Executive Summary

The 1994 Northridge, California, earthquake caused dozens of deaths and over $20 billion in losses. In 1995 an earthquake in Kobe, Japan, killed more than 5,000 and resulted in losses of well over $100 billion. These disasters show the damage earthquakes can inflict. Although future losses are uncertain, there is general agreement that **damaging earthquakes will strike the United States in the next few decades, causing at the minimum dozens of deaths and tens of billions of dollars in losses.**

Since 1977, the federal government has had a research-oriented program to reduce earthquake losses. This program—the National Earthquake Hazard Reduction Program (NEHRP)—has made significant contributions toward improving our understanding of earthquakes and strategies to reduce their impact. However, much of the United States remains at risk for significant earthquake losses. Risk-reduction efforts lag far behind the knowledge base created by research; this lag, or "implementation gap," reflects the limitations of NEHRP's information-based strategy for encouraging nonfederal action. NEHRP also suffers from a lack of clear programmatic goals.

THE EARTHQUAKE THREAT

Much of the United States is seismically active. Risks vary widely from region to region:

- The greatest likelihood of repeated economic losses due to earthquakes is in the coastal regions of California, where moderate earthquakes are frequent and population densities are high. California, in addition, faces a lower probability of larger, very damaging earthquakes.
- The Pacific Northwest has experienced rare but very large earthquakes in the past; the timing of future earthquakes in this region of the country is uncertain.
- Quakes in the section of the Intermountain West running from southern Idaho and western Montana through Utah and Nevada can endanger communities historically unprepared for any seismic activity.
- The central United States (chiefly, the region near the intersection of Missouri, Kentucky, Tennessee, and Arkansas) and sections of the eastern United States have experienced infrequent earthquakes in the past. Future occurrences are very uncertain, but if and when they do occur, losses could be quite high as these areas are largely unprepared.

The primary hazard associated with earthquakes is ground shaking, which damages and destroys buildings, bridges, and other structures. Ground shaking also causes liquefaction, landslides, and other ground failures that endanger structures. This damage and destruction has both

short- and long-term implications. In the short term, people are killed and injured by falling buildings and other objects. The fires associated with earthquakes are often difficult to fight because water pipes have been broken and roads have been blocked by debris. In the long term, the costs of repair or replacement, coupled with the loss of customers and employees (e.g., due to impassable roads), can force businesses and industries to close. Local governments may be forced to cut services to cover the costs of infrastructure repair. And if reductions in the supply of housing lead to higher rents, there may be increased homelessness.

THE U.S. POLICY RESPONSE TO DATE

The federal government currently responds to the earthquake threat with a number of policies and programs. Its primary effort is the National Earthquake Hazard Reduction Program (NEHRP), established in 1977 to "reduce the risks of life and property from future earthquakes in the U.S...." The program combines the efforts of four federal agencies:

- the U.S. Geological Survey (USGS),
- the National Science Foundation (NSF),
- the Federal Emergency Management Agency (FEMA), and
- the National Institute of Standards and Technology (NIST).

NEHRP's original charter included wide-ranging provisions for earthquake prediction, earthquake control, and vigorous implementation of seismic safety knowledge. In practice, however, the program has centered on the performance and dissemination of science and engineering research. Thus, 64 percent of the NEHRP budget goes (via USGS and NSF) to research in the earth sciences, and another 14 percent supports engineering research; the remaining 22 percent of the budget goes to "implementation" activities such as technical translation, education, and outreach.

NEHRP: PROGRESS AND PROBLEMS

NEHRP-sponsored research has yielded an impressive list of accomplishments. Although past accomplishments do not ensure future ones, it is clear that **NEHRP has led to significant advances in our knowledge of both earth science and engineering aspects of earthquake risk reduction.** For example, NEHRP-supported research led to recognition of the seismic risk in the Pacific Northwest, and NEHRP funding helped develop the knowledge base that now makes it possible to design and construct new buildings that are unlikely to collapse in earthquakes. Although NEHRP is principally a research program—over 75 percent of its funds are directed toward research—it has made some contributions to the implementation of earthquake mitigation, as well. Thus, for example, we now have model building codes that reflect a national consensus on new building seismic design, as well as several interdisciplinary centers that work to translate research results into useful information for decisionmakers.

Despite these successes, however, earthquakes continue to cause massive losses in the United States. The 1994 Northridge earthquake caused more than $20 billion in losses, and scenarios of possible future U.S. earthquakes suggest that thousands of casualties and tens or even hundreds of billions of dollars in losses may occur. Although there is no consensus on what level of loss is acceptable,[1] **there is clearly a significant remaining exposure to earthquake damage—due in large part to a failure to implement known technologies and practices.** Many communities, especially in California, have taken steps to reduce earthquake losses, but there still remains a large gap between what current knowledge says could be done and what actually is done.

The failure to implement known technologies and practices, or "implementation gap," is a direct result of NEHRP's approach to reducing earth-

[1] Although no losses would seem desirable, achieving zero losses would be either impossible or impractically expensive.

quake losses. NEHRP's approach can be thought of as supplying information on earthquake risks and possible countermeasures to those who may wish to mitigate. By supplying this information, the program hopes to motivate individuals, organizations, and local and state governments toward action while providing guidelines on how to proceed. This approach implicitly assumes that the interest or incentive for mitigation is sufficient for people to act on such information. However, the current paucity of mitigation activities suggests that individuals, organizations, and local and state governments lack sufficient incentives for mitigation. Whether or not the federal government should play a role in ensuring that there are sufficient incentives for mitigation is a sensitive policy question. In any case, **NEHRP's approach of supplying information alone clearly limits the program's impact.**

NEHRP faces serious operational problems as well. Numerous congressional reports and expert review panels have noted that **NEHRP lacks clear and workable goals and strategies.** Although NEHRP's authorizing legislation does set broad overall objectives for the program, actual NEHRP spending by the four participating agencies does not suggest any unified multiagency agreement on specific goals, strategies, or priorities. In the absence of a multiagency consensus on NEHRP goals and strategies, each of the four participating agencies (USGS, NSF, FEMA, and NIST) has developed a portfolio of NEHRP activities that reflects its own agency mission and priorities. In addition, the lack of agreement on goals and strategies makes it difficult to judge the impact or success of the overall program, since there are few criteria by which to measure performance.

POLICY OPTIONS

OTA has identified several policy options that Congress could consider to improve federal efforts to reduce earthquake losses. Three general types of policy options are discussed:

- One type of option involves changes in the specific research and other activities that NEHRP undertakes. OTA identifies key research and implementation needs that NEHRP could address within its current scope.
- The second type of option involves management and operational changes in NEHRP. Such changes could make NEHRP a more efficient, coordinated, and productive program.
- The third type of option includes changes to federal disaster assistance and insurance, regulation, and financial incentives. Such changes are outside the current scope of NEHRP and would represent a significant change in direction for the program. However, **such changes are necessary to yield major national reductions in earthquake risk.**

CHANGES IN SPECIFIC ACTIVITIES OF NEHRP

Earth Science Research

Decisions about what earth science research to support should be made in the context of the goals of the earthquake program. If Congress would like NEHRP to reduce earthquake losses in the short term and also to focus on implementing known technologies and practices, then the earth science research portfolio should favor more applied, short-term work such as microzonation, ground motion mapping, and hazard assessment. In contrast, if Congress views NEHRP as a program for reducing earthquake hazards over the long term, it would be appropriate to retain the current focus on basic earth science research.

Earthquake Engineering Research

A new structure that meets current seismic building codes will be very resistant to collapse due to earthquakes. The construction of buildings that are resistant to collapse is a great technical accomplishment in which NEHRP played a considerable role. Since this has been achieved, it is time to consider moving some resources to the next research challenge—reducing earthquake-related structural, nonstructural, and contents damage.

Much of the risk of both structural failure and nonstructural and contents damage lies in existing structures, which do not incorporate current codes and knowledge. Relatively few of these structures

have been retrofitted to reduce risk; and where retrofits have been performed they have often been expensive, complex, and of uncertain benefit. More research is needed to improve retrofit methods.

Implementation

One of NEHRP's most promising implementation activity is to directly assist communities in their efforts to understand earthquake risk and to devise mitigation options. Analytic tools to estimate likely losses in the event of a future earthquake and to predict the likely benefits of mitigation would be of great help to communities.

FEMA currently has several programs intended to promote implementation of known mitigation technologies and practices. Very few of these programs have been evaluated carefully in the past, leaving current program planners with little guidance as to what works, what does not, and why. All mitigation programs should be evaluated carefully, and the results should be used to improve, refocus, or—if necessary—terminate programs.

In addition to direct support for implementation, NEHRP also supports some research into the behavioral, social, and economic aspects of mitigation. Further research of this type could improve our understanding of some key issues that currently hinder mitigation.

MANAGEMENT AND OPERATIONAL CHANGES

NEHRP spending by the four participating agencies suggests a loosely coordinated confederation of agencies with no overarching agreement on specific goals, strategies, or priorities for NEHRP. One policy option is for FEMA, as the lead agency, to work with other NEHRP agencies and with the professional earthquake community to come up with specific goals and priorities for NEHRP. Defining overarching goals for NEHRP would not be easy and would have to address the difficult issue of acceptable risk. Yet it is necessary for NEHRP to move beyond a loose confederation of four agencies. Congress could require FEMA to report on progress toward defining and meeting specific goals for NEHRP. Since FEMA has no explicit budgetary or other control over the other agencies that participate in NEHRP, Congress may wish to provide oversight to ensure that all these agencies work toward defining and meeting the agreed-on goals.

The continuing congressional dissatisfaction with FEMA's management and coordination of NEHRP has led some to consider transferring lead agency responsibility from FEMA to another agency. OTA's finding that implementation is emerging as NEHRP's key challenge, however, suggests that, of the four principal NEHRP agencies, FEMA appears to be the most appropriate lead agency. FEMA has the most direct responsibility for reducing losses from natural disasters; it is in direct contact with state, local, and private sector groups responsible for reducing earthquake risks; it has a management rather than research mission; and it coordinates regularly with other agencies in carrying out its mission. The other NEHRP agencies are principally involved in research and therefore may find it difficult to develop the strong implementation component necessary to lead the program. One policy option would be for Congress to allow FEMA to continue as lead agency but to provide frequent oversight to ensure that lead agency responsibilities are carried out.

BEYOND THE CURRENT NEHRP

Congress could consider other policy options that go beyond the scope of the current NEHRP. These include using federal disaster assistance as an incentive for mitigation, an increased federal role in disaster insurance, increased regulation, and greater use of financial incentives to promote mitigation. These policy options have the potential to significantly increase implementation of seismic safety knowledge—something NEHRP, in its current form, is unlikely to accomplish. However, these options would likely require new legislation and would be a significant departure from current policy. They would also be quite controversial.

In considering these options, a central issue is: **What is the appropriate role of the federal government in mitigation?** Some argue that increased investment in mitigation by the federal government would save money by reducing future disaster outlays. Others argue that the very existence of federal disaster assistance programs creates disincentives for mitigation. Still others argue that mitigation tools, notably land-use planning and building regulation, are state and local issues in which an increased federal role is inappropriate. These arguments involve different political and philosophical beliefs; OTA does not attempt to resolve them but rather suggests that policymakers consider the policy options in light of their own beliefs.

Insurance and disaster assistance can be a vehicle for mitigation, as well as a disincentive against mitigation, depending on how the program is structured. Congressional decisions as to the fate of hazards insurance legislation will involve many issues, most of which are beyond the scope of this report. With respect to mitigation, however, it is clear that insurance can be a strong incentive for earthquake mitigation—if the cost of insurance reflects the risk. In addition, social science research suggests that individual mitigation decisions are not made on an economically rational cost-benefit basis but are considerably more complex. Insurance programs should recognize these complexities.

One policy option, largely outside the scope of NEHRP as currently defined, would be for the federal government to take a stronger position on implementation via regulation. In the current policy environment, regulation in the form of building codes is the most widely used mitigation tool, but it is performed at the state or local level. The federal government plays only an indirect role by providing technical support for code development and implementation. In addition, Executive Order 12699 (issued January 5, 1990) requires that new buildings constructed with federal assistance meet current codes. A more aggressive policy option would be to require states and localities to adopt model building codes, or demonstrate a minimum level of code enforcement, as a condition for receiving federal aid. Nonstructural mitigation efforts could be advanced through an executive order addressing this problem in federal buildings.