mechanisms of this type could potentially be extended to cover the consequences of hazardous materials spill. However, complicated questions of evaluation of long-term social costs and design of efficient administrative mechanisms may limit the applicability of this approach.

Direct government funding of technological R&D is accomplished through grants and contracts to universities and private industry and in government operated research laboratories.

Direct funding of research places the greatest responsibility on government agencies to efficiently (a) define specific research project requirements and approaches, (b) allocate resources for undertaking or monitoring projects, (c) evaluate results, and (d) transfer technical information to implementing organizations. Direct government technological research is required in areas of primary government responsibilities, i.e., support of regulatory activity and policy analysis. As alluded to earlier, this research is needed to accomplish such activities as (a) evaluation of the feasibility, costs, and benefits of technological alternatives; (b) development of standards for performance and condition; and (c) development of methods to test and/or evaluate adherence to standards. Direct government funding of basic research is also required because reliance on tax policy and regulatory mechanisms is not likely to induce private industry to fund basic research at the socially desirable level.

NEEDS AND OPPORTUNITIES FOR TECHNOLOGICAL INNOVATION

A critical need for technological innovation arises from a pressing need for solution to important problems. The simultaneous build-up of technical knowledge increases the likelihood that new technology can be developed or applied. In hazardous material and waste transportation safety, several factors combine to lessen the critical nature of needs for technological innovation. First, the hazardous material transportation safety record, despite the current public perception, does not clearly indicate areas where technical research would be of obvious public benefit. The problems in this areas are diverse and of limited impact, i.e., there are no specific technical bottlenecks that are holding up a wide range of safety improvements. In addition, many of the most important problems in this area seem to be most amenable to solution by non-technological means. Finally, in many areas where technology is thought likely to be profitably applied, existing techniques will suffice; the development of entirely new methods and equipment is not warranted.

The implication is not that there will be insignificant payoff from application of technology in hazardous material transportation, but that the areas where technological R&D investments should be made may be difficult to identify.

As indicated above, specific R&D projects should not be initiated without in-depth (cost/benefit) analysis. However, it is useful to identify areas of potential technological contribution that would then serve as a basis for further investigation by both industry and government. In order to foster discussion on this topic by conference participants, a list of potential technological R&D areas is presented as follows:

1. Emergency Response Communications--CB/telephone/satellite systems for improving communications at the accident site and with carriers, shippers, the National Emergency Response Center and CHEMTREC; and remote-site accident detection and warning systems.

2. Hazardous Material Neutralization and Disposal Methods--Long-term environmental and health impacts from single exposures to hazardous material spills; air and water contamination from chemical spills and on-site disposal; and use of neutralizing chemicals to lessen immediate impacts of spills or to aid in clean-up activities.

3. Training Techniques and Equipment--Computer-based emergency response simulations and hazard/materials handling information dissemination via audiovisual cassettes.

4. Estimation of Hazardous Materials/Waste Movement--Computer-based manifest/consist tracking systems and use of high-resolution airborne photography to locate vehicles containing hazardous materials/wastes.

5. Methods to Render Materials Less Hazardous During Transport--Combustion retardant packaging and additives, gelation and leak plugging materials, and shipment of less hazardous compounds and/or components.

6. Advanced Test Equipment and Methods--Automatic cargo condition sensing devices, wide spectrum analyzers for identification of chemicals at the accident site, in-ground pipeline condition test equipment, and non-destructive tests for hazardous material tank and hose condition.

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Application of Automated Data Base Technology to an Intense Regulatory Climate

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Comprehensive hazardous waste management regulations were recently promulgated by EPA. At the center of the regulations lies the requirement that a written manifest accompany each shipment of hazardous waste from "cradle to grave."

The application of existing automated data management technology to the problems of hazardous waste and its transportation is promising. However, considerable obstacles remain before the full potential can be realized. One such obstacle is the myraid of inconsistent state regulations with respect to hazardous waste manifests. The effect of this collection of differing state requirements is to minimize the application of automated data base technology to the problems of hazardous waste management. This paper presents background information for manifest requirements, then discusses two pri-

mary issues facing the application of data base management techniques:

1. Should the federal government mandate a single uniform hazardous waste manifest format to be used throughout the United States?
2. Should the federal government itself develop an automated data base management system to replace the requirement for a written manifest?

As of November 19, 1980, each load of hazardous waste leaving a generator's plant site must be accompanied by a manifest. The manifest is a part of EPA's Resource Conservation and Recovery Act (RCRA) regulations that require a cradle-to-grave accounting for the transportation of hazardous wastes. This regulatory program has and will continue to cause an extensive upheaval in the transportation industry. Consideration of hazardous waste as a commodity in transit is a relatively new phenomenon. While hazardous materials in transit have traditionally been accompanied by shipping papers, waste materials have not. Written hazardous waste manifests required by EPA and DOT must now accompany waste shipments from the generator of the wastes to transporters to treatment/storage/disposal facilities (T/S/DF) and back to the generator. Each manifest must contain, as a minimum, the following data:

1. A document number;
2. Waste generator's name, address, telephone number, and EPA identification numbers;
3. Initial and subsequent transporter's names and their EPA identification numbers;
4. A designated T/S/DF and up to one alternate site by name, address, and EPA identification number;
5. A description of the waste in accordance with DOT regulations;
6. The total quantity of each hazardous waste; and
7. A certification containing specific language.

There is, however, no specific manifest format required by the federal regulations. The seven requirements listed above can be supplemented by state requirements. Several states have adopted mandatory manifest formats that require more specific waste description information. A few state regulations do not permit the use of T/S/DFs of manifests prepared by out-of-state generators unless the state format of the generator is identical to the T/S/DF state format.

The paradox is made complete when the generator and T/S/DF are separated by, let us say, six states, each with a different manifest format requirement. Each hazardous waste shipment would then conceivably require eight separate manifests, one each for the generator, disposer, and intermediate transit states. Any one of the manifests, taken alone, probably would have protected the public interest by assuring an auditable trail in the event of a mishap or intentional mismanagement.

There are important procedureal differences in addition to the substantive manifest requirements between states. Manifest document numbers and generator, transporter, and T/S/DF site codes may vary from state to state. In addition, some states require that copies of the manifest be mailed to a state agency for tracking by that agency.

In response to federal and state hazardous waste manifest requirements, several vendors are now offering an automated data base management system designed to assist hazardous waste generators in complying with manifest requirements. Such automated data base management systems serve a relatively straightforward data editing and manifest tracking function. Although specific applications differ somewhat, the following scenario is intended to illustrate the capabilities of such a system.

A generator, seeking to ship a hazardous waste from state A to state C journeying through state B, accesses a computer via a remote data entry terminal. The manifest form required by state A is displayed on the terminal screen for completion. As the data entry clerk enters the data to the form, the computer automatically checks and verifies each data entry. EPA identification codes, waste categories, waste descriptions, and other manifest requirements are all checked against a master file containing such information. Should the clerk indicate, as in this case, that disposal of the waste shipment is intended in another state (here, state C), the terminal will then display a different manifest (should one be required) for T/S/DFs operating in state C. Should the intermediate state (state B) require a different manifest format, that format will be automatically displayed by the computer terminal for completion.

A properly constructed data base can be instrumental in preventing inadvertent violations of differing state manifest requirements. However, such systems are not currently available for use in more than a handful of states. Reasons cited by vendors offering such services include the uncertainty of new state regulatory requirements and the anticipation of new federal requirements with respect to manifest.

THE ISSUES

The issue is thus squarely presented: Should the federal government mandate a uniform format for hazardous waste manifests and thereby promote the use of existing computer-based automated data management systems to solve the problems of hazardous waste transportation? A corollary to the question raised is whether the federal government should itself develop an automated data base management system for use by hazardous waste managers.

It would be unfair to accuse EPA of failing to consider the use of automated data base management techniques in promulgating its hazardous waste manifest requirements. Indeed, throughout its preamble to those regulations, EPA made reference to the fact that many hazardous waste managers would choose automated record management as a means of complying with the regulations.

The problem that EPA faced in selecting a hazardous waste manifest format (or in failing to do so) was in gaining a consensus among the various states as to the required contents for the hazardous waste manifest. What is needed is direction from a federal agency as to what pertinent information needs to be on a manifest. EPA attempted to give this direction in its regulations, but did not mandate that a common manifest be used by all states. Consequently, the states, naturally, took EPA's direction to mean they could add other pertinent information which they deemed essential to the manifest.

If a common manifest were used by all states, the use of a computer for data storage, reporting, and tracking of manifests would be enhanced. Such a uniform manifest format need not necessarily limit the additional information available to the states. A uniform format could be adopted that would permit some record fields to remain optional, depending on state regulations. These fields would not be completed in all states by all generators. However, the format would remain the same, thus simplifying a centralized approach to automating the hazardous waste data base. This is not to say that some

effort should not be made to limit the number of data fields contained in the uniform hazardous waste manifest format. Obviously, the more data fields stored in a computerized system, the more complicated (expensive) the system itself, and the more sophisticated (expensive) the equipment required.

The preceding paragraphs have discussed the opportunity for the federal hazardous waste manifest requirements to be modified to enhance the application of existing computer-based technology in hazardous waste management. The more fundamental question remains, however: Should the regulations themselves be changed to embrace the use of automation as a substitute for the written hazardous waste manifest?

The trend in our economy is toward a paperless commercial system. Commercial "paper" is transferred electronically without the benefit of paper, or with paper as a confirming back-up system. If a federal agency such as DOT or EPA were to adopt a centralized automated data base for tracking and reporting hazardous wastes, would not the result be better protection for the environment and the public health and safety with a lessened economic burden on industry? Under such a system, a generator wishing to transport a hazardous waste shipment would contact a trained data entry clerk, using an interactive computer terminal, could instantly verify permit status, waste acceptability, and the variety of EPA and other identification codes associated with wastes, generators, transporters, and disposers. At the other end of the shipment, when the disposer receives a shipment of hazardous wastes, it too will contact the central data base to remove that manifest from the active portion of the file and put the manifest information in a summary file for use by interested parties.

Telephone contact is not an essential part of such a system. Large-volume users could be equipped with their own remote data entry stations. Creation of such a centralized computer data base would, of course, raise other questions:

1. Should the system be maintained by a federal, state, or regional agency or by a private corporation or by a combination of private and government entities?
2. Could such a system be developed in which a common manifest is supplemented by other legitimate state information requirements?
3. Are we prepared, as a society, to dedicate the resources necessary to enforce regulations as quickly as violations are detected by the automated data base management system?
4. Can appropriate security measures be incorporated into the system to assure that proprietary business information is not inadvertently disclosed?

SUMMARY

The principal issue addressed by this paper is the problem created by the proliferation of inconsistent hazardous waste manifest requirements by the several states. While differences in state approaches to hazardous waste management are recognized in the statutes supporting EPA regulations, differences between the states in hazardous waste manifest requirements as such threaten to wreak havoc in interstate commerce and frustrate the ongoing efforts to apply existing computer data base management technology to the problems of hazardous waste management. Finally, the issue of federal assumption of data management responsibilities with respect to hazardous waste manifests is presented to initiate and stimulate discussion on this important question.