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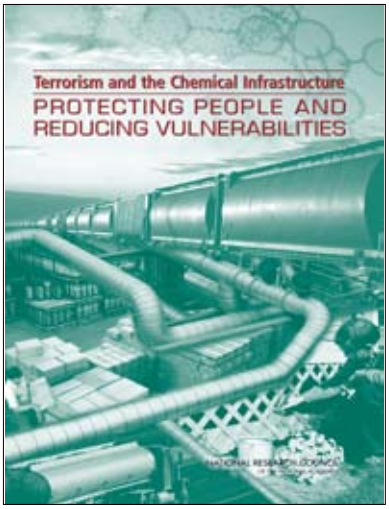
REPORT IN BRIEF

Terrorism and the Chemical Infrastructure
Protecting People and Reducing Vulnerabilities

The consequences of a deliberate attack on chemical facilities or chemical in transport would be expected to be similar in nature to the chemical accidents we have already experienced. Under limited circumstances, such an attack could cause catastrophic casualties and loss of life, but it would take several simultaneous events to cause catastrophic economic consequences. Societal responses could either amplify or mitigate the consequences of chemical events depending on the quality of the communication to the public. Absent specific threat information, authorities should invest in mitigating and preparing for various types of vulnerabilities, including improved emergency preparedness and response, and investments to develop economically-feasible, inherently safer, chemical processes and storage procedures.



Since the attacks of September 11, 2001, the Department of Homeland Security has been undertaking an unprecedented review of the nation's infrastructure to determine potential targets for future terrorist attacks, including the Chemical Industry and Hazardous Materials sector. The chemical sector is a key part of the national economy. Direct products of the chemical industry include plastics, fibers, and drugs, and many more products such as paper, fabrics, cosmetics, and electronics are dependent on the products of the chemical industry.

Chemical firms run the gamut from those that continuously manufacture huge volumes of chemicals, such as petrochemical feedstocks, to those that produce small batches with highly specific uses, such as pharmaceuticals that may require many days of processing and purifying. Some of these chemical products are toxic, flammable, or explosive. The facilities in which chemicals are produced are also varied—from refineries covering square miles of land with many high volume chemicals on site, to startup specialty chemical companies occupying thousands of square feet in light industrial parks. Products can be transported to their final place of use by truck, rail, pipeline, marine vessel or other means in both large and small quantities.

At the request of the Department of Homeland Security, this report identifies the vulnerabilities and points of weakness in the supply chain for chemicals and chemical processes that could result in a catastrophic event in order to guide research and development to protect against such losses and minimize their impact. As outlined in the Department of Homeland Security's National Response Plan, a catastrophic event is defined as one that "results in large numbers of casualties and/or displaced persons, possibly in the tens of thousands." Catastrophic economic consequences are on the order of tens to hundreds of billions of dollars.

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Potential Vulnerabilities in the Chemical Infrastructure

History proves that chemical incidents can be catastrophic in terms of human casualties. In December 1984, a leak of methyl isocyanate gas from the Union Carbide India Limited Bhopal claimed 4,000 lives, resulted in an estimated 200,000 to 500,000 injuries, and contributed to an accumulation of 15,000 to 20,000 disaster-related deaths in subsequent years. America's worst chemical catastrophe occurred on a loading dock in Texas City, TX on April 16, 1947 when an explosion of 2,300 tons of ammonium nitrate in a Liberty ship cascaded into widespread destruction of nearby petroleum refineries, chemical production facilities, and another fertilizer liberty ship, ultimately claiming nearly 600 lives and causing approximately 3,500 injuries.

The consequences of a deliberate attack on the chemical infrastructure would be expected to be similar in nature to the accidents we have already experienced, although they could be larger in magnitude under the wrong circumstances. All of the potentially catastrophic scenarios considered in this report are some combination of the following basic scenarios: (1) release from high volume storage (either fixed site or in transit); (2) shortage of key chemical or chemical product; and (3) misuse of a chemical (tampering or theft). Terrorists could conceivably cause a single terrorist incident or multiple terrorist incidents, geographically co-located or dispersed, simultaneously or over a period of days or weeks.

By far the largest number of casualties would be anticipated from situations that involve large-scale releases of toxic chemicals in a gaseous form. Casualties would be higher for large releases that occur close to populated areas. Damage to infrastructure and subsequent economic loss is more readily caused by the flammable and explosive properties of chemicals.

The report concludes that there is no obvious chemical for which a shortage would cause catastrophic economic loss. Where stockpiles do not exist, market forces quickly compensate for loss of production by increased production at another facility or a different company, or by temporary substitution in industrial processes of another chemical with similar properties. An incident could result in changes to business and manufacturing processes, either voluntarily or through regulation, but those changes would be borne by individual companies and local economies.

Public Response Helps Determine Event Consequences

The perception of disasters among members of the public sometimes escalates as a consequence of a breakdown in communications. Conversely, a well-informed public can often take action to minimize the effects of a disaster. Information must reach the end-users in a comprehensible and useful form, it must be perceived by them as relevant to their situation, and they must have the capacity and the necessary resources to use this information to better prepare for, respond to, and recover from a hazard/disaster situation. This is especially true in a chemical attack because event specific conditions such as the type of chemical, quantity of material, and release location will be critical to determining the appropriate course of action.

Public responses to any acts of terrorism in this country involving the chemical infrastructure could invoke both positive or negative consequences. These consequences could significantly affect sectors of the economy, such as the negative impact on the travel and airline industries after September 11th. They may also impact public morale, the level of trust and confidence in the government's ability to protect its citizens, and exacerbate feelings of vulnerability leading to social (sociological) and psychological effects.

Recommendation: In investing in and utilizing behavioral and social science research, the Department of Homeland Security should give particular attention to understanding and preparing for the societal response that will occur following a major chemical incident.

Recommendation: The Department of Homeland Security should explore ways to enable rapid analysis and communication of data for decision-making and communication to the public during and after an emergency.

Recommendation: The Department of Homeland Security should support research directed towards enhancing emergency preparedness, emergency response, and disaster recovery.

Developing Safer Chemistries, Processes, and Storage

The most desirable solution to preventing explosive and harmful chemical releases is to reduce or eliminate the hazard where possible. This can be achieved by modifying processes where possible to

minimize the amount of hazardous material use, lower the temperatures and pressures required, replace hazardous substances with less hazardous substitutes, or minimize the complexity of a chemical process.

Many of the advances required for developing practical, safer alternatives to today's chemicals and chemical processes are fundamental and aren't motivated by competition. The economic incentives for industrial funding are frequently absent, which leads to the need for either a government investment in research, or government provided financial incentives for industrial investments. Inherently safer chemistry such as process intensification, "just in time" chemical manufacturing, and the use of smaller scale processes offer the potential for improved safety at chemical facilities, but these applications at present are still quite limited in scope.

Improving storage security is another priority. A container holding significant quantities of a hazardous chemical provides an obvious terrorist target. While efforts to strengthen existing containers against intentional rupture are on-going, there may be opportunities to fundamentally change the means by which hazardous chemicals are stored. For example, methods to store chemicals in adsorbents are currently available, but are generally limited to small quantities of chemicals. Research could seek to enable use of adsorbents at the cylinder scale and for transport. Other possibilities for fundamental change in storage include low pressure storage (which would reduce the release rate in the event of an unintended rupture) or underground storage technologies.

Recommendation: The Department of Homeland Security should support research and development to foster cost-effective inherently safer chemistries and chemical processes.

Recommendation: The Department of Homeland Security should support research to determine the combinations of incentives and disincentives that would best encourage the private sector to invest in safety and security. This will require research to identify the nature of the interdependencies and weak links in the supply chain and consideration of public/private partnerships to encourage voluntary adoption of protective measures by the weakest links in the chain.

Recommendation: As a central element of a longer-term research program, the Department of Homeland Security should seek ways to improve the safety and security of chemical storage in both fixed facilities and transportation.

Improving Detection and Monitoring

Emergency response effectiveness can be enhanced through the development of reliable detection techniques that can be widely distributed, are easy to use, and would give accurate results quickly and clearly. Such Techniques can aid in "early warning" of chemical releases before they become catastrophic, and would aid in decision making and response, prevention of catastrophic release or more timely and effective emergency response. In research and development on chemical sensors, efforts should focus on furthering technologies that are relatively inexpensive to deploy and easy to use.

Using inventory controls as a means to quickly identify theft of hazardous chemicals may provide a fundamental means to prevent a terrorist attack. This capability may prove difficult if not impossible to mimic with sensor technology. Investments aimed at improving compliance with such procedures would be appropriate.

Recommendation: The Department of Homeland Security should invest in science and technology to enhance real-time monitoring of breaches in containment, the chemical infrastructure and any disruptions to it, and any resulting consequences of an event.

Recommendation: As it pursues sophisticated technologies for security monitoring, the Department of Homeland Security should not neglect lower-technology solutions, such as inventory audits and inspections.

Disaster Impact Model Accuracy Needed for Appropriate Preparation and Response

There is a mismatch between current disaster impact models and current security needs. Current models have been generalized from natural disasters and accidents, and may have features that do not apply in the event of deliberate attacks. Further research is needed to confirm that these models' assumptions and relationships are valid in such situations. Research is also needed on whether human responses to intentional terrorist events differ significantly from those responses to natural disasters or accidents.

A higher level of accuracy and precision in predictive models of casualties could improve emergency planning and response. While the physics of a hazardous materials release can be described using models, effects on populations are not yet well characterized. Efforts are hampered by limitations in understanding

of the toxic effects of many substances, and in the understanding of the dose/response relationship of hazardous chemicals over time, especially for vulnerable populations such as children, the elderly, and the poor. Some previous emergency planning efforts had been based on reports that overstated potential consequences of individual events, leading to significant confusion and alarm among various decision makers and the public. Better, more appropriate data should be used and clear explanations of the change need to be provided to different stakeholders.

Recommendation: The Department of Homeland Security should support research to extend the applicability of current disaster impact models to chemical events.

Recommendation: The Department of Homeland Security should support the development and application of robust models to predict off-site consequences of chemical events and ensure that the type of model used is appropriate to the situation.

Prioritizing Investments

While the consequences of a terrorist attack on the chemical infrastructure are of significance to the population affected, there is no reason to deviate from the principles and approach of good risk assessment/management decision-making when prioritizing investments to mitigate these consequences. Each assessment should consider a realistic scenario and its vulnerabilities, likelihood of occurrence, and consequences, if it were to occur. Each scenario should be processed though a series of tests to assess if it can be significantly disruptive or catastrophic. These scenarios should consider loss of life, economic impact, and the ability of state and local government to respond to the event, and should also consider the impact of social amplification. This should be followed by an analysis to assess the trade-off between expected benefit and cost of the proposed solution.

Recommendation: When considering investments to prevent or mitigate vulnerabilities, the Department of Homeland Security should complete an overall risk assessment which would consist of analyzing the combination of vulnerability, threat/likelihood, and consequence of an event.

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This report brief was prepared by the National Research Council based on the committee's report. For more information, contact the Board on Chemical Sciences and Technology at (202) 334-2156 or visit http://dels.nas.edu/bcst. *Terrorism and the Chemical Infrastructure* is available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.