ments. Performance standards do not limit technological innovation. S.193.2007 on definitions of the recently published liquefied natural gas regulations tells industry what the safety requirements are, but not how to meet them.

Under a performance standard, the operator analyzes the individual operation and devises appropriate means of meeting the regulatory requirements. Although now required to do so, the operator will be inclined to follow the practices recommended in consensus standards. But--and this is critical to the future health of regulated industries--the operator is not prohibited from incorporating current technological developments into the operation.

MTB has the ability to state its requirements in performance language as we have seen in much of the recently issued regulations for liquefied natural gas. MTB has stated its intention to rewrite all its regulations in performance language, insofar as it is feasible to do so. All that remains is for MTB to get on with the project on a high-priority basis.

REGULATIONS/CONSENSUS STANDARDS RELATIONSHIP

When safety regulations are properly written, regulations and consensus standards serve different purposes. The regulations tell industry the safety standards that it must meet, but not how to perform the function. In fact, since safety is but one facet of the overall function, safety cannot properly be addressed except in the context of the overall function. The consensus standard advises industry on a wide range of operational matters relating to the overall function, including means of complying with the safety requirements. In short, they serve these complementary purposes: The regulations prescribe what and the consensus standards describe how.

Historically, standards writing committees were the prime means through which industry accumulated and evaluated operating experience and exchanged information as to good operating practices. In recent years, regulatory agencies have compromised this function. When a regulatory agency makes a practice of incorporating consensus standards into the regulations, the standards become embryonic regulations. As standards committees come to understand this new role, they will eliminate operational advice and include in the standards only those things that they are willing to have in the regulations. Except as a means of manipulating the regulatory process, the committees will then lose their value to industry.

Industry began using consensus standards because there was a need to exchange operational information. Government agencies should let these standards return to their historic role, before their usefulness is destroyed. MTB should rewrite its regulations in performance language leaving the how-to-do-it details to the consensus standards committees.

Government Role in Fostering Innovation

Simon Prensky

The U.S. government has had a substantial influence on technical research and development activity since World War II, supporting more than 50 percent of the nation's R&D investment for most of that period (1). Although its direct involvement has been concentrated in the defense and health sectors, the government has impacted research in all segments of the economy including hazardous material and waste transportation. Public research and development programs, while numerous and diverse, have generally served the purposes of either developing new technology for public sector needs or advancing basic knowledge or understanding. For the most part the federal government has avoided the support or conduct of research to develop new private-market products or services (2). Even so, the overall role of the federal government in supporting public technological R&D has been questioned in light of allegations of waste and mismanagement of some research programs.

The 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 research and development activities. This position is commonly supported on grounds that bureaucratic systems lack effective mechanisms for resource allocation, government programs are more susceptible to the distortions of political influence, and government personnel lack appropriate real-world and technical expertise. These arguments, though overstated in their most extreme form, are persuasive in leading to the conclusion that the public interest is not best served when government preempts or supplants private research efforts.

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 material safety, the federal government may be the only significant source for much of the needed additional research funds.

Although the U.S. private economy has had spectacular success in developing and bringing to the market a wide variety of commercial products, there are strong theoretical economic arguments that the private market has and will continue to fund R&D at below socially desirable levels. The most prominent reasons advanced to explain why the private market systematically underfunds R&D include the following:

1. Lack of private-market economic incentive,
2. Uncertainty of payoff from R&D investments, and
3. Restrictive regulation.

The private economy has a natural incentive to invest in the generation of goods that produce business profit. However, goods such as safety and environmental protection, while valued highly by the public, cannot be owned and sold by firms that contribute to their production. Accordingly, private investment in these areas will generally be less then the socially desirable amount. In particular, private investments in the production of new technology or other means of reducing the consequences of hazardous material spills will be made only to the extent that they are cost-effective in reducing liability and other private costs of accident. Government has the justification and responsibility for intervening in the private market to influence the production of these public goods in adequate quantities. (Safety and environmental protection are public goods in the sense that no one can be effectively excluded from obtaining their benefits and, therefore, they cannot be owned by individuals or firms.)

Economists ascribe the qualities of a public good to all research and development activities and thus often conclude that there is a general shortage of private-market funding for R&D. The argument can be summarized as follows: The most important product of research is the information generated simultaneously with the new product or process. Once generated, dissemination and use of this information throughout the economy cannot be effectively prevented. (The patent system is only partially effective at restricting the use of technical information.) In this way information is like a public good. Since private firms cannot fully own or profit by the technological information generated by research activities, they will invest less in its production than the socially optimal amount.

The uncertainty of future costs and benefits of technological research is another reason cited for the private-market failure to provide an optimal allocation of resource to R&D. "The outcome of any research project is necessarily uncertain and the most important results are likely to come from projects whose degree of uncertainty to begin with was the greatest" (3). Since private firms have been found to be generally adverse to risk with respect to investments in R&D, they will tend to underinvest in technological rsearch and skew their R&D investments away from basic or long-term research and toward applied, short-term endeavors. Because R&D expenditures in risky research are very likely to produce the most important benefits from society's point of view, an argument can be made for government intervention in the private R&D market, particularly in support of basic research.

Certain private technological investments will be underfunded, not because there is a lack of economic incentive or because there is excessive risk but because past government action has 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. It is the nature of government regulation that acceptable designs will not generally include the latest and most efficient technologies. To the extent that extra costs and/or delays are incurred in obtaining government approval of new designs, regulated firms will tend to underinvest in new technology. In addition, the ultimate risk of new product prohibition increases the uncertainty of R&D activity and therefore also discourages technological innovation. A well-noted example of this type of restrictive regulation in hazardous material transportation is the use of design sepcifications for packaging. A thorough discussion of the benefits and problems associated with conversion to performance standards is presented elsewhere in this paper.

Such arguments indicate that the specific areas in which the government could intervene in R&D to increase the general public welfare are difficult to define. Classical welfare economic theory gives little assistance. Its prescription, i.e., invest until the marginal social benefit just equals the marginal social cost, cannot be employed in practice because of the uncertainty of estimates of social costs and benefits. Government intervention in the R&D process generally results in increased administrative costs and can lead to misdirection of private as well as public resources. Before specific public intervention can be justified, it is necessary to compare each option's prospects for remedying the market defects with the mischief that these options may themselves generate (4). The government, therefore, should be very careful in devising strategic and tactical 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 (measured by employing marginal cost/benefit analysis in a qualitative manner, if necessary) and favor methods of intervention that cause the least disruption to the economic process.

In addition, it is clearly desirable for the government to improve methods to evaluate the merits of technical R&D investments to narrow the uncertainty of estimates of public benefits and costs. As a consequence of extending and refining data and basic understanding (including the improvement of technology forecasting and risk analysis techniques), a greater percentage of potentially worthwhile projects will be supported while projects of questionable value will likely be dismissed.

The federal government can intervene in the technological R&D process in the following major ways: (a) tax policy, (b) regulation, and (c) direct funding.

Tax policies that may be effective in increasing the overall amount of private R&D investment include general tax cuts, investment tax credits, exemption from taxes for new ventures, accelerated depreciation of research plant and equipment, etc. These mechanisms have the advantage of leaving the greatest amount of management prerogative for direction of R&D projects in the hands of the private sector. Given the belief in the private market's relative advantage in efficiency, these techniques should lead to production of the greatest value of useful products per government dollar invested. However, the incentives tend to induce more of the same kind of R&D currently being done, whereas R&D in areas of the greatest public need may continue to be underfunded. In addition, use of tax policy in R&D runs the risk that federal funds will largely substitute for private funds, not augment them (5).

Regulation indirectly influences R&D spending by prohibiting certain activities and modifying others into prescribed patterns. Properly formulated regulations can be used to promote R&D activity, as effectively as some regulations inhibit it. One way in which regulations can induce increases in private R&D activity is by establishing standards of performance that are at levels not attainable by technology currently employed in the regulated industry. An example of using regulation in this manner is the Average Fleet Fuel Economy Standards for the U.S. automobile industry. By setting yearly miles per gallon goals (and penalties for missing them), the government forced domestic automobile makers to more rapidly change their fleet to advanced fuel-efficient designs. This approach requires that prior to promulgation, the government establishes that (a) the proposed standards are both technically and economically feasible and (b) the time frame suggested for their implementation does not cause undue financial harm to the regulated industry. Regulated performance standards have the advantage of leaving a great deal of the management control for R&D in the private market, and they can be more selectively employed than tax incentives.

Another regulatory approach to induce greater private R&D investment is to develop mechanisms that make private firms more fully responsible for the societal costs of their operations. For example, the purpose of the recently enacted hazardous waste superfund legislation is to assign the costs of cleaning up waste sites to chemical companies who share responsibilities for the problem. Chemical companies who produce hazardous chemical wastes may respond by increasing R&D investment in areas that lead to reductions in chemical pollution, thus reducing their liability under the Act. Liability 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-