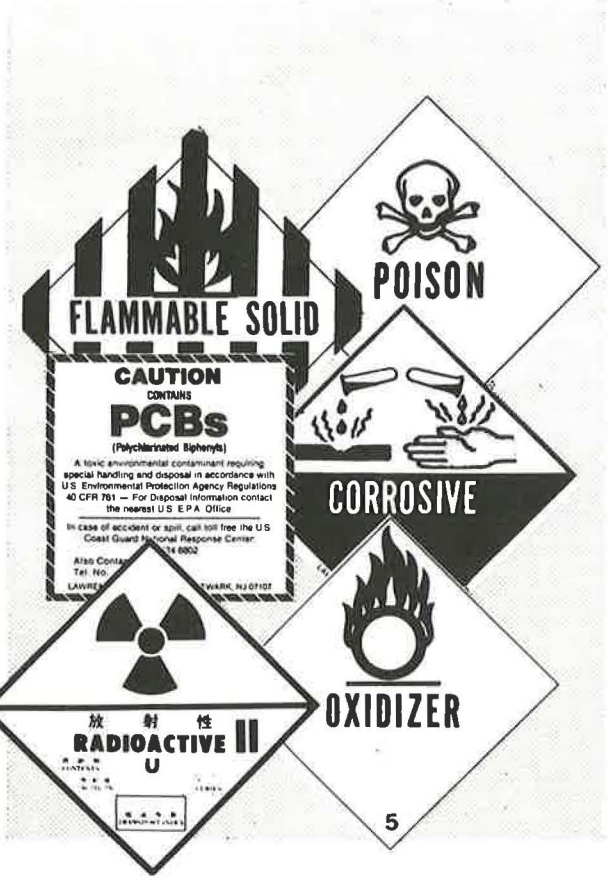

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TABLE OF CONTENTS

INTRODUCTION

Hazardous materials transportation safety continues to be a significant concern in our society. The hundreds of publicized accidental releases in communities around the nation each year heighten the public's concerns about our nation's ability to safely transport hazardous material (HM). Such transportation is so widespread that all of us are perceived to be exposed to the risks of accidents involving these materials. This transportation is performed by industry and government under a complex set of governmental regulations. If the public's confidence in the ability to perform this transportation safely is to be restored and maintained, continuing research and development efforts to clarify and control the risks posed by accidental HM releases are needed. All those who share responsibility for HM transportation must collaborate in the needed research and development programs. The risks associated with the occurrence, control and mitigation of HM releases during transportation must be considered in these efforts. Research and development efforts require that the policies, plans, control programs, procedures, equipment, facilities, routes, communications, regulations and people that constitute the transportation systems for HM - and their interactions - be understood clearly. This understanding should be sufficient to assure that they are adequate and functioning as advertized.

A basis for collaboration in improving our nation's hazardous materials transportation system was published in Transportation Research Circular 219 (July, 1980) entitled "The Ten Most Critical Issues in Hazardous Materials Transportation,"[1] which was prepared by the Transportation Research Board's Committee on Transportation of Hazardous Materials (Committee A3C10). Circular Number 219 also has increased the level of awareness of these issues within the research community and among the parties responsible for control of risks, namely: legislators, regulators, shippers, carriers, planners, emergency management officials, and manufacturers.

Subsequently, in February 1981, the Committee sponsored a "National Strategies Conference on the Transportation of Hazardous Materials and Wastes in the 1980's" in Williamsburg, Virginia. This document is the Committee's next step in the process of developing a comprehensive, coordinated research and development program. It suggests six specific research projects selected for consideration by the Research and Development Subcommittee and concurred in by the parent Committee A3C10. The projects are derived from the list of candidate projects indicated in Transportation Research Circular 219, from the reviews on the findings, conclusions, and recommendations of the National Strategies Conference (Price, 1981, and TRB Special Report 197)[2, 2a], and from the following three sources: (1) a critique of hazardous materials transportation safety programs by the General Accounting Office (Comptroller General, 1980)[3]; (2) an appraisal of the Department of Transportation's hazardous materials research and development program by the Committee on Transportation of the National Academy of Sciences (1980)[4]; and (3) a survey of expert opinion on research and development needs conducted for the U.S. Dept. of Transportation (Philipson, 1980).[5]

Numerous reports and special studies of safety issues, regulatory factors, and particular safety enhancement measures also establish some of the background of the presently proposed projects. Not the least of these have been many accident reports, hazard and risk analyses and assessments of approaches to increasing the utility of such analyses through improved analytical techniques and data sources. In one way or another, all of the proposed projects are oriented to these improvements, or to the more effective decision making that they will support.

Using all of the above sources, research needs have been defined and integrated into the following recommended specific projects by the Committee A3C10:

1. Effects of the accidental release of hazardous materials,
2. Risk assessment by mode of low probability/high consequence accidents,
3. Identification and prioritization of critical localized risk situations,
4. Accident dynamics and mitigating measures,
5. Cost and performance effectiveness of hazardous materials transportation regulations, and
6. Improved data bases and risk assessment techniques.

These projects are recommended by the Subcommittee for their potential for enhancing hazardous materials transportation safety. For each project, the definition of the problem to be addressed is outlined, representative related work is noted, the objectives of the project and an approach to its implementation are defined, and finally, the project's estimated cost and potential funding sources are noted. They are in response to one or more of the eight recommendations found in the Williamsburg report (2a) and appear in order of decreasing priority. However, they are all considered important. A future supplement to this Circular may be developed to deal with other Williamsburg research and development recommendations, if they prove amenable to definition as specific research projects. Significant effort has been focused on these areas. Legislative action and implementing existing legislation can do much toward meeting the remaining recommendations.

RESEARCH PROJECT NUMBER 1: EFFECTS OF ACCIDENTAL RELEASE OF HAZARDOUS MATERIALS

The Problem and Related Work - For many, if not most hazardous materials regularly shipped in the United States, only very imprecise information exists on the effects that will occur following an accidental release. Information is needed on the harmful effects of releasing various types, quantities and forms of hazardous materials through an accident. Further knowledge is also needed on the dispersion effects of various materials. The considerable body of literature on dispersion modeling does not address these effects in transportation releases. This is so despite observations from many incidents, and theoretical and experimental research supported by industry, the U.S. Department of Transportation (USDOT), the U.S. Department of Energy (USDOE), the Army, and the Navy (the latter two especially for explosive reactions).

The problems primarily revolve around the likely outcome following the release of various quantities and forms of hazardous materials in a transportation accident. These effects have not been studied adequately in past experimental releases. The likely effects of releases involving more than one hazardous material also are not understood in sufficient depth. Little understood effects include: hazard-initiating conditions; evaporation rate-source strengths; dispersion or propagation rates and

patterns; acute or latent consequences to people, property, and the environment and possible countermeasures. Information is needed on these effects for: establishing safeguards and safety procedures; emergency response planning and actions; analyzing risks; determining the need for mitigation measures; and evaluating the effectiveness of alternative mitigation measures.

Objectives and Implementation - The objectives of this project are:

1. to identify, explain and document the processes which determine the amount of harm that results from accidental releases, and
2. to define those factors which most directly influence those processes and their outcomes, and how they might be controlled more effectively.

Because so many HM are transported, priorities for initial studies are needed. A possible basis for selecting materials and cases to research is to establish a subjective risk-ranking scale, based on such known or estimated factors as:

1. relative reported injury and loss count for a given HM;
2. relative injuries and losses per unit quantity released, considering estimated people and properties exposed during releases;
3. expected value of future losses from the material;
4. relative quantity shipped per year; and
5. behavior of similar or comparable materials during releases.

It must be emphasized that this scaling for initial decisions would be accomplished with readily available data or expertise. As the research progresses, the risk or behavior factors identified as most influential in the losses, such as possibly the dispersion rates, dispersion patterns, lethality, etc. as well as the expected value of the findings, would be substituted for these initial rating factors.

Given a prioritized set of materials for investigation and estimates of the resources required, plans would then be developed for the conduct of the research needed for each material. Private industry research and development programs would be the most appropriate on the effects of the accidental release of hazardous materials produced on an industry-by-industry basis.

Efforts on the highest priority materials should obviously be initiated first. The priority list might be revised as results are obtained that provide all necessary information on a material, where significantly more effort than planned would be needed for a material, or where data reveal that a material's ranking should rise or fall in the priority list.

The results of the research would be made available to regulators, shippers and carriers, federal, state, and local emergency planners and emergency response coordinators. The USDOT's Research and Special Programs Administration (RSPA), with coordination by the Coast Guard and the Federal Emergency Management Agency (FEMA), might be involved in overall coordination of the project and for the dissemination of results in forms readily understood and applied by each user to establish improved safeguards and procedures.

This project is directly responsive to Finding and Recommendation: 1 (F&R 1) in the Williamsburg report which calls for the development of transportation policy and procedures for hazardous materials. It also addresses F&R 8 somewhat by providing some of the information required for communicating the relative safety existing in hazardous materials and waste transportation.

Cost and Potential Funding Sources - It is estimated that initial development of an overall program plan and a priority list from a selected set of materials could be accomplished for $50,000 in six months. An initial research effort, sufficient to establish the worth of the project concept, and its long-term approach and appropriate level of funding, could require up to $500,000 and eighteen months to accomplish.

Potential funding sources might be the RSPA, the Coast Guard, the FEMA, and manufacturers, shippers, and carriers of hazardous materials. The latter three might provide grants for work at universities and elsewhere outside the government but under the overall coordination of an appropriate management agency or a government/industry task force. The possibility of government/industry joint funding could be advantageous to both and should be explored.

RESEARCH PROJECT NUMBER 2: RISK ASSESSMENT BY MODE OF LOW PROBABILITY/HIGH CONSEQUENCE ACCIDENTS

The Problem and Related Work. The primary concern of society about hazardous materials transportation is the potential occurrence of accidents with large-scale harm. Although such releases of dangerous HM have been infrequent and have resulted in few casualties among the public, the general public feels threatened by the possibility of large releases of hazardous materials at a time and place that would produce disastrous consequences. To enable policy makers as well as the general public to better appreciate such low probability/high consequence risks, improved methods are needed for (1) estimating the level of risk (a common objective with Research Project Numbers 1 and 6),(2) evaluating their objective significance in relation to other "ambient" risks and to the benefits that taking the risks provides, and (3) assessing how these risks are perceived and responded to, and what can be done (when warranted) to help clarify these perceptions and rationalize responses.

A mirror-image problem to that of rationalizing possible overreactions to low probability/high consequence events is the problem of justifying regulatory actions to reduce their probabilities still further when it may be deemed that it is desirable to do so, but straightforward cost-performance-benefit analysis cannot justify a reduction's cost.

These same kinds of improvements are being sought in other contexts where low probability/high consequence accidents are of concern, most notably that of nuclear power generation. Logic modeling, undertaken within its limits, has provided the basic approach to low probability risk estimation for nuclear plants. Although less satisfactory than fault tree modeling, the factoring of the probabilities of an unlikely event into a sequence of conditional probabilities of component events has been the usual approach used for transportation accidents involving hazardous materials. For example, a set of component events might include (1) train derailment, (2) tank car involvement, (3) tank failure, (4) material release, (5) propagation of effects to targets, and (6) loss occurrences. Each factor would be estimated from generic statistical data or from engineering estimates (usually "worstcase" analyses). The product of all the low component probabilities is then the very low probability of the unlikely consequence of interest. The need to make hazardous materials transportation risk estimates

more specific to particular conditions motivates investigations of the potential of other methods, including fault tree modeling, as well as improved factored event models and the data bases necessary for them. As noted above, fault tree modeling is not considered a panacea and must be used within its limits.

Methods are well established for the objective assessment of the significance and "acceptability" of estimated risks in relation to other risks and/or to the benefits of the activities inducing the risks. Nuclear power "safety goals" developed by these methods are in use in industry which produces HM and have even reached the point of formal consideration by the Nuclear Regulatory Commission. The translation of the methods to hazardous materials transportation risk assessments needs to be made specific but is not a major problem.

The development of useful measures of subjective assessments of risks by the public is not so straightforward. A great deal of philosophy and a limited number of psychometric investigations have been supported by various government agencies, including the National Science Foundation. The specializing and useful structuring of this work to meet the needs of decision makers who must determine whether particular hazardous materials transportation (and other) risks can be accepted or not remains to be accomplished.

Finally, the economic justifications of possible mitigating actions of low probability/high consequence risks are usually not easily established. This is due to the low probability resulting in the straightforward expected economic worth of a risk decrease and because the losses are not well understood or measured. A method is needed for expressing the disproportionate value that society assigns to losses occurring in catastrophes relative to the value of the same losses accumulated over many small accidents, if the benefits of mitigation are to exceed the cost of conducting that mitigating action. Several such methods have been suggested (Philipson, 1981)[6] and should be evaluated for their applicability to hazardous materials transportation safety regulations focused on low probability/high consequence risks.

Objectives and Implementation - The objectives of this project are (1) to investigate and evaluate improved risk analysis and estimation methods (both objective and subjective) and (2) to investigate risk mitigation evaluation techniques for low probability/high consequence hazardous materials transportation accidents. A large foundation of related work exists in the nuclear power and other major hazardous activity contexts. This work should be reviewed in depth, assimilated and interpreted for application to hazardous materials transportation risk analysis. Extensions to the specific requirements of hazardous materials transportation regulators and other safety managers in government and industry should then be carried out.

The project might be directed by the RSPA with support from the modal agencies and the FEMA, with industry involvement especially in the cost/benefits analysis area. It is to be emphasized that this project's concerns are not new to the USDOT; it is the integrated view and the basing of the effort on the related work in other contexts that may warrant its implementation now.

This project will provide a sound basis for developing the response to Williamsburg report F&R 8.

Cost and Potential Funding Sources - It is estimated that $200,000 would be required for this project. It might be provided through the RSPA, with contributions from the FEMA. A two-year program, including subsequent testing in practice of the policy development and decision support methods to be established, is suggested.

RESEARCH PROJECT NUMBER 3: IDENTIFICATION AND PRIORITIZATION OF CRITICAL LOCALIZED RISK SITUATIONS

The Problem and Related Work - One of the major difficulties in achieving effective hazardous materials transportation risk control and emergency responsiveness is the widespread character of hazardous materials movements by all modes. In any area of concern to government, shippers or carriers, the number of potential accident sites can be enormous, so that a selective approach to the allocation of resources to particularly critical locations (including the costs of avoidance of such locations) is essential.

The prioritization of particular locations must be a function of the potential severity of the effects of an incident with the materials carried (see Research Project Number 1), the equipment employed, and the operating conditions and practices. In other words, a risk-based prioritization scheme is needed that is comprehensive enough to be sensitive to the important determinants of a location's potential for significantly harmful incidents, but simple and replicable enough to be applicable over a vast number of locations of concern by local officials. An essential element of the applicability is the simplicity of the acquisition of descriptive data required for the prioritization process. A scaling procedure analogous to that noted for Project Number 1, employing objective data where readily available and usable, but primarily based on subjective assessments, appears as a most likely choice.

A foundation for the development of a prioritization process for specific risk locations and/or routes fortunately exists (Price et al., 1981 [7]; Russell et al., 1981 [8]; Urbanek and Barber, 1980 [9]). The implementation of appropriate data acquisition, risk-scaling and decision making procedures thus could proceed with confidence. The previous work includes (1) the implementation of local survey procedures and data, (2) data reduction methods, assessment forms, and decision criteria, (3) models for the relative risks of route segments that take into account the variations in quality of the transport systems, their reliability based on experience, (4) the nature and quantity of hazardous materials flows on specific transport routes, and (5) the characteristics of the population at risk near these routes. Some of the relevant work is too complex for direct application at large numbers of specific locations, but it can provide the basis for the development of simplified procedures that would be applicable.

Objectives and Implementation. This project would have as its objective the development of practical procedures for:

1. Surveys and judgmental assessment processes to obtain data on hazardous materials traffic quantities, classes, routes and accident and loss potentials;
2. Reducing the data to forms amenable with risk ranking factors to enable risk quantification; and
3. Generating risk ranking procedures and decision criteria to support selection of critical hazard locations, preferred routes, equipment and/or operating practice improvements or other hazard

mitigations, and emergency plans and resource allocations.

The results would be prepared in handbook form for dissemination to all levels of government and to shippers and carriers concerned with the transport of hazardous materials under specific circumstances.

The initiation and management of this project might be the joint responsibility of the RSPA, the U.S. Coast Guard and EPA, the latter two by virtue of responsibilities with respect to the National Contingency Plan and HM emergency response. Close support should be established by the modal agencies and by representative state transportation departments and other responsible departments, such as local agencies concerned with public safety and emergency control for particular locations.

This project responds directly to Williamsburg report F&R 4 which seeks to assure adequate and rapid emergency response through timely information availability. The project will also provide additional information for complying with F&R 8. Indirectly, the results from this project may, by helping to define problem locations and magnitudes, assist in developing the response to F&R 3 which shows the need for clear definition of roles and responsibilities of federal, state and local jurisdictions with respect to regulation, enforcement and emergency response for hazardous materials transportation.

Cost and Potential Funding Sources - It is estimated that federal funding of $375,000 would be required to carry out this project over a two-year period. This would include cost sharing with a representative sample of state and local governments during the development of the proposed handbook. State and local government and industry financial support would be required for ongoing application of the handbook's procedures to localized decision making.

RESEARCH PROJECT NUMBER 4: ACCIDENT DYNAMICS AND MITIGATION MEASURES

The Problem and Related Work - Accidents can provide useful guidance for improving safety, if they are adequately investigated and analyzed. This research project is concerned with methods for identifying and describing the actual process that takes place when an accident and HM release occur. Standard statistical analyses of accident data bases are not usually capable of discriminating between various types of personnel, equipment or procedural interactions associated with accident occurrences. Most current accident investigation methods do not appropriately define the beginning or termination of an accident sequence, and what happens in between with a replication method. Events analysis methods show promise and need to be developed in order to better understand the accident behavior of hazardous materials, their containment systems, and related elements of the system. In short, investigations of hazardous materials accidents should be considered as a primary research tool in and of themselves, rather than solely as data-acquisition efforts supporting secondary (off-site) analyses (e.g., ask questions such as, How could this accident have been averted?).

Further research is required in three areas:

1. Improved understanding of accident dynamics, using improved process investigation and analysis methods;
2. Related methods for evaluating the effectiveness of actual or potential control measures and safeguards and procedures (both as predictions prior to their introduction and as assessments of the experience with their use); and
3. Approaches for enhancing the acceptability of proposed risk control of mitigating actions under economic and regulatory constraints.

Non-statistical methods of analysis of dynamic events associated with accident occurrences could involve either (1) accident diagnosis techniques (where a history of relevant previous accident factors exists), (2) simulation of operations under various conditions and perturbations of these conditions, or (3) event/fault tree modeling. The National Transportation Safety Board (NTSB) and other agencies have used methods of the first kind. The Association of American Railroads, the Federal Highway Administration (FHWA), and the Coast Guard have supported the development of dynamic simulations; the Department of Energy's MORT program, NTSB reports and the development of fault tree models for dynamic situations (e.g., control processes) have been initially extended from chemical plants to transportation systems under a USDOT grant. The terms fault and failure relate to culpability, so event tree, logic tree or events analysis may help to avoid such connotation when used in place of fault tree or failure analysis, for example. Lack of replicability has been a significant deficiency in all the types of analyses.

New transportation vehicle and vehicle equipment designs (e.g., truck braking systems, tank truck and articulated truck configurations), tank designs (e.g., "Explo-Safe"), hazardous material mitigating processes (e.g., LNG gels), and operating procedures (e.g., train makeup, train control procedures, and associated automated train status information systems, tank truck loading standards, ship operations in narrow channels, etc.) have been assessed primarily by engineering judgment. While the latter should not and cannot be avoided, improved investigation and analysis techniques would enable more objective, precise and replicable evaluations of the effectiveness of such equipment and operational procedure changes. This would help to justify their research and development and subsequent application.

Even given such justifications, scarce government funds and private investment capital for the development of new equipment and procedures will be made available only if their acceptance in the regulatory environment appears assured. The trend towards performance-oriented standards in transportation safety regulations is a positive indication that the regulatory environment may more easily permit the adoption of worthwhile innovations. Policy research appears warranted on the innovation inhibiting influences of regulatory requirements and practices and on how to mitigate these influences by better accident investigaton outputs.

Objectives and Implementation - The objectives of this research project are (1) the furtherance of new investigation and accident process analysis techniques that can discriminate among personnel, equipment and operational interactions, (2) the development of methods for the evaluation of the effectiveness of changes in personnel, equipment and operations in decreasing expected accidental harm and in mitigating their consequences, and (3) the investigation of related regulatory policy and other institutional modifications that would facilitate the acceptance of worthwhile changes.

A program plan should first be developed to guide the long-term activities aimed at meeting these objectives. University and industry support should be sought in the establishment of the plan,

as well as contributions on program requirements and recommended approaches from concerned government agencies. The RSPA headquarters, through an inter-agency/interindustry/interorganizational steering committee, might take the lead for this project, with assistance from all modal agencies.

The program plan should define an evolutionary effort, with initially modest activities that expand as justified by emerging benefits. An ongoing assessment of the status of the areas to which the program objectives relate should first be conducted, together with a delineation of all ongoing research in the area. Needs for enhancements in this research, and variations from it where established requirements indicate this would be worthwhile, should then be defined. Revisions in the requirements and in specific research and development activities would be made as actions are taken in response to these needs, and the success or failure is met in these actions.

The results of this research would be employed by the transportation equipment manufacturing industry as guidance to its development efforts, by shippers and carriers in their use of such products, by the modal agencies of the USDOT in their development of changes in regulations and safety standards and by the media to explain accidents more accurately.

This project directly addresses Williamsburg report F&R 6. Also, this R&D will assist in responding to F&R 7 by providing an improved means for utilizing and evaluating the effectiveness of new technology and for the regulatory structure to keep pace. Part of the data base development in proposed Project Number 6 will be directly applicable to, and supportive of, this project. Results from this project would influence data base parameters in Number 6.

Cost and Potential Funding Sources - It is estimated that the development of a program plan would require $50,000 for one year. The initial activities of the program, conducted over a subsequent year, would require up to $750,000. The ongoing program would be funded in accordance with its merits as established by the utility of its outputs. Funding might come from the RSPA and the various modal agencies. It could also be possible that funding could be provided in part through grants from industry to universities, under the overall management of the RSPA. In addition, research within industry to meet agreed upon goals would in all likelihood be motivated by such a program. Cooperation in actual accident investigations by all parties would be imperative.

RESEARCH PROJECT NUMBER 5: COST EFFECTIVENESS OF HAZARDOUS MATERIALS TRANSPORTATION REGULATIONS

The Problem and Related Work - This research project would concentrate on cost/performance/ benefit and other evaluation methods for hazardous materials regulations. It has often been observed that the current body of regulations for hazardous materials transportation needs to be revised. Depending on the experience with any given regulation, it may be advisable to strengthen it, streamline it, augment it, replace it, or eliminate it. Every regulation brought into question in this way must be subjected to an evaluation of its relative costs and benefits with realistic consideration given to the practicality of making changes in the status quo. Although there are federal guidelines for regulatory cost-benefit analysis, they do not address the difficult aspects of deciding which regulations should be reviewed, what alternatives exist, and how to estimate the effectiveness of the alternatives when there has been no experience with them. Thus, methods need to be established both for estimating the effectiveness and the cost benefit of an alternative regulation or otherwise prepared prior to its implementation, and for "closing-the-loop" through an existing regulation's history of costs, performance and effects.

Risk-based procedures can be, and have been, considered for predicting the effectiveness of a regulation as the predicted decrease in risk it would induce. Problems in doing this can be significant, such as the following:

1. differentiating areas in which risk decreases can be uniquely ascribed to the particular regulation from those in which the regulation has synergistic effects with other regulations;
2. recognizing that "risk transfers" may occur so that a regulation, while enhancing safety in one activity, may diminish it in another (as through changes in relative operating costs of different modes brought about by the regulation);
3. discounting the future benefits of a regulation to compare to present and discounted future costs; and
4. establishing means by which the avoidance of low probability/high consequence events receives weighting appropriately reflecting societal concerns (as in Research Project Number 2).

A great deal of work has gone into attempts to solve these and other such problems by the USDOT, and in related considerations, by the NRC and CPSC. This work needs to be systematized and authoritative decisions made on exactly what procedures should be used under specified conditions related to (1) the nature and scope of a regulation of concern; (2) the information available to support estimates of the relevant risks and predictions of the relevant net risk decreases the regulation would induce, and (3) the economic costs of the regulation's development, introduction, and ongoing operation.

Evaluation of experience with a regulation to assess its actual performance costs and benefits in practice also has severe problems in many cases. The acquisition of unbiased and statistically significant data for the evaluation may be difficult. For regulations concerned with rare events it is likely to be impossible, except through reducing the data requirements to those for component or subsidiary events through modeling procedures (see Research Project Number 6 for possible such procedures). The selection of the regulations to evaluate should be based on government agencies' and industry's assessments that the experience with them appears unfavorable from the safety standpoint, cost standpoint, or both.

Objectives and Implementation - Intensive efforts are needed to improve risk-based methods for regulatory decision making. Related cost evaluation improvements are also needed to support effective cost-effectiveness analysis. The Department of Transportation has been concerned with the problems of accomplishing these improvements at least since a recommendation by the NTSB for the development and use of a risk framework for transportation safety decision making (NTSB, 1971 [10]). RSPA might consider establishing a coherent program to resolve these problems, developing and structuring for consistent application the most effective evaluation methods possible under the conditions obtained for each specific evaluation. The USDOT/Office of the Secretary (OST) might conduct, in parallel, a policy

study to establish the means for mandating the use of these methods within the several regulatory agencies of the Department.

By undertaking this project, DOT would be responding to the Williamsburg report F&R 1. The results would provide a systematic approach to regulatory policy and decision making. It would also have application to F&R 8.

Cost and Potential Funding Sources - It is estimated that $350,000 would be required for the development, testing, and promulgation of the cost-effectiveness methods concerned. This might be provided by OST, RSPA, and the modal regulatory agencies. A two-year program is recommended.

RESEARCH PROJECT NUMBER 6: IMPROVED DATA BASES AND RISK ASSESSMENT TECHNIQUES

The Problem and Related Work - Research is needed on the more effective use of, and improvements to, accident/incident and exposure data bases, and risk analysis techniques. Probabilistic risk analysis is generally recognized to be needed for efficient decision making on the acceptability of hazards in the transportation of hazardous materials and on means for mitigating such hazards when they are not acceptable. However, largely due to shortcomings in the available data and despite many attempts at modeling to overcome these shortcomings, risk analysis has yet to satisfy this need to a significant extent. A large number of analyses have been conducted, many of which certainly have helped to illuminate the relative hazards of different transportation actions and alternatives to them. Few, if any of these analyses have had important roles in the judgments they were intended to assist. A major reason for this has been the uncertainties that have been evident, or suspected, in the results of the risk analyses. The reduction of these uncertainties to the maximum practicable degree, and the clearer assessment of the uncertainties that cannot be avoided, are therefore important goals.

Among the many specific hazardous materials transportation risk analyses that have been carried out, the greatest number have been sponsored by the USDOT, most particularly the Coast Guard, the Materials Transportation Bureau, and the Transportation Systems Center (TSC), and the U.S. Department of Energy. Data development and analysis methodology investigations have been conducted as well. In particular, these studies have been done by the TSC for the Federal Railroad Administration (FRA) and other USDOT agencies, and from a general perspective, for the National Science Foundation (Philipson, 1982 [11]). Dr. Rowe is currently preparing a synthesis of hazardous materials transportation risk analysis methods for TRB.

As indicated, a considerable amount of experience exists both on risk analysis applications for all transportation modes, and on attempts to improve data sources and development procedures and to enhance analytical techniques. A carefully conducted effort to develop improvements in hazardous materials transportation risk analysis appears desirable. It may be noted that a related effort is being strongly supported by the NRC. It may also be noted that the System Safety Society, and perhaps, the new Risk Analysis Society can provide competent advice for the development here recommended.

Objectives and Implementation - The specific objectives of the recommended research project are: (1) improvements in the use of existing data and data reporting systems through their appropriate integration; (2) investigation of the use of derived risk analysis methods (e.g., fault tree analysis, diagraphs, and other methods considered for analyzing the effects of accidental release of hazardous materials, and verification of their validity; (3) development of ways to use accident investigation reports to check the validity of derived risk estimates; (4) improvements in the reporting systems (e.g., through reports that will provide data that support effective multivariate analyses of the factors associated with accidents, and through procedures for increasing reporting completeness and accuracy and minimizing biases); (5) the development of new systems (including new exposure data on shipment quantities, containers, modes, routes, sampling systems) where merited; (6) the integration of all relevant data systems into a hazardous materials transportation risk management information system; and (7) improvements in analytical methods made possible by, and also motivating, the supporting data developments.

Note that the analytical improvements could include new methods (e.g., advanced event/fault tree techniques), which would require new data elements (e.g., on failures of dynamic control loops), which in turn would require new data development approaches (e.g., simulations, operational tests, advanced accident investigation and analysis procedures).

It is recommended that the attaining of these objectives through the implementation of a risk management information system be considered. It would integrate the usable capabilities of present accident/information data systems, such as the Hazardous Materials Incident Report System and the several modes' Accident/Incident Reporting Systems, with the new data bases whose development has been alluded to. It would also comprise such new analytical techniques as have been noted, together with standard statistical methods, so as to be able to support trends analyses, analyses of association and risk analyses, and more specific sets of conditions than has heretofore been possible. The suggested information system might be established and maintained by the RSPA, but it should be freely accessible by all federal, state, and local government agencies, and all elements of industry concerned with the maufacture, shipment, and carriage of hazardous materials.

Cost and Potential Funding Sources - A risk management information system development program plan should first be developed. TSC, with contractor support and with industry involvement through joint government/industry steering committee, might serve as the implementing agency for this effort. It would be able to take advantage of previous planning efforts for related programs at TSC and elsewhere. An evolutionary program plan, with analytical and data needs considered together in an integrated manner, is envisioned. It is estimated that $50,000 and one year would be required to formulate the plan.

This project responds directly to Williamsburg report F&R 8. However, inasmuch as good information is the foundation for essentially all activities, the results from this project would find application to some extent to all the other seven F&R's. Part of the data base development in this project will be directly applicable to, and supportive of, proposed project Number 4.

The initial implementation of the system should be kept as simple and as easy to use as possible. Manual interfacing of existing data bases may be adequate at first, for example. It is estimated that an initial operational capability should be

implemented within two years at a cost of $800,000.

Funding might be provided through RSPA, with support from the modal agencies and from the FEMA in areas where this project interfaces with Project Number 2. It would also be of interest to explore the possibility of added support by industry in order to aid the development of capabilities of specific value to its activities (e.g., preferred route selection, emergency response planning, etc.).

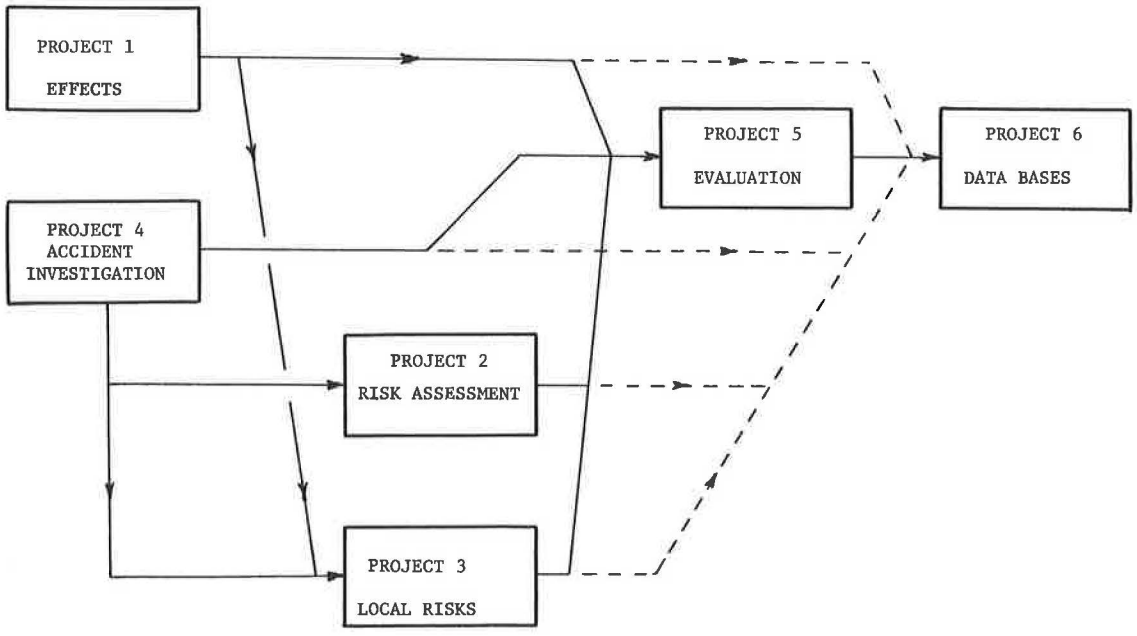
CONCLUSIONS

The six research projects that have been recommended reflect a consensus of the R&D Subcommittee of the A3C10 Committee following a number of reviews and surveys on preferred means by which government and industry can help to improve hazardous materials transportation safety. All of the proposed projects address safety decision making in some respect, considering improvements in the regulatory process at all government levels or in the allocation of government and industry resources to risk reduction. The development of better information and data to support the decisions of concern is a central focus, together with better techniques for the use of this information as well as the information that is already available. Emphasis is given on the need for improved accident investigation methods and methods for the evaluation of experience with existing regulations, as well as for predicting the cost benefits of proposed regulations and other safety-oriented constraints on hazardous materials transportation.

The total estimated cost for the six projects is over $3.1 million, primarily federal funding, with added cost sharing recommended by state and local governments and industry in some areas. It is recognized that in the present environment, this level of funding will not easily be attained, especially considering the research character of the recommended efforts and the consequent uncertainty in their degree of success. On the other hand, the amount is small relative to the potential loss from one major hazardous materials transportation incident in a populated area, should it occur. The projects as listed above have been placed in a very rough priority order. A flow chart suggesting a sequencing of these projects is shown in Exhibit 1. The projects that would be considered most important to safety enhancement and most worthwhile for support no doubt would vary over the different government and industry elements involved with hazardous materials shipping, transport, control and emergency response. Some of the projects are concerned with discrete, one-time efforts to derive specific information or techniques or policy elements. Other projects define ongoing programs that address an evolutionary development of data or procedures, preferably with increasing industry involvement.

What is needed now is the acceptance by an appropriate organization, perhaps the Research and Special Programs Administration in the USDOT, to take responsibility for the further delineation and evaluation as soon as practical of the recommended projects. The A3C10 Committee of the Transportation Research Board and other committees and individuals associated with the National Academy of Sciences who have related concerns stand ready to provide assistance to the RSPA in this effort. Funding of the projects finally decided upon should then be established and their work begun. It is suggested that the consideration of the projects should be completed in fiscal year 1984 and the finally selected projects initiated at the commencement of fiscal year 1985.

EXHIBIT 1. INTEGRATION OF RESEARCH OUTPUTS



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