UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

APPLICATIONS OF KNOWLEDGE PRODUCED IN THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: 1977 - 1987

AN INTERPRETATIVE REPORT BASED ON THE REPORT "A REVIEW OF EARTHQUAKE RESEARCH APPLICATIONS IN THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: 1977-1987" SHOWING WHAT HAS BEEN LEARNED ABOUT APPLICATIONS TO MITIGATE THE EARTHQUAKE HAZARD

Sponsored by:

The Federal Emergency Management Agency,
The National Institute of Standards and Technology,
The National Science Foundation, and
The U.S. Geological Survey

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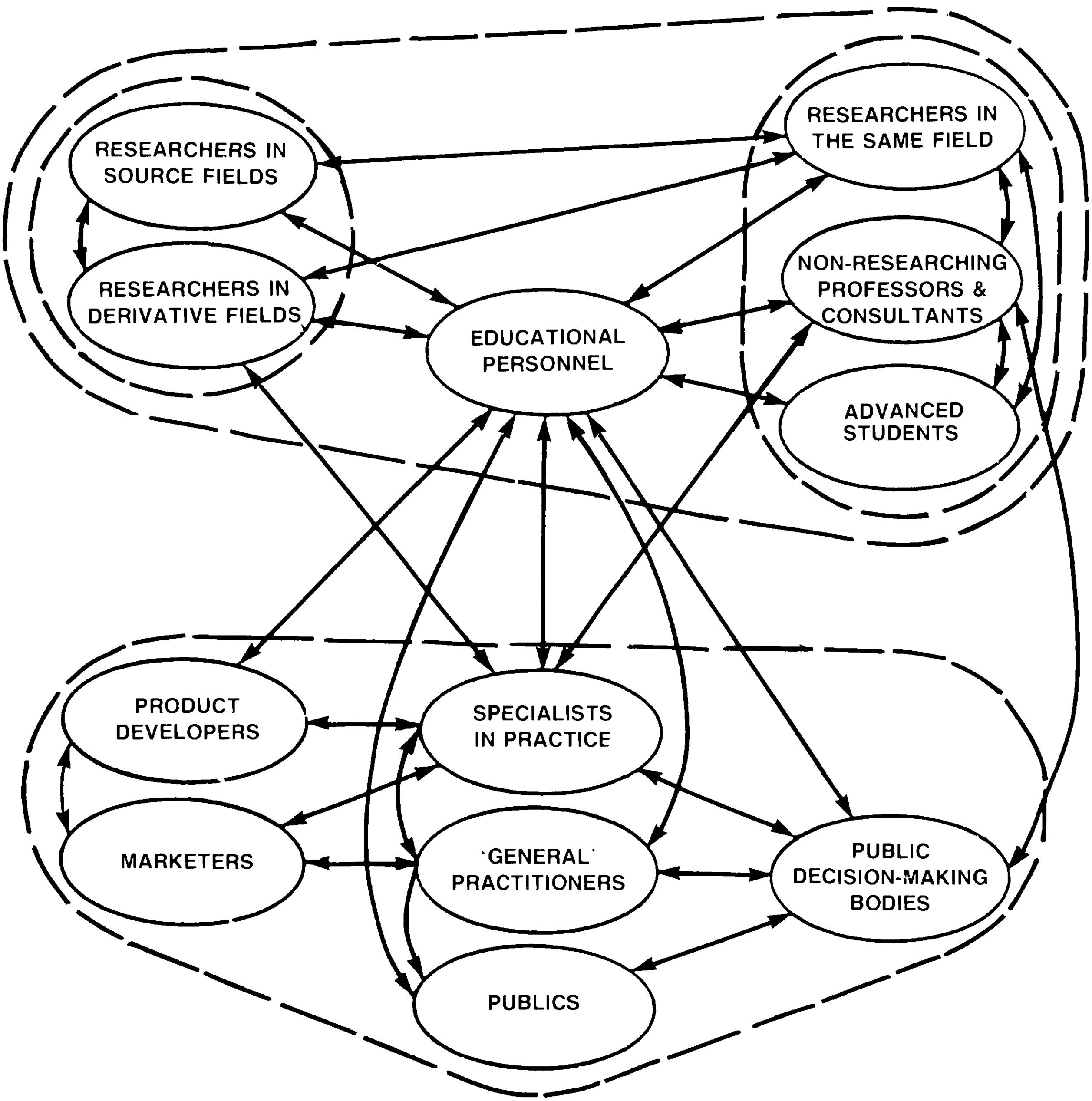
RESEARCH INFORMATION NETWORK



PRACTICE IMPROVEMENT INFORMATION NETWORK

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EXECUTIVE SUMMARY

APPLICATIONS OF KNOWLEDGE PRODUCED IN THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAMS: 1977-1987

INTRODUCTION

This report defines what has been learned about mitigating the earthquake hazard throughout the nation--the goal of the National Earthquake Hazards Reduction Program (NEHRP)--after 10 years of work and an expenditure of 610 million dollars by the four principal agencies of the NEHRP. It contains recommendations that build on the major accomplishments of the first decade of the NEHRP and extend and strengthen the capability for achieving earthquake hazard mitigation in every part of the nation during the second decade. It also calls for the four principal agencies, the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST), the National Science Foundation (NSF), and the United States Geological Survey (USGS) to work together to set priorities within the framework of their missions and to consider and adopt changes in their current programs that will accelerate progress in:

- research,
- development of professional practices, and
- implementation of loss-reduction measures that will mitigate or reduce the earthquake hazard in every part of the nation during the second decade of the NEHRP.

The report points out the urgent national need to realize objectives such as:

- Understanding the seismic cycle of the nation's seismogenic zones.
- Dealing with the enormous number of existing buildings throughout the nation that have a high potential for collapse in an earthquake.
- Eliminating and/or strengthening the large number of unsafe school buildings in the United States.
- Improving the siting, design, and construction of the nation's new buildings and facilities, valued annually at about 397 billion dollars.
- Enhancing the skills of the nation's professionals to apply the large body of available knowledge to mitigate the earthquake hazard.

- Increasing the state-of-preparedness in urban centers throughout the nation.
- Producing many more "champions" of earthquake hazard mitigation.

This report is a companion to and an interpretation of another report entitled, "A Review of Earthquake Research Applications in the National Earthquake Hazards Reduction Program: 1977-1987." Both reports were published as U.S. Geological Survey Open-File Report 88-13. Together, they provide sixty case histories of research applications in various parts of the United States and a synthesis of the conclusions and recommendations. The two reports represent the contributions and thoughtful review of over one hundred men and women ("champions") who have provided leadership in all regions of the United States for applications of knowledge to mitigate the earthquake hazard.

UNIQUENESS OF THE EARTHQUAKE HAZARD

Unlike other natural hazards such as floods, hurricanes, landslides, and volcanic eruptions, earthquakes are unique in their potential for causing great sudden loss. They have struck and will again strike urban centers throughout the United States with little or no warning, causing great physical and societal impacts over a broad geographic region within a few seconds to a few minutes. Without adequate preparedness and mitigation measures in place, an urban center faces the threat of damage and destruction of buildings, lifeline systems, and critical facilities as well as death, injury, homelessness, and joblessness for the populace. Economic losses can potentially reach a few to several tens of billions of dollars in many urban centers of the nation. The primary phenomena to be mitigated are ground shaking and permanent ground failure. The secondary phenomena to be mitigated are surface fault rupture, regional tectonic deformation, tsunamis, seiches, fire following earthquakes, flooding from dam failure, and the effects of aftershocks. A large percentage of the nation's 215 million people live in urban centers of the nation having a moderate to high risk of experiencing at least one damaging earthquake in their lifetime. Whether or not the event will produce a disaster depends on the earthquake preparedness and mitigation measures in place at the time of the earthquake.

CASE HISTORIES

Using a knowledge utilization model proposed in 1985 by Yin and Moore, sixty case histories were compiled, categorized, and evaluated in terms of enlightenment uses, decisionmaking uses, and practice uses. Collectively, the case histories dealt with: 1) primary and secondary earthquake phenomena, 2) physical, social, and economic models of urban and regional systems, 3) varying degrees of public and private apathy regarding the earthquake threat, which often is perceived as an infrequent, low-salience problem, and 4) strategies available for controlling and mitigating potential losses.

The case histories showed that applications of knowledge to protect people and property throughout the nation have happened as a consequence of a complex dynamic process (called herein the research applications process) linking knowledge producers (researchers) and knowledge users (practitioners). In this process, researchers typically produce fundamental knowledge answering the questions:

- What has happened in the past?
- What can happen in the future?
- Where did it happen?
- When will it happen?
- Why did it happen?
- How bad were the physical effects?
- How often will they recur?
- How did the populace behave?
- What can be done to keep these physical phenomena from causing damage, deaths, injuries, and loss of function?

From this knowledge base, products have been prepared and disseminated, including: hazard maps, land use plans, engineering standards, model building codes, methods for testing, methods for estimating loss of life and economic loss, and methods for improving regional, community, and personal preparedness. Practitioners take these products and determine if they can be used in their community to mitigate the hazard in a way that:

- will save lives,
- will reduce damage and economic loss,
- will reduce social and economic disruption,
- is in line with community values, is feasible, and is affordable.

COLLABORATION OF CHAMPIONS

The two most significant factors in the research applications process are activities that: 1) produce champions of earthquake hazard mitigation, and 2) give them a reason for collaboration. The research applications process works best when researchers and practitioners collaborate as partners on the same program. However, this goal is difficult to achieve because: 1) the researchers (typified by physical and social scientists and engineers) and the practitioners (typified by state and local government officials, investors, developers, insurers, professional and voluntary organization, engineers, and specialized consultants) do not collaborate naturally, and 2) there is a big difference in their perspectives. Effective collaboration happens over a period of time ranging from years to a decade or more as trust is built.

CRITICAL FACTORS

The critical factors for an effective earthquake-hazard-mitigation partnership are:

- A need and demand for research, development of practices, and applications - The need and demand must come from all levels of the partnership whose individual members are alert to windows of opportunity.

- People who are competent and motivated to lead and work cooperatively in research, development of practices, and applications - These individuals provide leadership, function as internal advisors and advocates, serve as external champions, and collaborate daily to advance the state-of-knowledge and state-of-practice.

- Resources that are adequate for research, development of practices, and applications - These resources facilitate the creation of timely programs and the balancing of technical, societal, and political considerations.

- Products that are capable of being used in practical applications to reduce and mitigate the earthquake hazard - These products must be based on a sound knowledge base and be credible and practical.

RECOMMENDATIONS

Looking ahead to the urgent needs of the nation and the challenges of the second decade of the NEHRP, the participants raised the issues of leadership, funding, priorities, and changes in programs to accelerate progress. While acknowledging on the one hand that major and significant advances were made in every part of the nation during the first decade and recognizing on the other hand that every part of the nation still needs to do many things to reduce or mitigate their earthquake hazard, the following recommendations were offered to the four principal agencies of the NEHRP for consideration. They are given in terms of the four themes of the fourth workshop:

1) Policies, programs, and practices - The four principal agencies of the NEHRP should collaborate more closely to eliminate and correct all perceived differences in agency policies, programs, and practices that have kept and will unless corrected continue to keep the goals of earthquake hazard mitigation in every part of the nation from being realized. Issues like leadership, coordination of Agency missions and programs, funding, and the forging of partnerships at all levels throughout the nation should be dealt with forthrightly and expeditiously.

2) Enhancing collaboration between researchers and practitioners - The four principal agencies of the NEHRP should be a model of collaboration for the nation because they represent the nation's researchers (NSF, USGS, and NIST) and practitioners (NIST and FEMA).

As a model for the nation to follow, the agencies should seed new and more effective ways to produce champions of earthquake hazard mitigation in the ranks of researchers and practitioners at all levels in the nation and to improve their collaboration.

3) Strengthening the research applications process - The complex long term process involving an interrelated network of people, events, ideas and methods of communication between researchers and practitioners must be made as strong as possible.

The four principal agencies should seek creative ways to improve the way the research applications process works. The process consisting of research, dissemination, communication, applications, and evaluation should be defined in a way that involves more champions of earthquake hazard mitigation during the second decade of the NEHRP.

The agencies should collaborate to strengthen their missions and funding. For example:

- NIST - should seek additional funding and lead out more in the application of engineering and scientific research by undertaking tasks ranging from testing the practicality of research results produced and/or sponsored by the USGS and NSF to writing and disseminating engineering standards and model codes for buildings and lifeline systems.

- FEMA - should seek additonal funding and lead out more in two areas: emergency preparedness and implementation. FEMA should utilize the technology developed and disseminated by NIST within the political and bureaucratic process to foster implementation of loss-reduction measures by state and local governments and the private sector.

- NSF - should seek addiatonal funding and lead out more in engineering, scientific, and social science research while providing support for applications.

- USGS - should seek additional funding and lead out more in scientific research while providing support for applications through special assignments of personnel as well as through grants.

4) Priorities

The four principal agencies should strengthen their resources and resolve for carrying out their individual missions, setting national priorities that will meet the urgent needs of the nation. For earthquake hazard mitigation, programs should balance the dual need for research and applications, focusing on highest priority national needs such as the following partial unranked list:

- Producing many more champions of earthquake hazard mitigation at all levels of government and in academia and the private sector.
- Creating programs that bring "champion researchers" and "champion practitioners" together.
- Making existing hazardous buildings safer.
- Siting and designing new construction and lifeline systems to withstand the ground shaking and ground failure hazards.
- Enhancing professional skills.
- Quantifying the seismic cycle of seismogenic zones.
- Increasing the state-of-preparedness in urban centers.

THE FUTURE

Implementation of these recommendations will make our nation safer from the earthquake threat. One outcome will be that a moderate magnitude earthquake like the December 7, 1988, Soviet Armenia earthquake will not be a disaster when some part of our nation is struck in the future. The magnitude 6.8 Armenia earthquake, which left an estimated 60,000 dead, 18,000 injured, 510,000 homeless, and reconstruction costs in Armenia reaching $16 billion, raised the sobering question: **Can a similar disaster happen in the United States?**

The answer to this hypothetical question depends on the accomplishments of the first decade of the NEHRP and what will be done in the second decade. **The answer is probably "yes" if such an earthquake happened tomorrow in almost all parts of the nation, except California, because three key mitigation strategies have not been fully implemented throughout the nation:**

- **Design and construction of new buildings to be earthquake resistant.**
- **Removal or strengthening of existing hazardous buildings.**
- **Preparedness planning and implementation of mitigation measures in earthquake-prone urban centers.**

The answer would probably be "no" if the earthquake happened a decade from now, provided that these three actions have been realized throughout the nation.

The United States has been challenged to join with, and indeed to lead, other nations throughout the world in concerted actions to make the 1990's a "decade of disaster reduction." This period, called the International Decade for Natural Disaster Reduction (IDNDR), is dedicated to improving and invigorating efforts to reduce the economic and death tolls from natural hazards such as earthquakes, floods, hurricanes and tornadoes, landslides, volcanic eruptions, tsunamis, wildfires, drought, and locusts. The need for reducing the economic toll from earthquakes and other natural hazards in the United States is urgent. The United States has a large number of seismogenic zones, active volcanoes, thousands of miles of storm-prone coastline, large and small flood-producing river systems, slopes susceptible to landslides, coasts susceptible to tsunami runup, and wilderness/urban interacts vulnerable to wildfires. Every year, economic losses from all natural hazards average about 10 billion dollars.

The economic losses will continue to increase as the nation builds and expands its communities along the water's edge, on floodplains, in earthquake-prone regions, on unstable slopes, in zones susceptible to volcanic eruptions, and at wilderness interfaces susceptible to wildfires unless mitigation measures are put in place simultaneously with the development.

APPLICATIONS OF KNOWLEDGE PRODUCED IN THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: 1977-1988

1. INTRODUCTION

1.1 Purpose and Scope

This report is the proceedings of the fourth workshop on research applications. It is the second of two reports designed to define what was learned about earthquake hazard mitigation in the first decade of the National Earthquake Hazards Reduction Program (NEHRP). The first report (U.S. Geological Survey Open-File Report 88-13-A) contained sixty case histories of applications designed to mitigate or reduce the earthquake hazard in various parts of the United States. Each case history, describing why a particular application happened, was discussed in three regional research application workshops convened in 1987. These unique workshops, were sponsored by the four principal Federal agencies of the NEHRP--The Federal Emergency Management Agency, the National Institute of Standards and Technology (formerly the National Bureau of Standards), the National Science Foundation, and the U.S. Geological Survey. This report provides an interpretation of the sixty case histories and contains the recommendations of the participants who met in the fourth workshop on November 1-2, 1988. Selected references are provided for context and background at the end of the report.

1.2 Participants in the Fourth Workshop

On November 1-2, 1988, twenty-eight individuals met in San Francisco to continue discussion of applications of knowledge produced in the NEHRP. They represented the three Program Committees of the three regional workshops held in San Diego, California, on June 23-25, 1987; in Denver, Colorado, on September 9-11, 1987; and in Knoxville, Tennessee, on October 20-22, 1987, and the Federal agencies plus a few experts who had not been able to participate earlier. They were:

Dr. Mihran Agbabian	University of Southern California
Dr. William Anderson	National Science Foundation
Dr. Richard Andrews	Governor's Office of Emergency Services, California
Ms. Genevieve Atwood	Utah Geological and Mineral Survey
Dr. James Beavers	Martin Marietta Energy Systems, Inc.

Dr. Robert Brown	U.S. Geological Survey
Ms. Jane Bullock	Federal Emergency Management Agency
Mr. Pat Byrne	Colorado Division of Disaster Emergency Services
Ms. Lori Friedman	Federal Emergency Management Agency
Ms. Paula Gori	U.S. Geological Survey
Dr. James Harris	J. R. Harris and Company
Dr. Walter Hays	U.S. Geological Survey
Mr. Gary Johnson	Federal Emergency Management Agency
Mr. William Kockelman	U.S. Geological Survey
Mr. Ray Lasmanis	Washington State Department of Natural Resources
Mr. Jeffrey Levinson	Legislative Aide to Senator Albert Gore, Jr., of Tennessee
Ms. Sarah Michaels	University of Colorado
Dr. Dennis Mileti	Colorado State University
Dr. Joanne Nigg	Arizona State University
Mr. Norman Olson	South Carolina Geological Survey
Dr. Risa Palm	University of Colorado
Ms. Jelena Pantelic	National Center for Earthquake Engineering Research (SUNY at Buffalo)
Dr. Miguel Santiago	University of Puerto Rico
Mr. Karl Steinbrugge	Consultant
Dr. Kathleen Tierney	University of Southern California
Mr. L. Thomas Tobin	California Seismic Safety Commission
Ms. Susan Tubbesing	Earthquake Engineering Research Institute
Dr. Richard White	Cornell University (by correspondence)
Dr. Richard Wright	National Institute of Standards and Technology

Through interactive discussions in the meeting and written communication after the meeting, the people listed above provided the insights on the research applications process contained in this report.

1.3 Current Strategies for Enhancing Research Applications in the NEHRP

The four principal agencies, their budgets under the NEHRP which collectively have reached 610 million dollars in the past decade, and their programmatic emphases are described below:

1) The Federal Emergency Management Agency (FEMA) which has an annual budget of $5 million. FEMA, the lead Agency, has a program which emphasizes: a) design practices and manuals for new buildings, b) guidelines on the abatement of seismic risk posed by existing buildings, c) seismic safety planning for lifeline systems, d) support for a study of a national earthquake engineering experimental facility, e) earthquake hazard

mitigation strategies, f) Federal response planning, g) state and local preparedness planning, h) earthquake education and information transfer, and i) post-disaster mitigation. FEMA implements its program through solicited competitive contracts and planning assistance grants to state and local government agencies.

2) The National Institute of Standards and Technology (NIST) (formerly National Bureau of Standards) which has an annual budget of $0.5 million. NIST's program emphasizes: a) improved seismic design and construction practices, b) prediction of the behavior of masonry walls and bridge columns, c) the feasibility and need for a national earthquake engineering experimental facility, and d) the U.S./Japan Panel on Wind and Seismic Effects. NIST performs its program with its staff and solicited competitive contracts.

3) The National Science Foundation (NSF) which has programs in the Earth Sciences Division ($10 million) and the Division for Fundamental Research in Critical Engineering Systems ($18 million). NSF's objectives in the first program are: a) basic understanding of earthquake processes, b) international activities, and c) workshops, symposia, and conferences. The objectives in the second program are research on: a) fundamental engineering issues related to earthquake ground shaking, b) earthquake responses of soil and geologic structures, c) tsunami engineering, d) seismic zonation, e) steel, masonry, reinforced concrete, and wood structures, f) lifeline systems and offshore structures, and g) postearthquake investigations. NSF implements its programs through unsolicitated grants awarded through a peer review process.

4) The U.S. Geological Survey (USGS) has an annual budget of $35 million. The USGS conducts or sponsors a program that emphasizes: a) regional monitoring and earthquake potential studies, b) earthquake prediction research, c) regional earthquake hazards and risk assessments, d) earthquake data and information services, e) engineering seismology, and f) knowledge utilization. The program is implemented through internal projects conducted by staff and external grants invited through annual program solicitations and awarded through a peer review process.

Initiated on October 1, 1977, the NEHRP has a goal of protecting people and property throughout the nation. Six hundred ten million dollars were expended in the first decade to accomplish this goal, using two broad integrated strategies:

- o Research to increase fundamental knowledge on the nature and extent of the physical and societal impacts and ways to mitigate and prepare for them.

- o Activities to foster applications of the products created from the knowledge base as hazard mitigation measures (also called the implementation program).

Now, after 10 years of experience in the NEHRP, a good understanding has been gained of the research applications process--the dynamic process that links researchers and practitioners. This complex long-term process has elements which can be stated in an over-simplified way as follows:

- o Research - studies designed to increase fundamental knowledge and to produce products that practitioners need for mitigation measures.

- o Dissemination - actions that place the research products (e.g., reports and map products) in the hands of practitioners who need them.

- o Translation - actions that give practitioners the best available answers to the questions: Where?, How bad?, How often?, and whenever possible, When?, in the context of the product and their explicit needs.

- o Communication - Two-way exchanges of information that increase the likelihood that practitioners will understand and use the products to adopt relevant seismic safety policies and to enact realistic loss-reduction measures in their communities.

- o Applications - actions by practitioners in the community or region that mitigate or reduce the earthquake hazard.

- <u>Evaluation</u> - actions to determine what happened and why and to introduce adjustments that make the process more effective, including redefinition of the above elements and they way they fit together.

1.4. Program of the November 1-2, 1988, Workshop

The program of the fourth workshop is included below.

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WORKSHOP ON "APPLICATIONS OF KNOWLEDGE PRODUCED IN THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: 1977-1987"

Sir Francis Drake Hotel
San Francisco, California
November 1-2, 1988

Sponsored by the Federal Emergency Management Agency (FEMA), the National Institute of Standards and Technology (NIST) (formerly the National Bureau of Standards), the National Science Foundation (NSF), and the United States Geological Survey (USGS)

PROGRAM

<u>Tuesday, November 1, 1988</u>

Workshop Facilitator: Walter Hays, U.S. Geological Survey

SESSION I: BACKGROUND AND OBJECTIVES

8:30 am WELCOME AND INTRODUCTIONS OF PARTICIPANTS
- -- Gary Johnson, Federal Emergency Management Agency
- -- Dick Wright, National Institute of Standards and Technology
- -- Bill Anderson, National Science Foundation
- -- Walter Hays, U.S. Geological Survey

UPDATE ON RESEARCH APPLICATIONS ACTIVITIES THROUGHOUT THE NATION
- -- "Sixty-Second Vignettes" by all participants on a recent activity

STATEMENT OF THE OBJECTIVES OF THE WORKSHOP AND BRIEF OVERVIEW OF THE INTERPRETIVE REPORT ON APPLICATIONS OF KNOWLEDGE PRODUCED IN THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM: 1977-1987
- -- Walter Hays, U.S. Geological Survey

Vignette on the research applications process by
- -- Bill Kockelman, U.S. Geological Survey

Vignette on the most important factor, "collaboration," by
- -- Paula Gori, U.S. Geological Survey

10:00 BREAK

10:30 SESSION II: THE FUTURE OF RESEARCH APPLICATIONS IN THE NEHRP: 1987-1997

Objective: To discuss the recommendations made by the 100 participants in the three research applications workshops convened in 1987. Panelists will serve as catalysts for brain storming on four major themes in the recommendations, seeking to get as many ideas on the table as possible. Different perspectives are encouraged. "Tongue in cheek" role playing is requested. For reality, assume a level budget (i.e., $600 million) for the next decade of the NEHRP

Background: The 100 "champions" of research applications who participated in the three research applications workshops convened in 1987 noted that every region of the nation will likely experience at least one damaging earthquake during most people's lifetime, and that most regions are unprepared for it--especially if it happens to be a catastrophic earthquake, the most likely event short of war in which the entire Federal Government will be called upon to assist state and local governments in their efforts to save lives and protect property. Accordingly, they recommended actions in four broad categories to improve and accelerate the research applications process in the decade 1987-1997:

- Policies, programs, and practices
- Enhancing collaboration between knowledge producers and knowledge users
- Strengthening weak links in the total process
- Priorities

At this point in time, all regions of the nation except California are still in the integration period of the research applications process--the period where solutions to problems, policy considerations, and political considerations are to be integrated. Only California is in the implementation period--the period where greater levels of state resources are being committed to:

- Repair and strengthening of existing buildings and lifeline systems
- Siting, design, and construction of new earthquake-resistant buildings and lifeline systems
- Regional earthquake preparedness
- Seismic safety organizations
- Public information and education
- Hazard mapping and assessment of the risk in urban areas.

PANEL I: POLICIES, PROGRAMS, AND PRACTICES OF THE FOUR PRINCIPAL AGENCIES IN THE NEHRP--SHOULD ANYTHING BE CHANGED?

Assume that you are now "in charge" of the NEHRP programs of FEMA, USGS, NIST, and NSF; what would you do to ensure that other regions in addition to California reach the implementation period?

Moderator: Gary Johnson, Federal Emergency Management Agency

Panelists

-- Joanne Nigg, University of Arizona (role playing--focusing primarily on USGS policies and practices)
-- Richard Andrews, California Governor's Office of Emergency Services (role playing--focusing primarily on FEMA's policies and practices)
-- Jim Beavers, Martin Marietta Energy System, Inc. (role playing--focusing primarily on NIST's policies and practices)
-- Risa Palm, University of Colorado (role playing--focusing primarily on NSF's policies and practices)

GROUP BRAIN STORMING

NOON LUNCH (Restaurant of your choice)

2:00 SESSION II: (Continued)

PANEL II: IMPROVING THE COLLABORATION OF KNOWLEDGE PRODUCERS AND KNOWLEDGE USERS

Assume that you have been asked to devise a national plan within the current NEHRP to enhance collaboration, what would you attempt to do that is not being done now?

Moderator: Bill Anderson, National Science Foundation

Panelists:

-- Kathleen Tierney, University of California (Perspectives of a Knowledge Producer)
-- Jim Harris, J. R. Harris and Company (Perspectives of a Knowledge User)
-- Tom Tobin, California Seismic Safety Commission (Perspectives of a Knowledge User)
-- Miguel Santiago, University of Puerto Rico (Perspectives of a Knowledge Producer)

GROUP BRAIN STORMING

3:30 BREAK

4:00 GROUP DISCUSSION: WITH PANEL I AND PANEL II

Co-Moderators: Gary Johnson, Federal Emergency Management Agency
Bill Anderson, National Science Foundation

5:00 BACKGROUND ON EARTHQUAKE INSURANCE: AN OPPORTUNITY TO APPLY EXISTING KNOWLEDGE?

Discussion leaders: Risa Palm, University of Colorado
Karl Steinbrugge, Consulting Engineer

GROUP BRAIN STORMING

5:30 ADJOURN

WEDNESDAY, NOVEMBER 2, 1988

8:30 am SESSION II (Continued)

PANEL III: STRENGTHENING WEAK LINKS IN THE RESEARCH APPLICATIONS PROCESS OF THE NEHRP

Once again, assume a level budget. You have been asked to develop a national plan to improve the process, seeking ways to strengthen each of the six elements: RESEARCH (grade of 8 in California, grade of 4 elsewhere), DISSEMINATION (grade of 4), TRANSLATION (grade of 2 everywhere), COMMUNICATION (grade of 2 everywhere) and APPLICATIONS (grade of 5 in California; grade of 1 elsewhere). EVALUATION, the sixth link is not graded. What strategies would be in your plan? How would you use existing knowledge, organizational resources, and technologies to strengthen the weak links?

Moderator: Richard Wright, National Institute for Standards and Technology

Panelists:

-- Genevieve Atwood, Utah Geological and Mineral Survey
-- Dennis Mileti, Colorado State University
-- Jalena Pantelic, National Center for Earthquake Engineering Research
-- Tom Tobin, California Seismic Safety Commission

GROUP BRAIN STORMING

10:00 BREAK

10:30 PANEL IV: PRIORITIES

Given a level budget, which regions of the nation would you seek to move into the implementation period? The basic premise is that the research applications process can make substantial progress by:

o Making better use of the existing knowledge base and existing seismic safety organizations.

- o Making better use of existing technologies (e.g., base isolation, retrofit, etc.).
- o Doing a better job of public information and education (e.g., training the trainers).
- o Doing a better job of explaining earthquake risk across the nation to decisionmakers.
- o Doing a better job of seizing opportunities (e.g., damaging earthquakes, the IDNDR), etc.

However, the budget constraints dictate that you can not do everything everywhere at the same time.

Co-Moderators: Bob Brown, U.S. Geological Survey
Jane Bullock, Federal Emergency Management Agency

Panelists:

-- Mihran Agbabian, University of Southern California
-- Karl Steinbrugge, Consultant
-- Norman Olson, South Carolina Geological Survey
-- Pat Byrne, Colorado Disaster Emergency Services
-- Ray Lasmanis, Washington Department of Natural Resources
-- Susan Tubbesing, Earthquake Engineering Research Institute

GROUP BRAIN STORMING

NOON LUNCH (Restaurant of your choice)

2:00 GROUP DISCUSSION WITH PANELS III AND IV

Tri-Moderators: Jane Bullock, Federal Emergency Management Agency
Richard Wright, National Institute of Standards and Technology
Bob Brown, U.S. Geological Survey

3:30 BREAK

4:00 BACKGROUND ON THE U.S. DECADE FOR NATURAL DISASTER REDUCTION, A PART OF THE INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION

Discussion Leaders: William Anderson, National Science Foundation
Walter Hays, U.S. Geological Survey

GROUP BRAIN STORMING

4:30 NEXT STEPS AND CLOSURE

-- Gary Johnson, Federal Emergency Management Agency
-- Richard Wright, National Institute of Standards and Technology
-- Bill Anderson, National Science Foundation
-- Walter Hays, U.S. Geological Survey

5:00 ADJOURN

1.5 Future Strategies Recommended by the Participants in the November 1-2, 1988, Workshop

The participants concluded that: a) earthquake hazard mitigation can be realized when certain critical factors are present, b) a key factor is a partnership which emphasizes collaboration within and between researcher "champions" and practitioner "champions" (see section 2), and c) significant progress was made in the first decade (see section 3). They also concluded that pragmatic efforts to sustain, improve, and accelerate earthquake hazard mitigation are still urgently needed in every part of the nation during the second decade of the NEHRP (see section 4). They stated that improvements must come from innovations by the researcher "champions" and practitioner "champions." The researchers are typified by physical and social scientists and engineers; whereas, the practitioners are typified by state and local government officials, investors, developers, insurers, engineers, professional and voluntary organizations, trade associations, and specialized consultants. The researchers are producing information to answer the questions: what happened, where, why, how bad, and how often will it recur--important aspects of the earthquake threat; whereas, the practitioners are seeking the best answers to the complex multifaceted question: Is there an action that will save lives, reduce damage and economic loss, and reduce social and economic disruption that is also in line with community values, feasible, and affordable.

The recommendations of the four panels are summarized below:

Panel I: Policies, Programs, and Practices

- The NEHRP should be restructured to ensure a focus on hazard mitigation or reduction--not just hazard research. Such a focus may require an adjustment of existing programs and new funding.

- Research on the factors that facilitate earthquake hazard mitigation should be vigorously carried out so that a concerted effort can be made to accomplish many breakthroughs during the second decade of the NEHRP.

- All agencies should collaborate to strengthen their missions and budgets:

  - FEMA, on fostering the adoption of national, regional, state, local, private sector, and personal preparedness and mitigation measures.

  - NIST, on testing engineering and scientific research results and transforming them into standards and model codes.

  - NSF on engineering, scientific, and social science research and support of applications to foster earthquake hazard mitigation.

  - USGS on scientific research and support of applications to foster earthquake hazard mitigation.

- Each agency should seek innovative ways to work together to devise demonstration projects showing how knowledge produced in the NEHRP can be applied for the benefit of the nation.

Panel II: Improving Collaboration Between Researchers and Practitioners

- Creative activities should be devised to break down the "natural" barriers that impede collaboration between researchers and practitioners. These barriers are described by the following facts.

  - Researchers are not trained to collaborate with practitioners.

  - The reward system for researchers does not usually reward them for collaborating with practitioners.

  - The need to publish for peers is paramount for researchers but of limited interest for practitioners.

  - Both researchers and practitioners in the natural hazards community talk mainly to themselves rather than to policy makers

-- Each discipline carries a "model of truth" which differs from that of other disciplines, making communication difficult until effective partnerships having a high level of trust have been forged.

- Opportunities should be sought to create programs that:

  -- Produce "champions" of earthquake hazard mitigation in both the researcher and practitioner communities.

  -- Provide an environment for researchers and practitioners to work together from the beginning to the end of a project.

  -- Encourage researchers and practitioners to focus on single topics of concern having a high payoff for a community, such as strenghtening existing buildings having a high collapse potential.

  -- Identify practitioners who need the research results and involve them in the collaborative process at the outset of a project or program.

  -- Equip practitioners to use the research results more effectively in their communities to mitigate their earthquake hazard.

Panel III: Strengthening the Research Applications Process

- The four principal agencies of the NEHRP should seek creative ways to eliminate any and all perceived weaknesses in the process: research dissemination--translation--communication--applications--evaluation. This activity may require a redefinition of the process to meet the needs of the nation more effectively in the second decade of the NEHRP.

- The four principal agencies should evaluate their individual and collective missions and resources, strengthening and revising them as necessary to accomplish the goals of the NEHRP more effectively. For example, current agency missions call for:

- -- USGS to conduct and sponsor scientific research primarily and to support applications secondarily.

- -- NSF to sponsor engineering, scientific, and social science research primarily and to support applications secondarily.

- -- NIST to transform engineering and scientific research into model standards and codes.

- -- FEMA to foster within the political process the implementation of standards and technology in ways that increase preparedness and mitigation at national, regional, state, and local scales.

o The fundamental issue is, **"Can the agency missions be strengthened and carried out with greater effectiveness in the second decade of the NEHRP? The challenge and objective of the four agencies is to make the answer, "yes."**

Panel IV: Priorities

o In the second decade of the NEHRP, a greater emphasis should be placed on finding ways to fund activities that produce many more champions of earthquake hazard mitigation and give them a reason to collaborate as partners in mitigating the earthquake hazard. All parts of the nation should work together to maintain and strengthen what they have in place and to create new initiatives. The choices include:

- -- Placing top priority on programs that contribute to life safety or building safety, as perceived by practitioners, not researchers.

- -- Increasing funding for creating working partnerships at the state and local levels to accomplish demonstration projects that will improve life safety and building safety and be an "exhibit" for the nation.

-- Increasing efforts to site, design, and construct safer buildings, working within the well-established building code process and the system of professional practices.

-- Increasing efforts to enhance the skills of professionals throughout the nation who are involved in increasing life or building safety and preparedness in their communities.

-- Reaching out to top Federal, state, and local policymakers to ensure political support at every level of government.

-- Increasing the outreach to the financial community, focusing on groups such as insurers, developers, and investors.

-- Taking advantage of "windows of opportunity," such as the International Decade for Natural Disaster Reduction, to achieve political attention, leverage, increased resources, and greater coordination and integration of programs.

The next section will describe the most significant results of the first decade of the NEHRP, as described by the case histories.

2. CASE HISTORIES OF THE RESEARCH APPLICATIONS PROCESS

2.1 Critical Factors

Study of the sixty case histories (see U.S. Geological Survey Open-File Report 88-13A) showed that applications of knowledge to protect lives and property from earthquakes is a complex dynamic process requiring people, funding, and time. For simplicity and ease of comparison, the case histories describing applications were evaluated in terms of:

- o Enlightenment (uses of knowledge to increase understanding, awareness, concern, and commitment). (Note: The program of an earthquake education center epitomizes enlightenment uses.)

- o Decisionmaking (uses of knowledge to build a basis for decisionmaking concerning legislation, building codes, regulations, earthquake insurance, investment, development, and comprehensive planning). (Note: The activities of a seismic safety organization typify decisionmaking uses.)

- o Practice (uses of information to change, modify, and improve the state-of-practice in siting, design, construction, land-use, preparedness, mitigation, and emergency management). (Note: A program of retrofit of unreinforced masonry buildings is an example of practice uses.)

These three categories of knowledge utilization were described by Yin and Moore in 1985 when they evaluated knowledge utilization models (see Appendix A).

These case histories and other past experiences in the nation showed that applications happen as a consequence of twelve factors which strongly influence the research applications process. These factors, which happen in combination with each other, are necessary but not sufficient by themselves to guarantee success (i.e., implementation of an action to mitigate or reduce the earthquake hazard). However, their absence guarantees failure. The factors are described individually in the following section and are illustrated in Figures 1-12. They are:

- o People to provide leadership in the research applications process efficiently,
- o Funding to create programs that forge a partnership between reseachers and architectures.
- o Time to reach the implementation period.
- o A knowledge base.
- o A perceived need for action.
- o Internal advisors and advocates.
- o External champions.
- o Credible products.
- o Useful products
- o Balanced technical, societal, and political considerations.
- o Windows of opportunity.
- o Collaboration of researchers and practitioners.

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THE CALIFORNIA SEISMIC SAFETY COMMISSION (CSSC)--THE FORERUNNER OF SEISMIC SAFETY ORGANIZATIONS IN THE NATION

(From: Lambright, 1988; Scott, 1988; Jones, 1988; Olson, 1988; Lindbergh, 1988; and Whitehead, 1988)

The February 9, 1971, San Fernando earthquake, which caused $500 million in direct losses, provided a window of opportunity which eventually led to the formation of the California Seismic Safety Commission in 1975. Senator Alfred Alquist played a major role in its birth and eventual institutional role as a symbol of seismic safety, a catalyst for action, and an incubator of applications to reduce potential losses. Since 1975, CSSC has served as an "enabling institution," playing a major role in the legislative process and the establishment of the Southern California Earthquake Preparedness Project (SCEPP) and the Bay Area Regional Earthquake Preparedness Project (BAREPP).

Although the causative factors, funding, histories, and missions differ, the CSSC has influenced the creation of seismic safety organizations throughout the nation: Utah in 1977; Nevada and Montana in 1978; South Carolina in 1981; Kentucky in 1982; the Central United States in 1984; New England, New York, and Puerto Rico in 1985 and Washington in 1986. The organizations in Utah, Nevada, Montana, and Washington were short lived; Puerto Rico's is still evolving. All have made an important impact on research applications in their region of the nation.

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2.2 People (see Figures 1, 2, 3, and 7)

People are the essential ingredient in the process leading to applications because they provide leadership for the programs that comprise the six elements of the research applications process. As researchers, they produce the knowledge base and products, and as practitioners, they apply it. They interact within and between their individual networks. They evaluate and make the required adjustments to improve preparedness and mitigation programs.

2.3 Funding (see Figure 3)

Adequate funding to sustain the programs is essential. The case histories show that although funding is necessary, it is not a sufficient condition for guaranteeing applications of knowledge. The critical issues are:

- Funding that is adequate to support a critical mass of researchers and practitioners working together on a program, and

- Continuity of funding over a period of 5 to 10 years or more to complete the integration period.

2.4 Time (see Figure 11)

The case histories showed clearly that most states of the nation are still in the integration period which may sometimes last a decade or more. Researchers accept this fact, because they work on a long timeline, but practitioners do not understand or accept it. Therefore, the critical issue is:

- **Can the time required for applications of knowledge for mitigation of the earthquake hazard be shortened? If so, what is the best way?**

  The answer is to produce many more champions of earthquake hazard mitigation and to give them a reason to collaborate.

2.5 Knowledge Base (see Figures 1 and 2)

Building a sound knowledge base that practitioners can use should be the goal of the researchers. Experience shows that practitioners can attain adequate understanding of the physical, social, and economic makeup of the region/urban system for successful applications to be realized. Such an understanding of these complex parameters, their central tendency and variability, and their sensitivity to extrapolation, comes only from collaboration between the researchers and practitioners in the development, translation, and use of the knowledge base.

All preparedness and mitigation measures require a knowledge base that can be used to answer basic questions such as the following:

Questions Addressed by the Researchers

- Where have earthquakes happened in the past? Where are they occurring now?
- How frequently do they occur?
- How big have they been? How big can they be?
- What kind of physical, social, and economic effects have they caused? What are the worst effects they could cause in a given exposure time (e.g., 50 years--the useful life of an ordinary building).
- How have soils, buildings, and lifeline systems performed under earthquake loadings?

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THE SOUTHERN CALIFORNIA EARTHQUAKE PREPAREDNESS PROJECT (SCEPP)
(From: Goltz and Flores, 1988)

The Southern California Earthquake Preparedness Project (SCEEP) demonstrates many elements common to successful research applications. SCEPP was initiated in response to a perceived need by the state and Federal governments in the late 1970's to prepare for a major earthquake in southern California. Four unrelated events: a) the "Palmdale Bulge," b) the prediction of a moderate earthquake by a scientist at the California Institute of Technology, c) the eruption of Mount St. Helen's in 1980, and d) the request made after the eruption by the National Security Council to examine the possibility of a major earthquake in

California led to the formation of SCEPP in 1980. SCEPP was institutionalized in 1986 by the California State Legislature.

SCEPP has had both internal and external supporters in its infancy and throughout its lifetime, enabling it to endure changes in state and Federal administration, changes in funding, and changes in perceived level of earthquake potential. Very early in the process, SCEPP developed partnerships with local governments and businesses, the potential users of its products and information. In conjunction with selected businesses, cities, and counties, SCEPP developed prototype planning products capable of being transferred to other organizations. Conferences with other businesses, cities, and counties are held periodically to "transfer" the prototype products and experiences.
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- o How have people behaved before, during, and after a damaging earthquake? How are they likely to behave in the future?
- o What earthquake preparedness and mitigation measures are available for application? Which measures are most effective from the technical-societal-political perspectives? What actions are required?

Questions Addressed by the Practitioners

- o Will the loss reduction measures save lives and prevent injuries?
- o Will the measure reduce property damage and economic losses?
- o Will the measure reduce social and economic disruption?
- o Is the measure in line with community values?
- o Is the measure feasible and can it stimulate actions by others?
- o Is the measure affordable?

2.6 A Perceived Need For Action (see Figures 4, 5, and 8)

Knowledge alone makes no contribution to the reduction of earthquake losses if the knowledge is unknown, misunderstood, inappropriate, unintelligible, misdirected, or ignored by knowledge users. **The reality is that full use of the knowledge base produced in the NEHRP has not yet been made--probably for all of the above reasons--even though all regions of the nation have advanced their capacity to mitigate the earthquake hazard.**

Both researchers and pratitioners (e.g., earth scientists, social scientists, architects, engineers, planners, emergency management specialists) have played a major role in calling attention to the need for dealing with the earthquake hazard in their region or community. Increased awareness of the hazard and professional skill enhancement have served to clarify the need and to equip professionals for action.

Programs to increase awareness and to enhance professional skills were created, enacted, and institutionalized during the first decade of the NEHRP. Examples include:

- The California Seismic Safety Commission (Lambright, 1988; Scott, 1988)
- The Southern California Earthquake Preparedness Project (SCEPP) (Goltz and Flores, 1988)
- The Bay Area Regional Earthquake Preparedness Project (BAREPP) (Eisner, 1988)
- The Utah Earthquake Hazards Program (Sprinkel, 1988, Tingey, 1988)
- The Central United States Earthquake Consortium (CUSEC) (Jones, 1988)
- Western States Seismic Policy Council (Truby, 1988)
- South Carolina Seismic Safety Consortium (Olson, 1988)
- New England Earthquake Project
- Continuing Education Committee of Earthquake Engineering Research Institute
- The California Earthquake Education Project (Thier, 1988) (Note: this project is totally supported with state funds.)
- Public Information and Awareness Programs in the Puget Sound, Washington, area (Martens, 1988).
- Charleston Earthquake Education Center (Bagwell, 1988)
- Outreach programs of the Tennessee Center for Earthquake Research and Information (Metzger, 1988)

2.7 Internal Advisors and Advocates (see Figures 2, 8, and 9)

Internal advisors and advocates are very important in fostering applications of knowledge to mitigate the earthquake hazard in their community or region. These are men and women who may or may not have a scientific or technical background, but who are aware of and understand the reality of the earthquake threat to their community and who are willing to be personally involved in the solution. Because of their knowledge, understanding, commitment, and position of responsibility in the organizations they represent, they usually find themselves in a position to advise and influence the heads of their organizations with respect to seismic safety and to recommend policy. Often, they may be charged with evaluating and recommending loss reduction measures that are appropriate for the need and are balanced in terms of internal and external societal and political considerations. These special people play a major role in influencing policymaking and action taking (Thiel, 1988). The case histories contain many examples showing how internal advisors and advocates have contributed to the research applications process.

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A PARTNERSHIP IN UTAH TO ASSESS EARTHQUAKE HAZARDS AND RISK AND TO FOSTER IMPLEMENTATION OF LOSS-REDUCTION MEASURES

(From Sprinkel, 1988; Tingey, 1988; Barnes, 1988; and Reaveley, 1988)

Researchers and practitioners met in 1983 to formulate an integrated five-year research and implementation program in the ten county area adjacent to the Wasatch fault where approximately 90 percent of the populace live. The principal partners were the Utah Geological and Mineralogical Survey (UGMS), Utah Division of Comprehensive Emergency Management (CEM), FEMA, and USGS. Universities and the private sector participated through grants. The singular accomplishments in the first 5-years included: a) annual workshops to enhance collaboration between knowledge producers and knowledge users, b) production, dissemination, communication, and evaluation of an improved knowledge base, c) institutionalization of a county geologist's program, d) production of an award winning video, "Not if--But When," for use in training and awareness programs in Utah, and e) improved emergency response plans.

Because of the five-year study, Utah is now taking steps to deal with an estimated loss of $3 to 5 billion in a magnitude 7.0-7.5 earthquake on the Wasatch Front. The solution must deal with the large percentage of unreinforced masonry buildings in the state.

A similar partnership was created for an analogous five-year study in the Puget Sound, Washington--Portland, Oregon area in 1985.

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2.8 Champions (see Figure 3)

The term "champion" is used for the men and women who tirelessly promote earthquake hazard mitigation. They may have widely different backgrounds. For example, they may be engineers (e.g., the late Professor Nathan Newmark, University of Illinois), earth scientists (e.g., the late Professor Otto Nutli, St. Louis University), emergency management specialists (e.g., the late Erie Jones, Executive Director of the Central United States Earthquake Consortium) public officials (e.g., the late Robert Rigney, San Bernardino County), or volunteers (e.g., Corrine Whitehead, League of Women voters). These individuals have such a strong commitment to earthquake hazard mitigation that they are able to influence public officials, policymakers, researchers, and practitioners to join with them in fostering and implementing mitigation measures. Their influence, which benefits the entire nation, comes from intrinsic motivation.

The case histories identified some of the current champions who have promoted earthquake hazard mitigation during the first decade of the NEHRP. Many of these individuals are new in their role as champions; they only emerged during the past 10 years. Clearly, many more champions are needed during the second decade of the NEHRP because:

- **the key to earthquake hazard mitigation throughout the nation is the production of champions who will collaborate with other champions to reach the goal of earthquake hazard mitigation in their communities.**

2.9 Credible Products (see figures 2 and 4)

Credibility of the products (data, reports, maps, loss estimation models, computer models, model building codes, etc.) produced by researchers and disseminated to practitioners for applications is essential. Credibility is an intangible quantity that will be "high" (good) or "low" (not good) as a function of factors such as: 1) the reputation of the researcher(s) in the research community, 2) whether they are local or "foreign," 3) the organization supporting the researcher, 4) the organization sponsoring the research, and 5) the peer-review and/or consensus development process that was used to institutionalize the results.

A period of time ranging from a few years to a decade or more is required in most cases to develop a "high" level of credibility; credibility can be lost much faster than it is attained. Examples of the importance of "high" credibility include:

- The Parkfield, California earthquake prediction--credible because of the extensive reviews by the National Earthquake Prediction Evaluation Council (NEPEC), the California Earthquake Prediction Review Council, and the institutional reputation of the USGS (Goltz, 1988).

- The reports, "A Study of Earthquake Losses in Hawaii," and "Earthquake Vulnerability of Honolulu and Vicinity"--credible because of the high professional stature of the principal local consultants: Dr. A. S. Furumoto, Walter Lum, N. Norby Nielsen, and James Yamamoto (from Hawaii), and the external consultants Karl Steinbrugge and Henry Lagorio (from California) (Gransback, 1988).

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ROLES OF THE ARCHITECT, ENGINEER, AND URBAN PLANNER
(From: Mader, 1988, and Barnes, 1988)

The seismic performance of a city's buildings and lifeline systems depends on the architect, engineer, and urban planner. The architect deals with the individual building--its concept, configuration, and planning. The architect and engineer share the responsibility for seismic design, especially when conformance to the seismic design provisions of a building code is required. The urban planner is concerned with buildings in groups that form a street, a community, or a city. Architecture, engineering, and urban planning are complimentary.

Urban planning involves the preparation of plans for future growth and change in urban areas, open spaces, and the implementation of these plans to address topics such as: land use, open space, transportation, hazardous areas, and emergency evacuation routes. Implementation requires zoning and subdivision, regulations, and building codes. One example of the planning process in California is the seismic safety element, a requirement introduced in California in the early 1970's.

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- Tsunami hazard maps for Alaska--credible because of the reputation of the researcher, the sponsoring agency (NSF) the quality of the work, and the recent memory of the physical effects of the 1964 Prince William Sound, Alaska earthquake (Pruess, 1988).

- Seismic design provisions for building codes--credible because of the ongoing work by the model code bodies to develop a consensus (Corley, 1988, Arnold, 1988).

- Guidelines for design of low-rise buildings subjected to lateral forces--credible because of the activities of the Council of low-rise Buildings that was created with support from the National Science Foundation to meet a perceived need (Gupta, 1988).

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SEISMIC SAFETY LEGISLATION

(From: Tobin (1988), Fowler (1988), and Meek (1988))

A combination of many factors is responsible for seismic safety legislation throughout the nation. Research results must be credible, but they often are oversimplified or exaggerated and are but one element in the process; often they are not the most important element. Unlike the objective and measured process of scientific research which produces carefully written and qualified reports that are peer reviewed and published in journals, the legislative process lives with unique rules, last-minute deadlines, competing interests and political philosophies, and compromise. From this process, seismic safety policy is born in legislatures throughout the nation.

In many cases, major seismic safety legislation is enacted after a damaging earthquake. Even foreign events can serve as a catalyst in the legislative process.

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2.10 Useful Products (see figures 2 and 4)

In order for applications of knowledge that mitigate the earthquake hazard to happen, the research products must be both credible and useful (i.e., user friendly). It is entirely possible for a product (e.g., a ground-shaking hazard map) to be credible but not useful. Useless products usually result when:

- The practitioners in the community were not involved in the research-applications process until after the research was completed and the results were disseminated (i.e., the practitioners did not have a stake in energizing the process).

- The product is scientifically correct, but socially unacceptable and/or politically naive.

- The product, although scientifically correct, has not been translated for use by nonspecialists to answer the key questions:

  Where, how bad, when, and the probability of occurrence.

The case histories illustrate many examples of useful products. They include:

- A ground-shaking hazard map (produced by USGS) for a scenario earthquake in the Mississippi Valley region. The map was used in a six-city loss study (sponsored by FEMA) and in hazard awareness and "Train the Trainer" programs (conducted by CUSEC) (Jones, 1988).

- The "lessons" learned from earthquakes (sponsored by NSF) and earthquake loss studies in northern and southern California (prepared by USGS and sponsored by the predecessor organizations of FEMA) by the University of California system to evaluate the need for strengthening of existing buildings (McClure, 1988).

- Research on unreinforced masonry buildings (sponsored by NSF) to devise and enact a plan to repair and strengthen existing buildings in the Los Angeles area (Kariotis, 1988; Asakura, 1988).

- Social science research (sponsored by NSF) to evaluate and improve response and recovery planning in St. Louis, Missouri (Gillespie, 1988).

- Research on structural systems (sponsored by NSF) by a practicing architectural engineering consulting firm to foster earthquake damage and loss control (Scholl, 1988).

o Computer programs for probabilistic hazard analysis and dynamic structural analysis (from projects sponsored by NSF) by an engineering consulting firm to plan and implement seismic strengthening of the Palo Alto Civic Center (Sharpe, 1988).

o Technology for retrofitting existing hazardous buildings (sponsored by NSF) and comprehensive technical program planning (sponsored by FEMA) by university researchers to devise a research agenda and a strategy for evaluating and strengthening existing buildings in the Eastern United States (Soong and White, 1988).

o Experience and reputation gained from studies sponsored by NSF to evaluate the effectiveness of land-use planning measures in Provo, Utah, and Bellingham, Washington (Bolton, 1988).

o Information on regional earthquake hazards (from projects sponsored by NSF and USGS) to improve earthquake preparedness (sponsored by FEMA) in San Juan and other urban areas in Puerto Rico (Molinelli, 1988).

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WINDOWS OF OPPORTUNITY PROVIDED BY A DAMAGING EARTHQUAKE

(From: Tierney, 1988; Jennings, 1988; Singh, 1988; Bartholomew and others, 1988; Holt, 1988; Fratto, 1988; Meet, 1988; and Santiago, 1988)

A damaging earthquake, almost independent of where it occurs, makes the earthquake threat more salient to officials of state and local government and the financial community throughout the nation. The event reinforces awareness and concern by showing how destructive and disruptive even a moderate-magnitude (magnitudes of 5.5 and greater) can be to a community. With few exceptions, the event serves as a catalyst for action by knowledge producers and knowledge users. Media coverage can stimulate a public call for action, especially if deaths, injuries, homelessness, and joblessness are high. The legislative process is usually enhanced by a damaging event, as are new initiatives for research and loss reduction.

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o Loss estimates (prepared by the USGS under the sponsorship of the predecessor organization of FEMA) by FEMA to improve earthquake preparedness in the Puget Sound, Washington, area (Buck, 1988).

2.11 Balanced Technical, Societal, and Political Considerations (see figures 2 and 11).

For earthquake hazard mitigation to be realized, the societal and political considerations must be balanced along with the technical. Dr. John Wiggins introduced the concept of balanced risk in the early 1970's in conjunction with an assessment of the seismic hazard to existing buildings in Long Beach, California (Wiggins, 1988). Many others (e.g., Selkregg and Pruess, 1988) have verified the concept.

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A LESSON LEARNED IN ALASKA
(From: Selkregg and Pruess, 1988)

"In order to achieve effective implementation, any plan for seismic risk mitigation should reflect the shared responsibility among all levels of government. . . . better communication must be established among these partners and between government decisionmakers and the public."

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However, one well known fact should be reiterated:

o **A damaging earthquake changes the rules of the game for a short period of time. Applications that were lagging before the earthquake because of the "pocketbook issue" or the "legal liability issue" can be achieved after the earthquake because of a new factor, the window of opportunity.**

2.12 Windows of Opportunity (see figures 2 and 11).

In most cases, the legislative process requiring implementation of loss-reduction measures can be accelerated by the occurrence of a damaging earthquake. Even events outside the United States (e.g., the 1985 Mexico and 1988 Soviet Armenia earthquakes) create opportunities. After the earthquake, a window of opportunity is opened for a short period of time (typically a few months to a few years). Regions where public and private apathy exists because earthquakes are perceived as infrequent, low-saliency problems can use the tragedy as an opportunity to call for relevant action to impact and improve awareness, decisionmaking, and practice. The organizations that are prepared can achieve notable successes in: legislation, adoption of the seismic provisions of building codes, funding for emergency response, funding for research and equipment, funding for retrofit programs, et cetera Every damaging earthquake is important, some more than others. Examples of how a window of opportunity was seized to accelerate the applications process in the NEHRP include:

- The 1976 Tangshan, China, earthquake, which was a contributing factor to the enactment of the NEHRP Act in 1977.
- The February 8, 1971, San Fernando earthquake (Jennings, 1988; Lambright, 1988) which caused all seismic design criteria to be reevaluated.
- The 1985 Coalinga, California, earthquake (Tierney, 1988)
- The 1979 Imperial Valley, California, earthquake (Singh, 1988)
- The 1983 Borah Peak, Idaho, earthquake (Meek, 1988)
- The August 18, 1959, Hebgen Lake, Montana, earthquake (Bartholomew and others, 1988)
- The 1886 Charleston, South Carolina, earthquake (Lindbergh 1988, and Elton 1987).
- The October 11, 1918, Mayaguez, Puerto Rico, earthquake and the September 19, 1985, Mexico earthquake (Santiago, 1988; Molinelli, 1988).
- The October 10, 1980, El Asnam, Algeria, earthquake (Thiel, 1988).

The legislative process is usually but not always enhanced when the window of opportunity is opened. Examples include:

- California (Tierney, 1988; Tobin, 1988; Mader, 1988; and Palm, 1988).
- Washington (Fowler, 1988).
- Idaho (Meek, 1988).

However, one should remember that a window of opportunity does not stay open very long and that some of the accomplishments may be rescinded later when the window closes.

2.13 Collaboration of Researchers and Practitioners (see figures 9 and 12)

Collaboration is the complex process researchers and practitioners use to pass information to each other to work together to make applications happen. The collaborative process requires an interrelated network of people, events, ideas, and communication methods.

The case histories showed that long term collaboration of champions of earthquake hazard mitigation is the single most important factor for success. From the beginning (the research) to the end (the applications of the research), collaboration of researchers and practitioners is essential for earthquake hazard mitigation. Opportunities to gain support for and to accelerate the research cannot be seized unless there is a high degree of collaboration between researchers (e.g., scientists, engineers, architects, planners, social scientists). The same is true in gaining support for applications; there must also be a high degree of collaboration between the practitioners. The case histories showed clearly that:

- o The key to successful applications of knowledge is not only a function of collaboration within the networks, but also between the networks. (i.e., Tobin, 1988; Goltz, 1988; Whitehead, 1988; Sprinkel, 1988; Tingey, 1988; Andrews, 1988; and Pruess, 1988).

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MYTHS OF COMMUNICATION
(From: Hays, 1978)

Gilbert White noted five myths in communication in the 1978 workshop on "Communicating Earthquake Hazards Information," sponsored by USGS. People everywhere make mistakes by assuming that:

- *o There is a general public or "the public."*
- *o Mailing a report constitutes communication.*
- *o Scientific consensus is the equivalent of overall consensus.*
- *o There is a consistency between what people say and what they do.*
- *o There is a general relationship between the provision of scientific information and what is done with the information.*

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Collaboration of researchers and practitioners is complex and very difficult to achieve quickly. Explanations for the inherent difficulty include:

- o People having different educational backgrounds and experiences have difficulty collaborating. They naturally have different perspectives (Szanton, 1981) which affect their willingness and ability to collaborate effectively as well as their levels of trust.

- o Communication--communication--and more communication is the key for narrowing the differences between researchers and practitioners and for creating trust between people and synergism between programs.

- o Collaboration is not an act; rather, it is a dynamic process that must be done consistently over a long period of time.

The case histories contain many examples of the importance of communication to collaboration (e.g., Thiel 1988; and Gillespie, 1988).

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ENHANCING UTILIZATION
(From: Thiel, 1988)

"Publication of the results of research and dependence on the users to find and interpret it (or the "toss it through the transom" approach) is not a particularly effective method of getting information to those who that need it. Research suggests that the most effective approaches are those that focus on the involvement of the nonresearcher, particularly internal advisors/advocates and external champions who are viewed within their community as leaders, in workshops, prototype studies, priority setting exercises, advisory groups, and any other approach that exposes them to the problem."

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EXPERIENCE IN ST. LOUIS, MISSOURI
(From Gillespie, 1988)

"The emergency management practice community in St. Louis . . . claimed: 1) results are too "scientific" or vague for practitioners, 2) little dissemination of research findings, 3) resistance on the part of the practitioners to the dissemination of research results, for political or personal reasons, 4) frustration, and hence resistance, on the part of practitioners who perceived that scarce resources are being used on research

rather than practice, 5) research is only for the self-gratification of the research community, and 6) emergency management and training programs often do not use research results. Each of these problems could be reduced if there were more contact and communication between researchers and practitioners."

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2.14 Summary of the Research Applications Process (see Figures 1-12)

The nation has an urgent need for: 1) a comprehensive body of fundamental knowledge on earthquake hazards and risk and 2) many more champions who will collaborate in the applications of the knowledge to mitigate the earthquake hazard. The process of creating this body of knowledge and publishing the results is well advanced; however, the process of translating, communicating, and applying the knowledge in the form of enlightenment uses, decisionmaking uses, and practice uses by "partnerships" throughout the nation is not as well advanced and much work remains to be done. Applications of knowledge lag behind the production of knowledge in a region when there is an imbalance between or the absence of some or all of the following factors:

- People to provide the leadership, perform the collaboration, and forge the partnerships in the dynamic long term research application process.
- Funding to create and sustain programs having a critical mass of researchers and practitioners working as partners to create, disseminate, translate, communicate, and apply knowledge and evaluate the results.
- Timeliness as well as time--independence of programs.
- A sound knowledge base.
- A perceived need for action.
- Internal advisors and advocates.
- External champions of earthquake hazard mitigation.
- Credible products.
- Useful products.
- Balanced technical-societal-political considerations.
- Windows of opportunity.
- Collaboration of researcher and practitioner champions.

The next section will describe some of the accomplishments of the NEHRP.

THE RESEARCH APPLICATIONS PROCESS

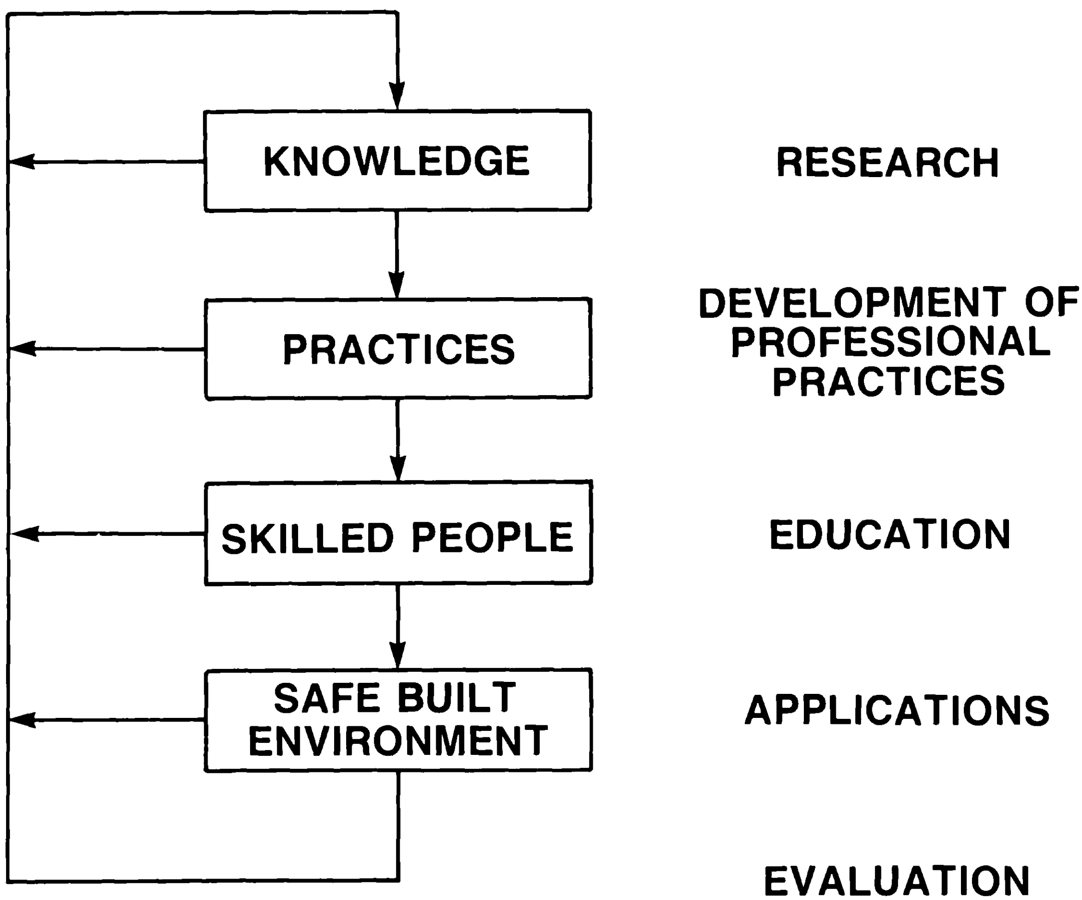

Figure 1:--Schematic illustration of research applications process (from Richard Wright, NIST).

THE RESEARCH APPLICATIONS PROCESS

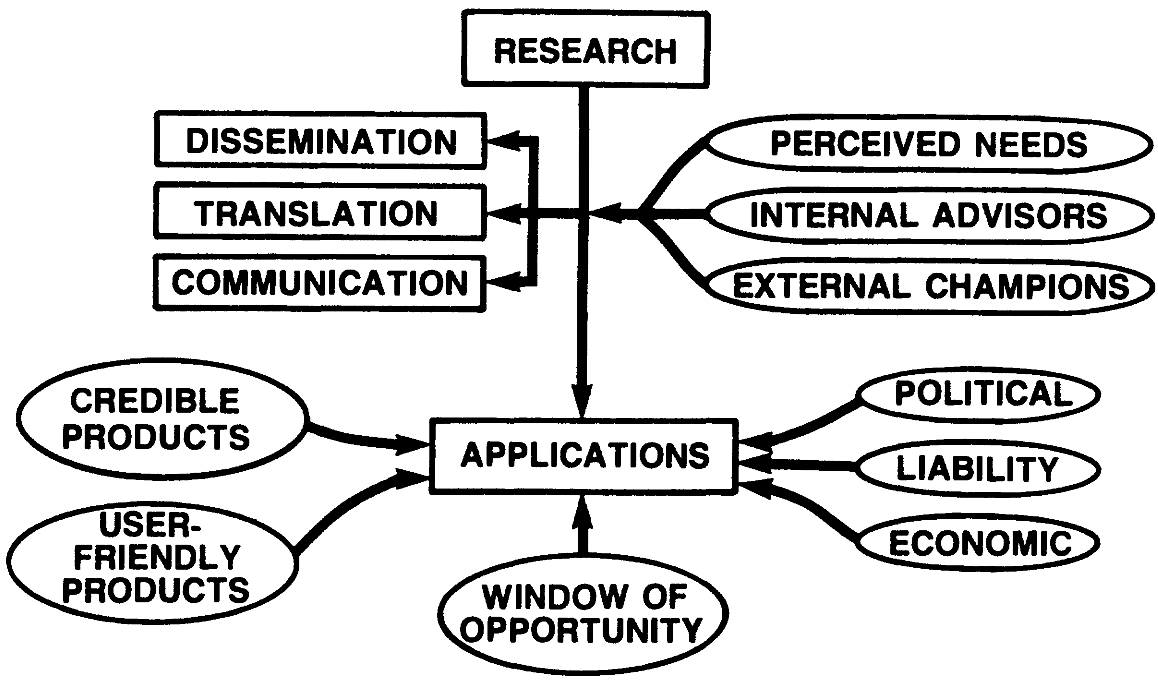

Figure 2:--Schematic illustration of factors contributing to the success of the research applications process. The two most significant factors that lead to success in the long term are activities that: a) produce champions of earthquake hazard mitigation and b) give them a goal or cause to work for in collaboration with other champions.

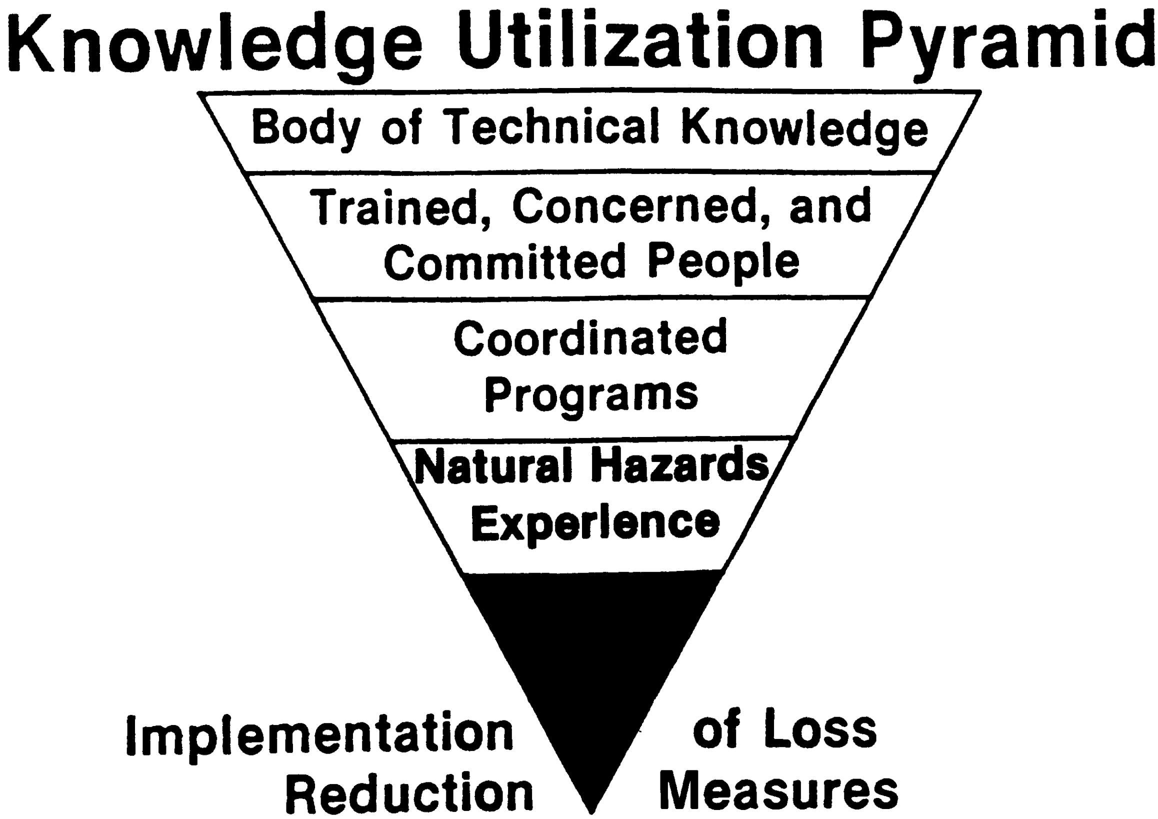

Figure 3.--Schematic illustration of the knowledge utilization pyramid. The gamble throughout the nation is whether implementation of loss-reduction measures will happen before the damaging earthquake strikes.

GROUND SHAKING HAZARD

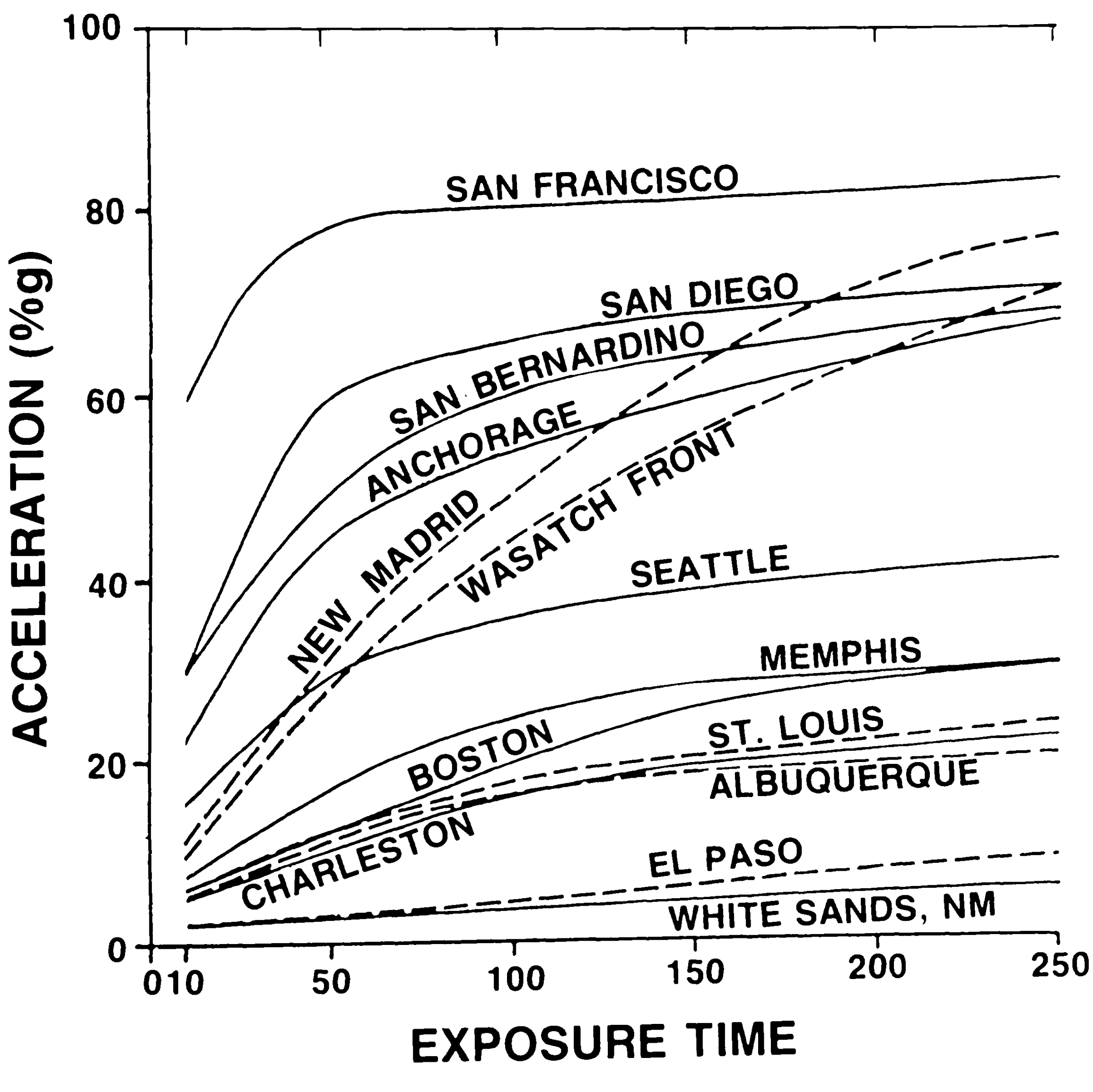

Figure 4.--Graph showing a comparison of the ground shaking hazard in the conterminous United states. Preparation of the maps from which these hazard curves were derived required the collaboration of several hundred researchers and practitioners over a period of 15 years. (Source: S. T. Algermissen, and others, 1982, U.S. Geological Survey Open-File Report 82-1033).

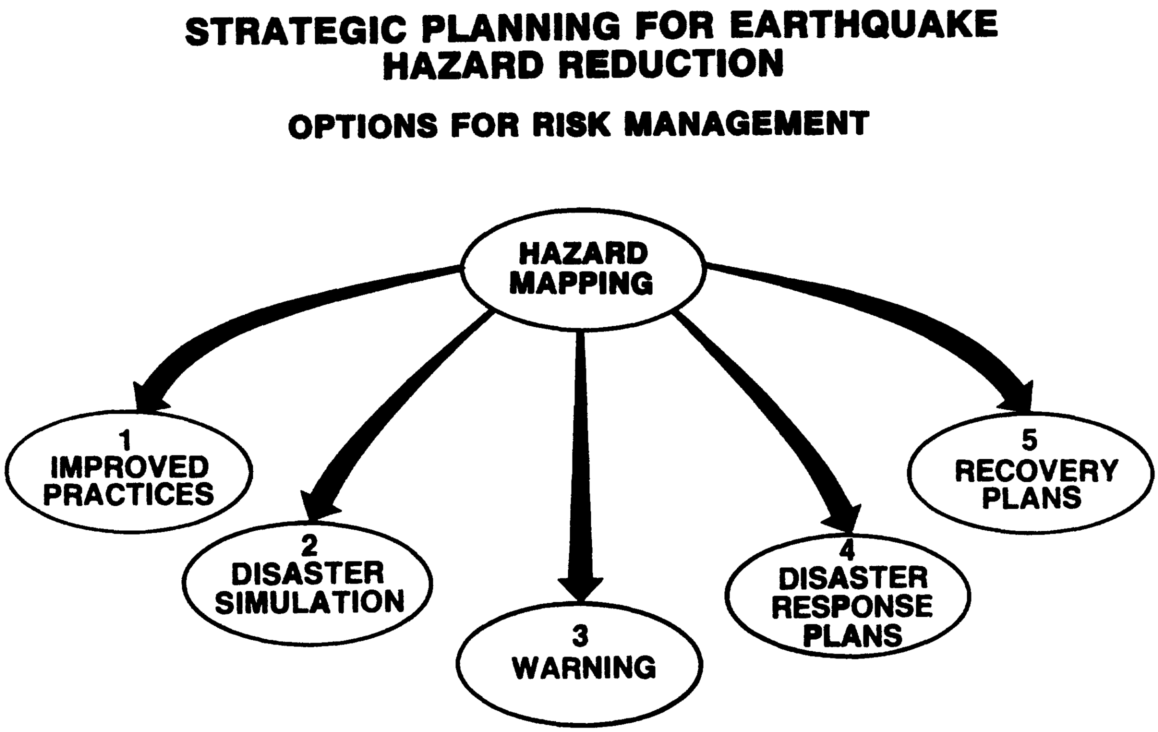

Figure 5.--Practitioners use maps of the ground-shaking hazard, an essential first step in many applications of knowledge, to devise the earthquake hazard mitigation measures.

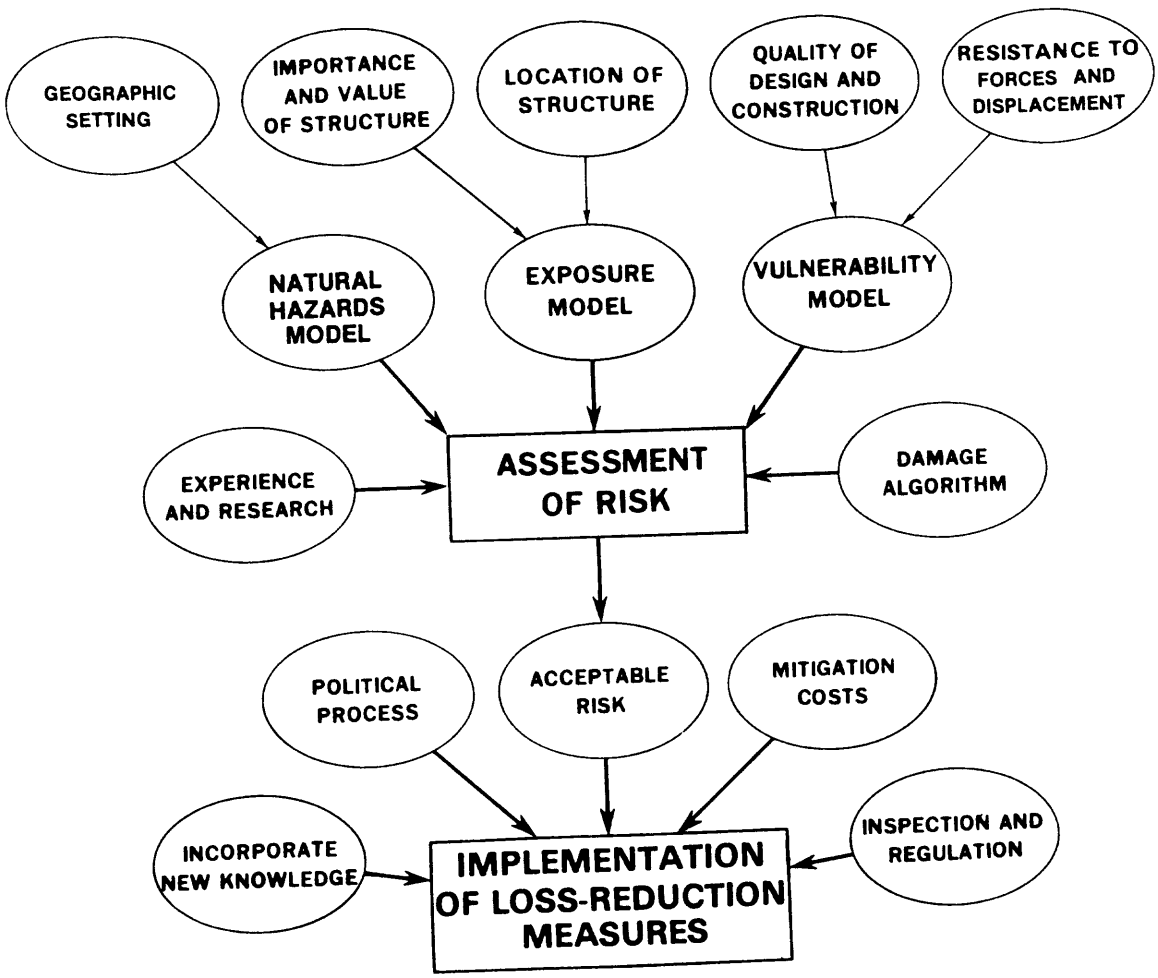

Figure 6.--Schematic illustration of important topics that researchers and practitioners must deal with in order to foster earthquake hazard mitigation (after Petak and Atkisson, 1983).

Differences in the perspective of scientists-engineers and decisionmakers (from Szanton, 1981).

ATTRIBUTES	PERSPECTIVES	
	SCIENTIST/ENGINEER	DECISIONMAKER
1. Ultimate objective	Respect of peers	Approval of electorate
2. Time horizon	Long	Short
3. Focus	Internal logic of the problem	External logic of the problem
4. Mode of thought	Inductive, generic	Deductive, particular
5. Most valued outcome	Original insight	Reliable solution
6. Mode of expression	Abstruse, qualified	Simple, absolute
7. Preferred form of conclusion	Multiple possibilities with uncertainties emphasized	One "best" solution with uncertainties submerged.

Szanton, Peter, 1981, Not Well Advised: Russell Sage Foundation and Ford Foundation, 81 p.

Figure 7.--Differences in the perspectives of researchers (typified by scientists and engineers) and practitioners (typified by "decisionmakers") (after Szanton, 1981).

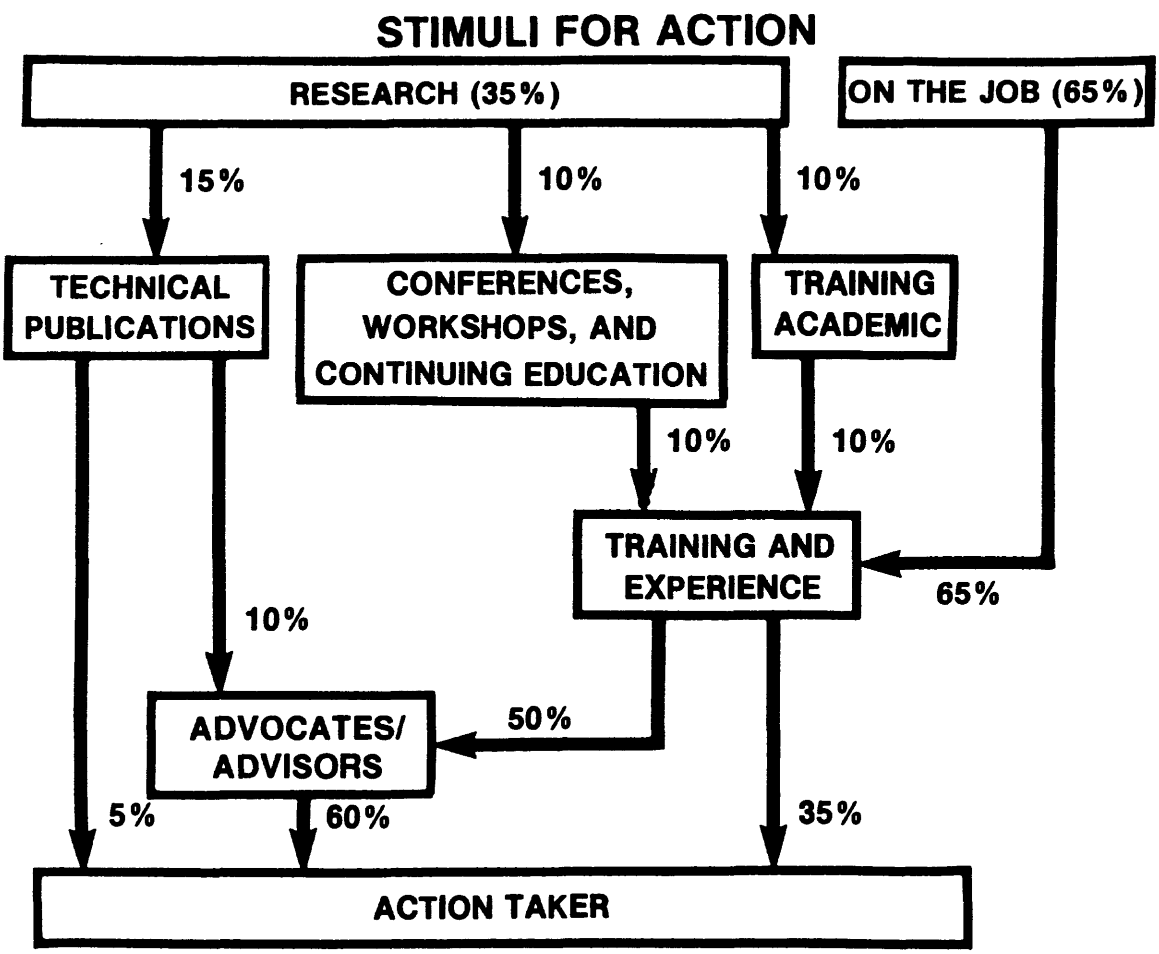

Figure 8.--Schematic illustration showing the relative importance of various external influences on an action taker. The influence of on-the-job training, workshops, experience, and advocates/advisors is very high; whereas, that of mailing publications is very low (from Thiel, 1988).

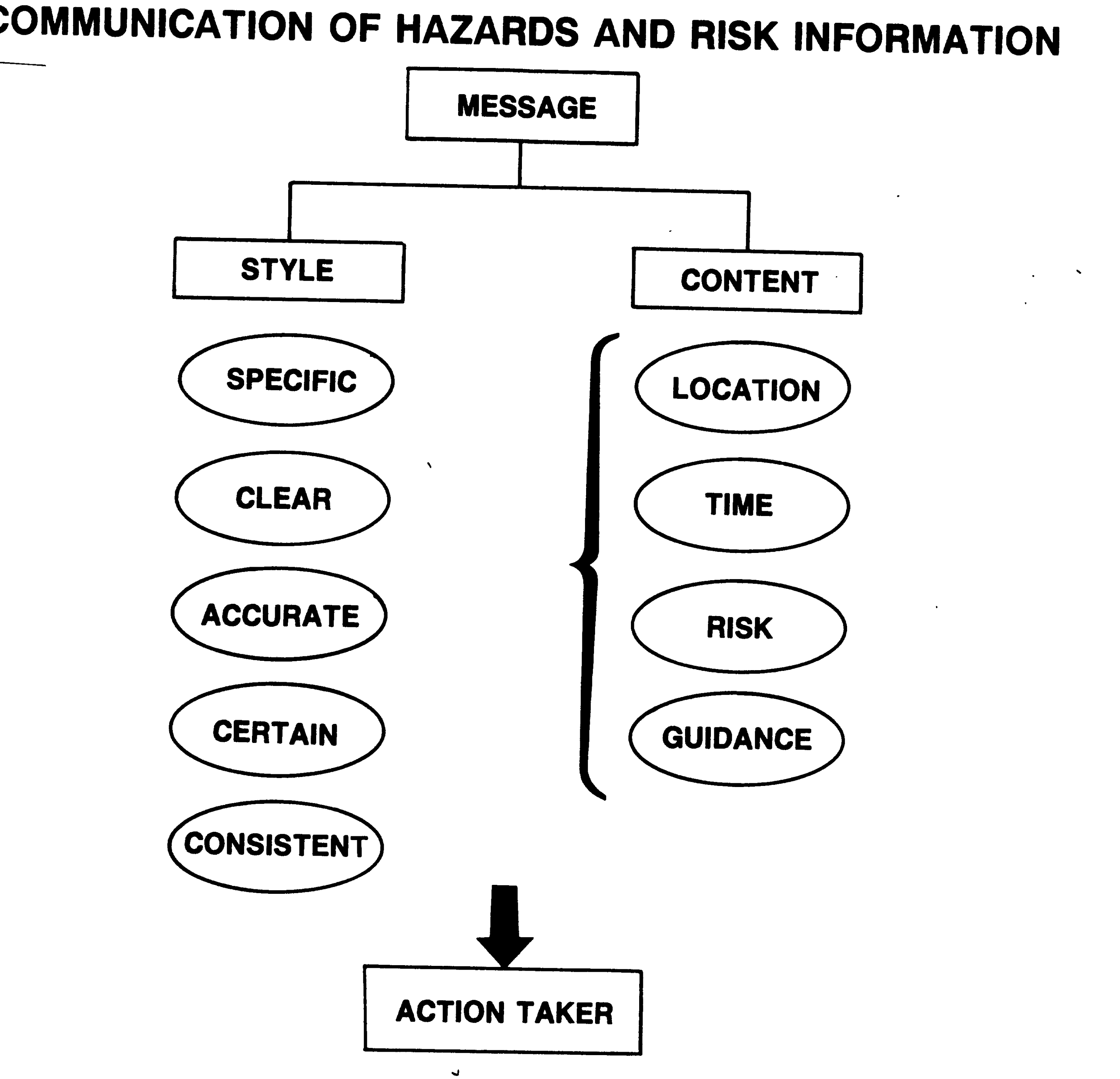

Figure 9.--Schematic illustration showing the essential characteristics of a well designed message to communicate earthquake hazards and risk information (after Mileti, 1987).

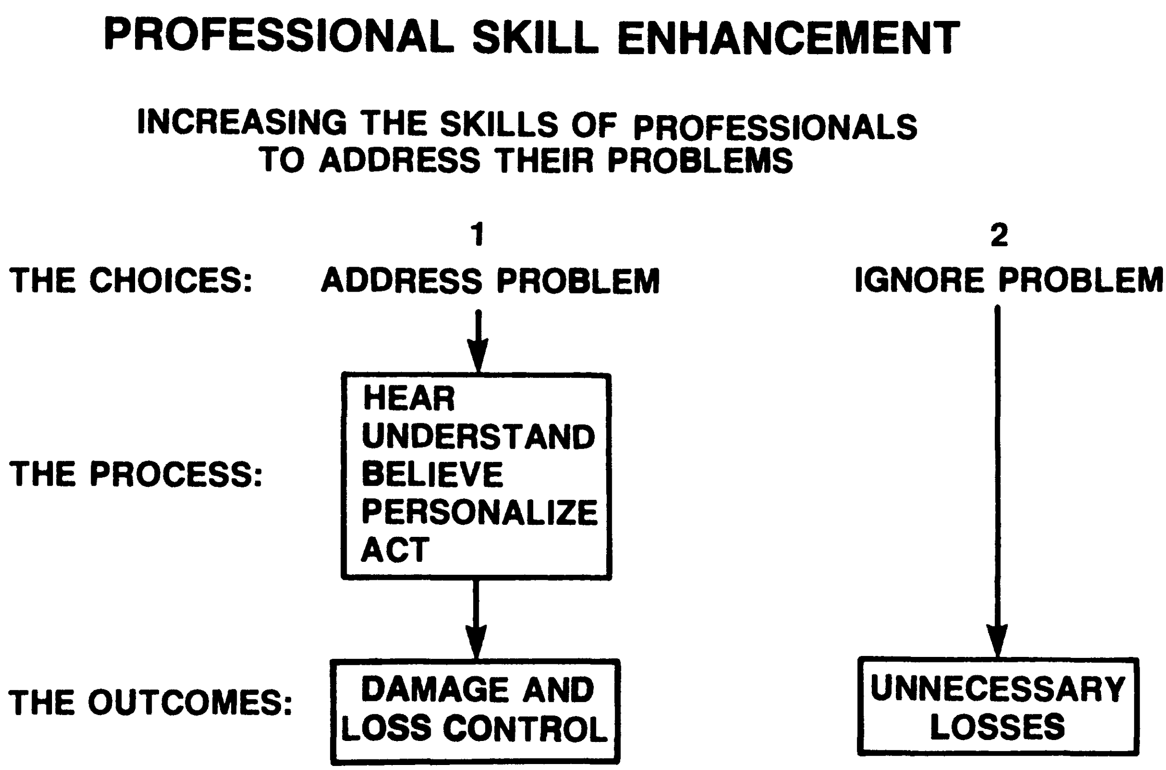

Figure 10.--Schematic illustration showing the basic process of professional skill enhancement.

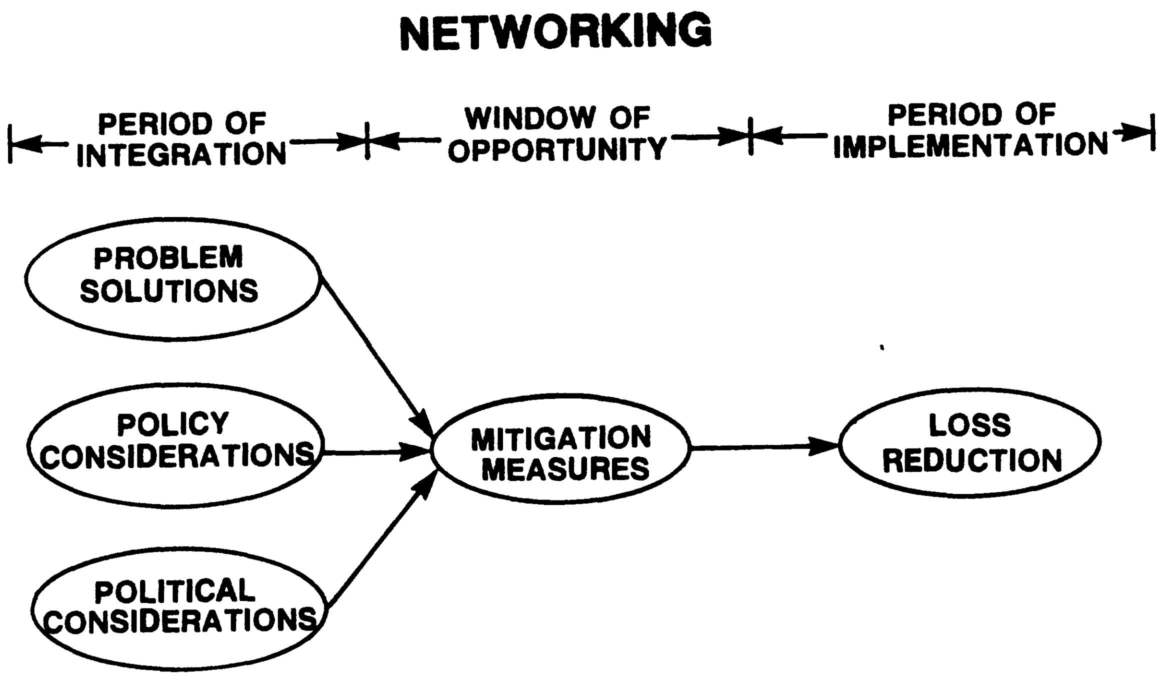

Figure 11.--Schematic illustration of the time-dependent flow of actions in the research applications process of the NEHRP. The first decade of the NEHRP has been characterized mainly as a period of integration in all states except California.

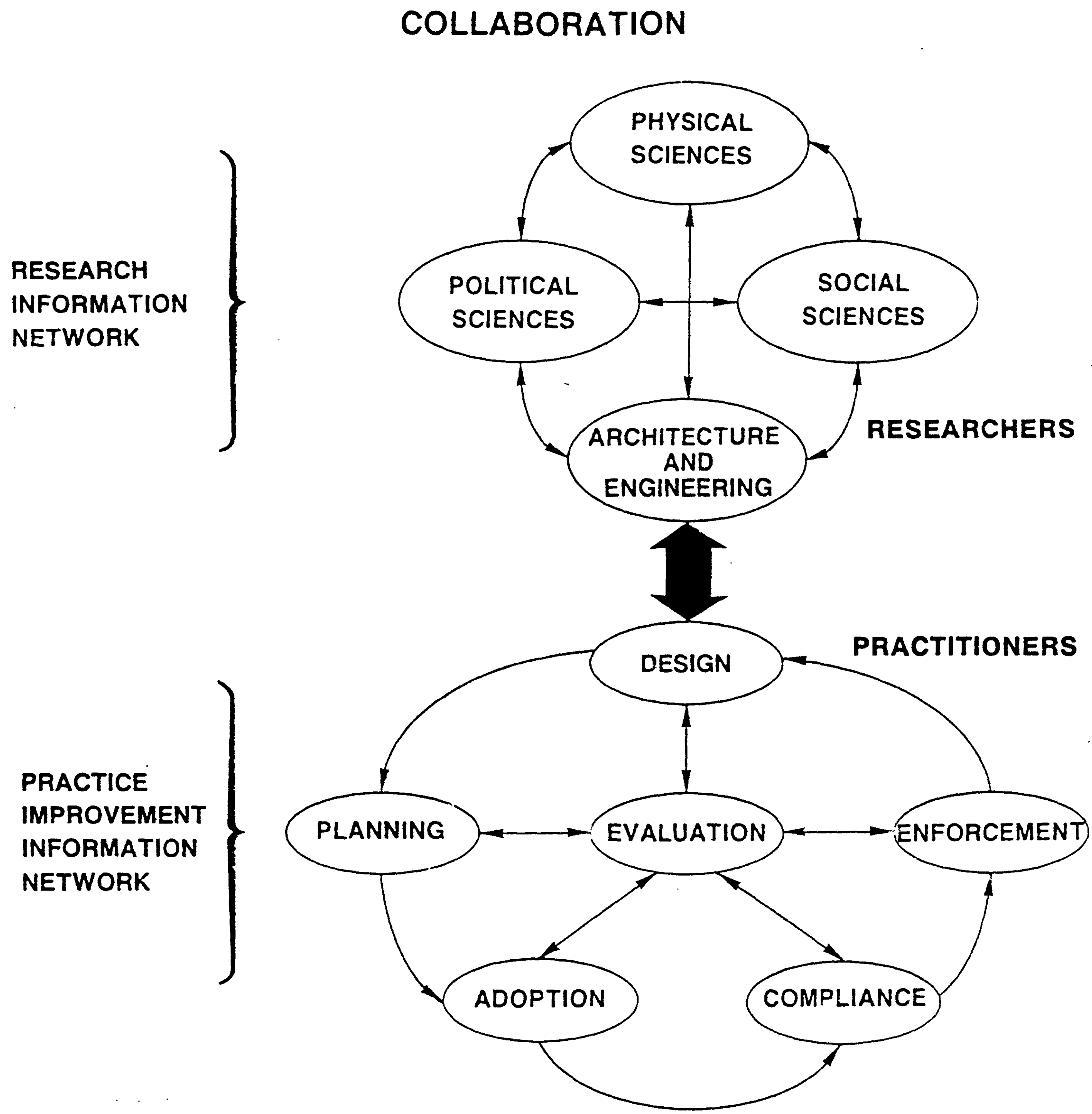

Figure 12.--Schematic illustration of collaboration between researchers and practitioners. In the first decade of the NEHRP, many researchers and practitioners exhibited a disdain for collaboration and limited ability to collaborate effectively. The key factor leading to earthquake hazard mitigation seems to be activities that: a) produce champions of earthquake hazard mitigation in each network and b) give them a reason for collaboration. One deficiency of the research program is that very little research was performed to aid emergency medical response and disaster response operations.

3. ACCOMPLISHMENTS

3.1 Summary of Major Accomplishments in the First Decade of the NEHRP

The major accomplishments during the first decade of the NEHRP included:

- Major changes in earthquake-resistant design in the Western United States and the beginning of changes in the Eastern United States.

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THE GROUND-SHAKING HAZARD

Many communities throughout the United States do not have or do not require modest seismic design requirements in their building codes. Consequently, many buildings may prove to be underdesigned when the inevitable major earthquake strikes. Modern maps of the ground-shaking hazard are helping to improve the building code process which tends to lag behind the accumulation of knowledge. Many communities in the nation are vulnerable because the ground-shaking hazard is often underestimated in siting and design and not utilized in emergency management.

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- Major revisions in building codes, standards, and practices to incorporate new knowledge on earthquake ground shaking and the behavior of soils, construction materials, and lateral force resisting systems when subjected to these loadings.

- Improved understanding of the active fault systems, paleoseismicity, (i.e., earthquake recurrence history), and earthquake source mechanics in California, Utah, the Mississippi Valley, and other earthquake-prone regions of the nation.

- Improved national- and regional-scale maps of the ground-shaking and ground-failure hazards, and loss estimates in selected urban areas.

- Broader and more effective training of state and local government professionals at FEMA's National Emergency Management Training Center.

- Increased understanding, awareness, and concern about the nature and characteristics of the earthquake threat in the Intermountain Seismic Belt, the Pacific Northwest, and the Eastern United States where there was limited understanding and little, if any, concern a decade ago.

- Publicly-based earthquake preparedness projects in California, in the West, Midwest, Southeast, East, and in Puerto Rico where none existed a decade ago.

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EARTHQUAKE PREPAREDNESS

(From: California at Risk: Steps to Earthquake Safety for Local Government, California Seismic Safety Commission Report No. SSC-88-01).

"Cities and counties all over the state of California are taking the earthquake threat seriously. Small communities are working with their counties, councils of governments, or nearby large cities to develop earthquake threat safety programs. Regardless of their size and resources, cities and counties are finding many ways to increase seismic safety that are within their budgets and in tune with political realities. They are also finding that preparing for earthquakes enhances their readiness for other natural and man made disasters."

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- Adoption of ordinances in California to identify and strengthen or remove buildings that may collapse during earthquake ground shaking.

- New knowledge on retrofitting or repair of unreinforced masonry buildings and applying base isolation technology in new and existing buildings.

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HAZARDOUS BUILDINGS

The number of hazardous buildings problem nationwide is enormous. California alone still has about 60,000 unreinforced masonry buildings located in older areas of cities and towns throughout the state. As shown by Coalinga's downtown in 1983 and in Whittier's uptown in 1987, many of these buildings often end up as rubble after an earthquake. Outside of California, few communities have dealt with this problem.

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- Initiation of two "partnerships" of researchers and practitioners in the Wasatch front, Utah, and the Puget Sound, Washington/Portland, Oregon, areas to collaborate on earthquake research and hazard mitigation programs.

- Increased numbers of champions of earthquake hazard mitigation who collaborate throughout the nation. Use of earthquake hazards workshops as a neutral forum to build trust and synergism between champions.

- Investment by the business community to protect property and to provide for continuity of business after a damaging earthquake.

- Initiation of a program of continuing education for professionals by Earthquake Engineering Research Institute.

- Initiation of projects on public information and earthquake education in California, the Northwest, Midwest, and Southeastern United States.

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EARTHQUAKE EMERGENCY RESPONSE PLANS

Local jurisdictions throughout the nation are beginning to improve earthquake emergency response plans that were too general, out of date, or incomplete. Plans written to comply with Federal and state requirements sometimes fall short of reflecting actual operational needs. Many existing plans fail to recognize that a major earthquake has regional impacts. Also, there has been a need for active training for disaster response, especially for catastrophic earthquakes which could impact the resources of the entire nation.

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- Improved earthquake emergency response in California. (Note: see the statement on the October 1, 1987, Whittier-Narrows, California, earthquake in section 3.2).

- Initiation of a planning process by FEMA involving researchers and practitioners to deal with catastrophic earthquakes throughout the nation.

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POSTEARTHQUAKE INVESTIGATIONS

(From: Reducing Earthquake Hazards: Learning from Earthquakes, Earthquake Engineering Research Institute Report 86-02)

One of the most important outcomes of post earthquake studies made since 1964 is a clear recognition of the value of cooperation and

communication between all of the disciplines: geology, seismology, engineering seismology, geotechnical engineering, lifeline engineering, structural engineering, architecture, social sciences, and emergency management. Multidisciplinary post-earthquake investigations provide many important lessons that benefit the nation and improve hazard mitigation.
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- Establishment of the National Center for Earthquake Engineering Research (NCEER) at the State University of New York in Buffalo, New York. With programs of research and technology transfer, NCEER has the potential to become a major stimulus for helping researchers and practitioners to collaborate in the East and to forge partnerships with the West.

- Improved understanding gained from post-earthquake investigations of the physical, social, and economic impacts of earthquakes and human behavior during the pre- and postearthquake environments.

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WORKSHOPS AND TRAINING

In the first decade of the NEHRP, more than forty-five workshops sponsored by Federal-State "partners" in earthquake-prone regions of the nation were organized and convened by USGS. The "USGS/FEMA" or "FEMA/USGS" workshops have involved more than 4,000 researchers and practitioners and given them a forum for collaboration and increasing professional skills.

Training activities increased markedly during the first decade of the NEHRP. In 1987, FEMA conducted training courses for several hundred participants at their National Emergency Management Training Center, emphasizing: a) emergency preparedness planning, and b) "train the trainer programs." These courses have also been transported to the community rather than having the community travel to Emmittsberg, Maryland.

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3.2 Accomplishments in 1987

Following the three regional workshops convened in 1987, USGS, with assistance from an external contractor, conducted a voluntary survey to determine the accomplishments in 1987 of the individual firms and institutions. The results of the survey showed:

- Publication of approximately 3,000 papers and reports by more than 600 researchers and practitioners who also participated in 36 professional and standards committees and in more than 100 conferences, workshops, seminars, and professional society meetings.

- Development of a model ordinance by the Structural Engineers Association of Southern California (SEAOSC) for use by the California Seismic Safety Commission in fostering the identification and abatement of hazardous buildings in California having high collapse potential.

- Preparation of a planning scenario showing the potential impacts of a magnitude 7.5 earthquake on the Hayward fault system in northern California.

- Detailed investigations of a recently discovered geologically young active fault system--the Meers fault in Oklahoma. The discovery that this fault is active will impact current criteria for the siting and design of critical facilities in the midcontinent.

- Preparation of an improved set of six ground-shaking hazard maps (constructed by USGS) for use in the 1988 Recommended NEHRP Seismic Design Provisions prepared by the Building Seismic Safety Council (BSSC), which has served as an advocate (with FEMA support) for incorporation of the recommendations for seismic design made in 1978 by the Applied Technology Council (ATC).

- Improvements in emergency response. The October 1, 1987, Whittier-Narrows earthquake of magnitude of 5.9 caused extensive damage to unreinforced masonry buildings and a total loss exceeding $350 million. The emergency period for the earthquake lasted about 4 hours in contrast to more than 24 hours for the somewhat larger 1971 San Fernando earthquake. The improved emergency response reflects the value of FEMA and the State of California commitments to the Southern California Earthquake Preparedness Project (SCEPP) in 1980.

- Postearthquake briefings on all aspects of the Whittier-Narrows earthquake which were provided to 1,250 professionals in San Francisco, Los Angeles, Phoenix, Washington, D.C., and Seattle within 12 weeks of the earthquake.

  (Editor's Note: Although not a part of the 1987 survey, postearthquake briefings of the December 7, 1988, Soviet Armenia earthquake which killed an estimated 60,000 people, left 510,000 homeless, and caused losses reaching $16 billion were provided to more than 1,500 professionals in Washington, D.C., New York City, San Francisco, Los Angeles, Irvine, Salt Lake City, Memphis, Charleston, Portland, and Seattle. The high interest by professionals in current information shows the high degree of interest in earthquake hazard mitigation.)

The next section will discuss the recommendations for enhancing earthquake hazard mitigation in the second decade of the NEHRP.

4. DISCUSSION OF RECOMMENDATIONS

4.1 The Need For Earthquake Hazard Mitigation

Without question, significant progress was made in the first decade of the NEHRP in applying knowledge produced in the NEHRP to mitigate the earthquake hazard throughout the nation. However, except for California, all other states are still working primarily in the integration period--the period where problem solutions, policy considerations, and political considerations are still slowly being brought together. Therefore, there is still an urgent need to improve and to accelerate the research applications process in every part of the nation. A large percentage (estimated at 70 percent) of the 215 million people live and work in or adjacent to the approximately 150 seismogenic zones that have either produced or have the potential for producing, or are now producing earthquakes. Most of these zones were delineated by geological and geophysical studies during the past decade. Many people live and work in and depend on ordinary buildings and lifeline systems, some known to be hazardous and others whose design in most cases has never been tested by a major earthquake. New construction is increasing at the rate of about $397 billion per year (1987 value) with about 80 percent being sited in areas of the nation rated as having moderate to high levels of seismic risk (National Academy of Sciences, 1982). Estimates of direct economic losses in a potential future large-to great-magnitude earthquake in northern California,

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ELEMENTS OF A DISASTER

"Three physical conditions determine the occurrence of an earthquake disaster. First is the magnitude of the earthquake, because a small earthquake will not have sufficiently severe ground shaking to produce extensive damage (unless it strikes directly under a city). In fact, in the highly seismic regions of the United States, an earthquake having a Richter magnitude greater than 5.5 is needed to produce significant damage. Second, the source of the earthquake must be sufficiently close to a city, because at greater distances the ground shaking will be attenuated below the level of serious damage. Third, the possibility of disaster depends on the degree of earthquake preparedness. A city with poor preparedness will suffer much more than a city with good preparation. Obviously, the larger and nearer the earthquake and the poorer the preparation, the greater will be the disaster." (National Research Council, 1982).

xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx southern California, Puerto Rico, New York, or the Mississippi Valley indicate that they could reach billions to several tens of billion of dollars at each location. Potential losses from joblessness and other societal impacts would be additional to these. Such earthquakes could kill, injure, and leave hundreds of thousands homeless, affect the environment, wipe out a generation of school children, create unpresidented demands on the insurance and medical community, and even disrupt the economic stability of the nation.

4.2 Recommendations of the Expert Review Committee for the NEHRP Five-Year Plan

In December 1987, as part of the internal NEHRP planning process, the Expert Review Committee for the NEHRP Five Year Plan noted that "although significant progress had been achieved, greater emphasis must be placed on implementation . . . within the next decade" (NEHRP Expert Review Committee, 1987, p. xi). The committee recommended that agencies of the NEHRP focus their implementation activities in the next decade on:

- Accelerating the development and updating of the tools necessary for effective State and local hazard reduction programs.

- Establishing additional regional planning consortia, such as the Southern California Earthquake Preparedness Project (SCEPP) and the Bay Area Regional Earthquake Preparedness Project (BAREPP), in high-risk areas and enhancing local government participation.

- Establishing a mechanism to accelerate the development of transferable earthquake engineering advances, their adoption into model codes, and subsequent enforcement.

- Developing the technical and societal tools necessary to implement and promote a comprehensive, national retrofit program for existing hazardous structures.

- Enhancing targeted education programs for the broad spectrum of public and private professionals responsible for earthquake hazards reduction programs, using the resources of professional associations whenever appropriate.

- Developing improved mechanisms for translating research results into application, establishing links between researchers and users, and improving dissemination of information through workshops and clearinghouses.

- Designing a coordinated strategy to "market" earthquake hazards reduction to all elements of society in the United States.

4.3 Recommendations Made by the Participants in the Research Applications Workshops

More than one-hundred champions of research applications (see Appendix B) who participated in the four research applications workshops were asked for their recommendations. Because of their vital role in the accomplishments of the first decade, they were encouraged to look at the total research applications process, focusing on each of the six simplified elements and the twelve critical factors and maintaining balanced Federal and non-Federal government perspectives. Their suggestions were based on the premise:

- **In a 50-year period, every part of the nation and many urban centers will likely experience at least one damaging earthquake. This event will happen during the lifetime of its citizens, and if the earthquake is a catastrophic one, a disaster will result unless the urban centers are adequately prepared for it.**

Accordingly, the participants recommended actions in four broad themes:

- Policies, programs, and practices (making agency policies, programs, and practices clear to researchers and practitioners across the nation).

- Enhancing collaboration between researchers and practitioners (forming many more effective "partnerships" of champions of earthquake hazard mitigation across the nation).

- Strengthening the research applications process (seeking ways to strengthen: RESEARCH (grade of 8 in California, grade of 4 elsewhere), DISSEMINATION (grade of 4), TRANSLATION (grade of 2), COMMUNICATION (grade of 2) and APPLICATIONS grade of 5 in California), grade of 1 elsewhere. EVALUATION, the sixth link is not graded. (Editors Note: the grades are illustrative only and have no factual basis.)

- Priorities (setting priorities that make better use of the existing knowledge base and existing seismic safety organizations, make better use of existing technologies (e.g., base isolation, retrofit, etc.); do a better job of public information and education (e.g., training the trainers); do a better job of explaining earthquake risk across the nation to policymakers, and do a better job of seizing windows of opportunity (e.g., earthquakes, the International Decade for Natural Disaster Reduction, etc.).

Suggestions of the participants in the workshop are summarized below:

- Policies, programs, and practices

  The four principal agencies of the NEHRP: FEMA, NIST, NSF, and USGS should start with themselves, reviewing their policies, programs, and practices, making certain that they are clear and internally consistent in their national goal of fostering the research applications process for mitigating the earthquake hazard, and encouraging the formation of partnerships between researchers and practitioners throughout the nation.

  In such a review, the following questions should be asked; if the answer is "no," then agency policies should be clarified and/or revised:

o <u>Do existing policies, programs, and practices of each agency</u>--

1) explicitly encourage activities that produce champions of earthquake hazard mitigation and give them a forum for collaboration?

2) explicitly encourage applications of the knowledge base in activities that will lead to loss-reduction in every part of the nation?

3) explicitly require peer review by reviewers who are qualified to evaluate and who are committed to both the research and the applications components of the NEHRP?

4) explicitly go beyond the "toss it through the transom" dissemination practice?

5) explicitly encourage translation of results for practitioners, and encourage "translators" to apply for grants and contracts?

6) explicitly foster the collaborative process, involving champions of earthquake hazard mitigation in partnerships that extend far beyond the annual professional meeting--the current extent of collaboration by many researchers and practitioners.

7) have an explicit mechanism for evaluating the final product of an internal project, grant, or contract to determine whether it was implemented and if not, to determine what it would take to foster implementation?

o <u>Enhancing collaboration between researchers and practitioners</u>

Policies, programs, and practices of Federal, State, and local government should have a vision for the future, paying special attention to the need for innovative steps that will strengthen "partnerships" between researchers and practitioners throughout the nation. Appropriate adjustments should be made now to improve interaction and collaboration between researchers and practitioners seeking ways to:

1) Enhance the capability of the present generation of "champions" to apply the new and existing knowledge produced in the NEHRP.

2) Grow a large, well equiped new generation of "champions."

3) Strengthen weak but critically important functions such as translation of research results for practitioners in a region.

4) Institutionalize some of the important functions that do not have adequate resources behind them.

5) Take advantage of the opportunity to validate the best existing technologies (e.g., base isolation, retrofit) instead of untried mitigation techniques.

6) Optimize the planning process needed to improve post-earthquake investigations to ensure that maximum learning occurs.

7) Take maximum advantage of windows of opportunity created by earthquakes and other natural hazards (e.g., floods, hurricanes, etc.) and programs (e.g., the U.S. Decade for Natural Disaster Reduction--a part of the International Decade for Natural Disaster Reduction)

o <u>Strengthening perceived weaknesses in the research applications process</u>

Because the research applications process in the NEHRP is only as strong as each part of the process, an innovative effort is needed to ensure that all six elements are as strong as possible. Consideration should be given to the following high-priority actions, especially if level budgets prevail during the second decade of the NEHRP.

1) Seeking out and involving the very best people throughout the nation (e.g., well-known champions) in the process, drawing from elected public officials, appointed officials, the private sector (e.g., the financial and insurance communities, academia, and others).

2) Building on the results of past studies such as the Intergovernmental Sciences Program, conducted by NSF, in the 1970's which attempted to influence the rate of applications of science and technology. Among the approaches tried were: a) technology agents, advisors, and traveling advocates, b) leader-follower models, c) "top-down" and "bottom up" strategies, d) politically- and nonpolitically-based strategies, e) specific technology development, and f) diffuse technology development. The results showed that:

   - Success varied widely, and success in one place did not guarantee success in another.

   - The <u>leader-follower model</u> seemed to be the best strategy, generally. However, a multiplicity of strategies seemed to be the best way to assure success when a well known champion was not involved:

   - The research applications process may be stronger if the entire process is redefined to utilize champions who are provided an incentive to collaborate.

- <u>Priorities</u>

Budget constraints and the level of the hazard with respect to human lives will constrain the priorities in most cases. However, highest priority in the second decade of the NEHRP should be given to funding activities (e.g., research, dissemination, translation, communication, applications, evaluation) that will lead to implementation of loss reduction measures in States and regions. A characteristic feature of the implementation period is a greater commitment of State resources for mitigation activities such as:

-- replacement, repair, and strengthening existing hazardous buildings,
-- emergency preparedness planning,
-- seismic safety organizations.

-- earthquake-resistant design
-- public education and information, and
-- hazard mapping and loss estimation.

Important functions of the process may need to be institutionalized for cost effectiveness and permanence.

The future of earthquake hazard mitigation in the nation depends on what we do now. By undertaking the recommendations cited above, every part of the nation will have the capacity to deal effectively with its earthquake hazard.

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OBJECTIVES FOR THE NEHRP: 1987 - 1997

The nation will greatly improve its comprehensive body of fundamental knowledge (data, maps, reports, publications, computer models, ordinances, model building codes, comprehensive emergency management, response and recovery plans, etc.). This knowledge will be implemented in all parts of the nation by scientists, engineers, architects, and social scientists working and collaborating with public officials, city planners, building and safety officials, and emergency managers in research, preparedness, and mitigation programs. Although barriers to mitigate will still exist in some regions, many barriers will have been removed through enhanced collaboration. Several states in addition to California will be well into the implementation period, and will be funding mitigation measures such as:

- *<u>Protection</u> - building new and strengthening existing structures and lifeline systems to withstand the physical phenomena (hazards) expected in an earthquake.*

- *<u>Land-use control</u> - identifying and avoiding sites where an event is expected to have the greatest severity of effects.*

- *<u>Alert and warning</u> - providing reliable advance notice in the form of predictions, forecasts, warnings, and scenarios to the affected populace on the location, severity, time and probability of an impending event.*

- *<u>Emergency preparedness</u> - making comprehensive plans to deal with the entire spectrum of expected requirements.*

- *<u>Indemnification</u> - spreading the economic losses from an event over an appropriately large population though insurance and other financial strategies.*

- *Response and recovery planning* - *making comprehensive plans to accelerate the recovery process in the case of a disaster-generating event.*

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4.4 The U.S. Decade for Natural Disaster Reduction

The International Decade for Natural Disaster Reduction (IDNDR) represents an unique oportunity to achieve hazard mitigation goals. The United States has been challenged to join with, and indeed to lead, other nations throughout the world in concerted actions to make the 1990's a "decade of disaster reduction." This period has been dedicated to improve and invigorate efforts to reduce the economic and death tolls from natural hazards such as earthquakes, floods, hurricanes and tornadoes, landslides, volcanic eruptions, tsunamis, and wildfires.

The need for reducing the economic toll from natural hazards in the United States is urgent. The United states has a large number of seismogenic zones, active volcanoes, thousands of miles of storm-prone coastline, large and small flood-producing river systems, slopes susceptible to landslides, coasts susceptible to tsunami runup, and wilderness/urban interfaces vulnerable to wildfires. Every year, economic losses average about ten billion dollars, comprised of:

- four billion dollars for floods,
- two billion dollars for landslides,
- two billion dollars for hurricanes and tornadoes,
- six hundred eighty million dollars for earthquakes with several urban areas facing potential losses in the tens of billions of dollars, and
- millions for tsunamis, volcanic eruptions, and wildfires.

The economic losses continue to increase as mankind builds and expands communities along the water's edge, on floodplains, in earthquake-prone regions, on unstable slopes, in zones susceptible to volcanic eruptions, and at wilderness interfaces susceptible to wildfires.

The United States has been very fortunate to escape the great loss of life and societal impacts experienced recently in other nations:

- o At least 60,000 dead and 500,000 homeless in Soviet Armenia from the magnitude 6.9 earthquake of December 7, 1988.

- o At least 300,000 to 500,000 dead and 1.3 million homeless in the cyclone and flooding that struck Bangladesh in 1988. Similar impacts were experienced in 1970.

- o At least 1,000 dead and 4,000 missing in the Reventador, Equador, landslide of March 1987 which also ruptured the Trans Ecuador oil pipeline.

- o At least 22,000 dead and 10,000 homeless from the eruption of Colombia's Nevada del Ruiz volcano in November 1985.

- o Sixty-nine dead and 11,000 homeless in Australia's Ash Wednesday wildfire of February 1983.

The Federal agencies are working with the National Academy of Sciences and others to develop a U.S. program for Natural Disaster Reduction during the Decade. The program's goals, objectives, and strategies, although consistent with other natural hazard reduction programs within the Federal Government, go far beyond any single program. A possible major part of the U.S. program, a Natural Hazard Geographic Information System, is already in a mature state of development. It will be made available to Federal and state government agencies, academia, and the private sector in all 50 states and territories as a basic resource for a wide range of loss reduction strategies such as:

- o <u>Prevention</u> - controlling the source of the event in a way that changes the physical characteristics of the physical phenomena generated in the event.

- <u>Protection</u> - designing and building new buildings and lifeline systems to standards developed for each natural hazard.

- <u>Hazard mapping</u> - making maps that depict the spatial and temporal variation of natural hazards.

- <u>Alert and warning</u> - providing warnings, forecasts, predictions, and scenarios of impending or potential events.

- <u>Retrofit and repair</u> - strengthening existing structures to withstand expected physical effects.

- <u>Emergency preparedness</u> - improving the state-of-preparedness in urban areas.

- <u>Indemnification</u> - devising financial strategies (e.g., insurance) to spread the risk.

- <u>Response and recovery planning</u> - making plans to respond and to recover from a potential disaster.

The Decade will lead to concerted actions both in the United States and throughout the world that will prevent needless catastrophies. The institutional framework and capacity to implement loss reduction measures developed during the Decade are expected to last far beyond 2000. Estimates of the benefit of the Decade suggest that the activities of the Decade could save 10,000,000 lives and ten trillion dollars worldwide during the Decade. Given worldwide funding levels on the order of one to 10 billion dollars for the Decade, the benefit to cost ratio ranges from about 100:1 to 1,000:1, without consideration of loss of life and societal impacts.

The NEHRP will benefit greatly from the IDNDR.

4.5 Acknowledgments

The active participation and contributions of more than 100 "champions" of earthquake hazard mitigation is gratefully acknowledged. They provided the insights contained in this report and are a primary reason for the gains in earthquake hazard mitigation across the nation during the first decade of the NEHRP.

The deailed reviews provided by the following individuals are sincerely appreciated: James Beavers, Robert Brown, Paula Gori, William Kockelman, Ray Lamanis, Norman Olson, Tom Tobin, and Susan Tubbesing.

A special note of gratitude is extended to Carla Kitzmiller, Paula Gori, and Peggy Randlaow for their administrative support.

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REFERENCES TO THE SIXTY CASE HISTORIES

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EVALUATION OF APPLICATIONS FOR ENLIGHTENMENT USES

EVALUATION OF APPLICATIONS FOR DECISIONMAKING USES

EVALUATION OF APPLICATIONS FOR PRACTICE USES

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APPENDIX A

Background on Knowledge Utilization

The references contained in section 5 provide background and confirm the difficulty of achieving knowledge utilization. To facilitate the process of understanding the research applications process in the NEHRP, the basic theories of knowledge utilization proposed by Yin and Moore in 1985 were adapted and used in the three research applications workshops held in San Diego, Denver, and Knoxville in 1987.

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THE UTILIZATION OF RESEARCH:
LESSONS FROM THE NATURAL HAZARDS FIELD
(From: Yin and Moore, 1985)

With a goal of improving the usefulness of natural hazards research for policymakers, state, and local officials, service providers, and citizens, nine applied research projects, whose innovative results were known to have been utilized, were analyzed and compared with three theoretical models for knowledge utilization. The models are: 1) the knowledge-driven model, 2) the problem-solving model, and 3) the social-interaction model. Each case history had one or more of the three utilization outcomes: enlightenment, decisionmaking, and practice. The principal findings were: 1) all three utilization models explained some of the outcomes, however, 2) utilization occurred in all of the nine case histories when the conditions of the social-interaction model were met and did not occur when they were not met, and 3) the single most important feature of successful utilization was professional communication between knowledge producers and knowledge users.

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2.2 Framework for understanding knowledge dissemination and utilization: Applications for the National Earthquake Hazard Reduction Program

In each of the three research applications workshops, Dr. Joanne Nigg of Arizona State University, presented a comprehensive paper on the subject of knowledge utilization. Her paper is reproduced in this report for completeness:

FRAMEWORKS FOR UNDERSTANDING KNOWLEDGE DISSEMINATION AND UTILIZATION: APPLICATIONS FOR THE NATIONAL EARTHQUAKE HAZARDS REDUCTION PROGRAM

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Tempe, Arizona

The question of how to successfully apply research findings to reduce earthquake hazards is indeed a complex problem. There are several issues that must be considered when answering this question: Which research results are to be applied? When there are competing or conflicting research findings, as there almost assuredly will be, who will determine which are valid? Who, if anyone, will be responsible for prioritizing the problems which these findings address? By whom are they to be applied? To what purposes are they to be addressed--for enlightenment, practice, or decision making uses? What characteristics are associated with these different types of utilization? Is utilization always the same, or does it change? To what extent is utilization situation-specific and to what extent is it generalizable? Who will benefit and who will be disadvantaged, or should these questions of vested interest be of concern when the "public interest" is being served by the application of research results? To what extent can knowledge actually affect either practice or policy? Do we, in fact, have an adequate amount of information to answer these questions about research utilization?

Before we can begin to address these questions, it is important to start with a set of common definitions of what is meant by "utilization." Larsen (1980) reminds us that without a standard terminology (which has been lacking in the field of knowledge utilization research), the comparison of research findings is almost impossible. For example, research in this area has frequently used the terms "research application," "technology transfer," "innovation diffusion," and "information dissemination" (or any mixture of these terms) interchangeably. What was being transmitted, however, and how it was being transmitted were often quite different, which yielded different conclusions about the factors and processes that affected the successful adoption or utilization of knowledge.

DEFINITIONS AND COMPONENTS OF UTILIZATION

For this reason, the following definitions (abstracted from Glaser et al., 1983) are being offered to provide some structure for the remainder of this paper:

Knowledge--an idea, product, process, procedure, or program of action.

Dissemination--the transmission of knowledge toward potential users.

Utilization--the application of available knowledge by a new user.

Whenever these terms are used, however, it will be important to specify what form of knowledge is being discussed, how that knowledge is being transmitted, to whom it is being transmitted, by whom it is being transmitted, and what form the application is expected to take. To better understand the need for this specificity, let us look at each of these components of utilization as they are related to the issue of earthquake hazard reduction.

Description of the Knowledge Being Transmitted

The "form" that knowledge takes will depend upon the use it is expected to have. Research results, as reported in final reports or technical papers, are usually not appropriate for direct application by some user group. This basic knowledge must be transformed in some way to make it more usable by an intended user group. For example, Davis and Salasin (1979), in their discussion of factors which are necessary and sufficient to account for utilization within an organization, highlight the importance of communicating about the proposed innovation (here referring to a new technique) in a clear manner that provides evidence for the workability of the proposed change (in language and concepts understandable to those making the adoption decision) as well as how it can be implemented.

Glaser and his colleagues (1983) discuss several factors related to the "innovative element" (that is, the form into which the knowledge is "packaged") that have been found to affect the willingness to adopt by a user group.

Perceived Advantage. Adoption of an innovation or idea (i.e., knowledge) by a user group is more likely if some advantage--either personal or organizational--is perceived to accompany it. For example, decision makers may be more likely to adopt an innovation if they believe it could assist them to resolve a persistent problem.

The adoption of an innovation may also have unanticipated consequences (referred to by Rogers and Shoemaker [1971] as "latent consequences") that could become defined by those affected as disadvantages. For example, the adoption of a new technique or procedure may be perceived by practicing professionals as disadvantageous if their prestige or status within the organization is changed because of the proposed adoption, thereby resulting in their resistance toward the innovation.

Another factor related to innovation resistance is the professional's perceived devaluation of current knowledge or skills. If, for example, new seismic design criteria are recommended for inclusion in a community's building code, some members of the engineering profession practicing in that community may oppose the adoption of such criteria because their experience with seismic design has been minimal, thus potentially limiting their ability to compete for some projects. This possibility could result in not just economic disadvantage but professional embarrassment that one's engineering skills and knowledge are somewhat deficient.

Kotter and Schlesinger (1979) have suggested four pertinent approaches to overcoming this resistance, each of which is related to the type of resistance encountered:

1. Education + communication--when resistance is due to the diffusion of misinformation within the user group.

2. Participation + involvement--when those other than the adopter have the power to resist.

3. Facilitation + support--when organizational role responsibilities change or skill enhancement is needed.

4. Negotiation + agreement--when some group with considerable power to resist "loses out" if change takes place.

Compatibility. The greater the compatibility between the new knowledge form and the users' values, norms, procedures, and facilities, the greater their willingness to adopt the innovation. This seems to be especially true when the innovation can be assimilated within the "professional ideology" of the adopter. For example, the usefulness of earthquake loss estimation studies may be widely supported by emergency managers because the results of such research could improve their capability to respond to a destructive seismic event, an activity which fulfills one of their professionally-recognized responsibilities. It should be recognized, however, that such support is often contingent on the <u>setting</u> in which the professional lives and works. The emergency manager in a community in a seismically active area is more likely to see the need for such loss studies than is the manager in a less active area.

<u>Comprehensibility</u>. A change or technique that is easily understood by the potential user is more likely to be adopted. Again, this points to the need to translate basic research findings into forms that can be understood within the cognitive and linguistic frameworks routinely used by the targeted receivers of the information. For this reason, Sundquist (1978) talks about the need for both "academic intermediaries" and "research brokers" who could stand between the researcher and the policy maker (or other user) to translate the disciplinary jargon in which most research results are couched into recommendations, techniques, or information items that would be of more direct applicability by a user group.

<u>Practicality</u>. Recommendations or techniques derived from research findings are more likely to be adopted by users if those users have the resources (funding, facilities, staff, and expertise) available to put those suggestions into effect. Even

if the new knowledge is understood by the potential user and is expected to assist the user in fulfilling his/her professional responsibilities, the suggestion is unlikely to be implemented if the organization or the community lacks sufficient resources to do so. For example, planning professionals in smaller, more rural communities may see the value of microzonation as a non-structural mitigation measure that could reduce direct exposure of people and structures to liquefaction-induced dangers but be unable to utilize such techniques due to a lack of personnel to perform such assessments or the lack of a financial base which would allow the community to hire someone with adequate skills to perform the assessment.

Knowledge Transmitters

One of the most frequently cited reasons for the failure of attempts to utilize research knowledge is the unsatisfactory transmission of that knowledge by knowledge producers (usually identified as academics or scientists). Szanton (1981), in an extensive review of attempts by knowledge producers (in this case academics) to advise local public officials on various policy problems, concluded that overwhelmingly both knowledge producers and utilizers considered the outcome of the advisement attempts to be failures. Unusable advice, he stated, was not good advice. From the perspective of the users, what frequently made advice unusable was overly complicated analysis of data (frequently referred to by academics as "elegant" analysis) and highly technical recommendations that were impractical (seen by the researchers as examples of ingenuity, scholarly innovation, "breakthroughs," and being on the "cutting edge" of their discipline).

To overcome these problems, Szanton identified several guidelines for advisors of local government officials to follow. Three of these are pertinent for this discussion of knowledge transmitters.

1. Identify a client. Although this may seem a simplistic suggestion, the identification of a targeted user who has the capability to utilize the advice (or knowledge) presented may be much more difficult than it appears. As mentioned above, the information being transmitted must fit the perceptions, values, and professional ideologies of the user, who also has to have the ability and resources to adopt and implement the suggestions.

2. Learn from the client. In order to enhance the likelihood of adoption, the knowledge producer must understand the constraints within which the user organization makes decisions. Weiss (1978) stresses the importance of understanding the political climate of a community because of the limitations it can place on the kinds of changes that are feasible, on how quickly adoption of changes can take place, and what the costs (social and political as well as economic) of the suggested change entail. To gain this insight, Szanton points out the necessity of developing a set of "working colleagues" within the targeted user group.

3. Find internal champions. A "champion" is someone who has credibility within the user group and who is willing to promote the adoption of new techniques or practices. Champions, Szanton observes, are more likely to actively promote the innovation or change if they have been involved in or consulted

with during the initial stages of the research development or translation process.

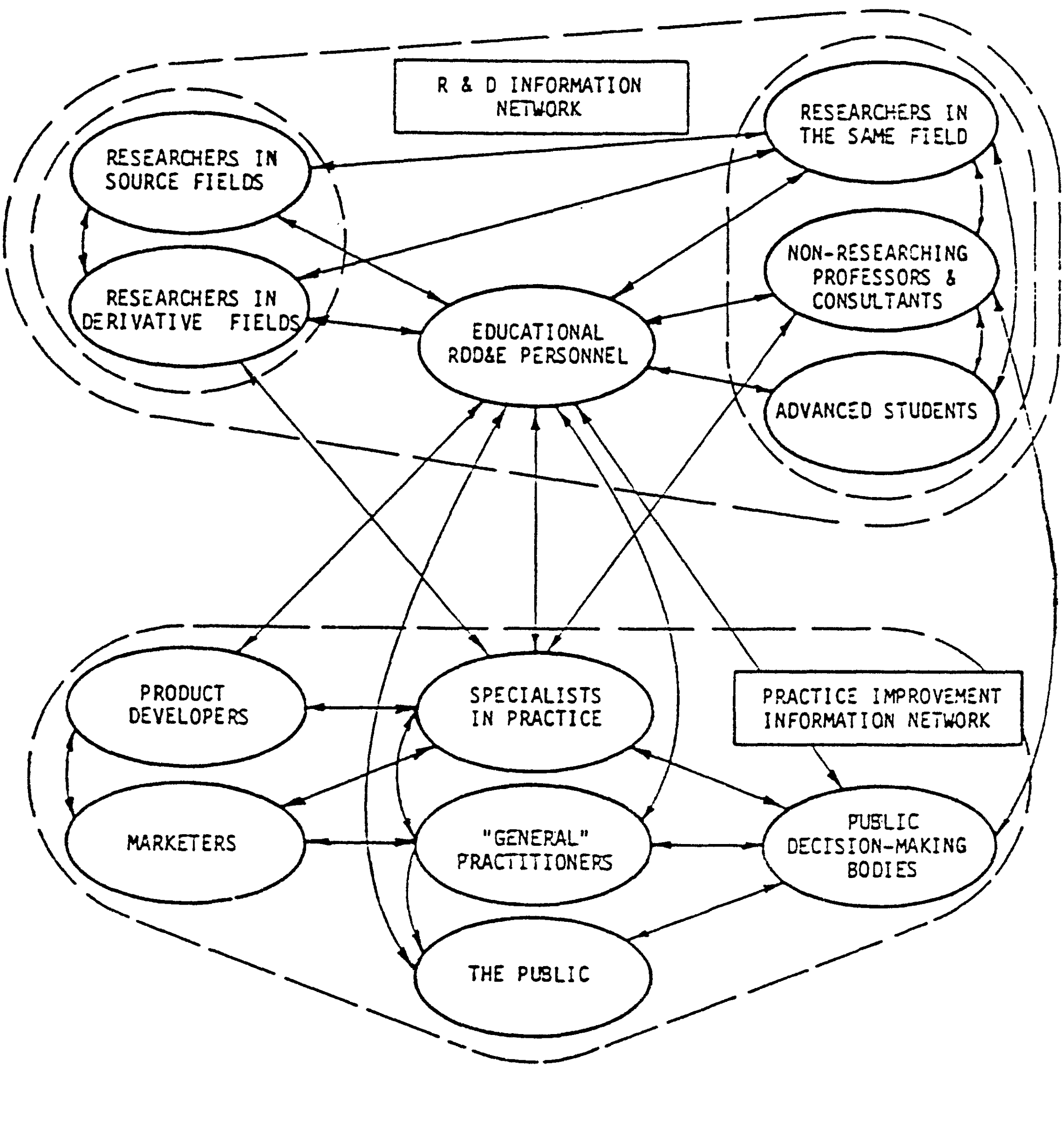
Two characteristics of potential champions may be especially desirable. Much of the innovation diffusion literature points out that successful, well-respected professionals and practitioners are seen as opinion leaders who can become influential in promoting the adoption of new ideas and new products (cf. Rogers, 1962). Also, role accumulators--those persons who are active in many non-overlapping social networks--are more likely to adopt innovations earlier and more frequently (Glaser *et al.*, 1983).

Knowledge Transmission

Throughout the knowledge utilization literature, direct interpersonal communication between knowledge producers and users is required for utilization to occur. In their studies of knowledge utilization, Yin and his colleagues (Yin and Moore, 1985; Yin and Gwaltney, 1981) have stressed repeatedly the importance of developing a network of two-way communication between the knowledge producer and knowledge user. Upon completing their analysis of the utilization of findings from nine research projects, Yin and Moore (1985:70) state "the most consistent pattern leading to utilization was the prevalence of rich and direct communication between knowledge producers and users throughout the design and conduct of the research project." Figure 1 illustrates the complexity of a mutually influencing network of researchers and potential users during the knowledge creation-dissemination process.

FIGURE 1.

AN ILLUSTRATION OF A MUTUALLY-INFLUENCING NETWORK OF RESEARCH PRODUCERS AND USERS.



SOURCE: YIN AND MOORE, 1985

Havelock (1969), in discussing the importance of linkages between producers and users, states the greater the overlap (in terms of both the number and variety of types of contacts) between the resource (or knowledge producer) system and the user system, the more effective the diffusion of new ideas and techniques will be. The redundancy of similar messages transmitted through different channels should improve the likelihood of acceptance of the message. Havelock also maintains that the medium of linkage--that is, the channel or channels through which information is disseminated--should be compatible with the experience and style of the receiver to increase the likelihood of positive acceptance.

Glaser and his colleagues (1983) reviewed an impressive body of literature on the influence of informal communication processes and concluded that the likelihood of utilization can be enhanced when messages are transmitted from (1) professional influentials, (2) those with enthusiasm about the benefits of the outcomes of the utilization, and (3) liked or compatible others in one's personal social networks.

To enhance the two-way flow of communication, however, requires special investment and commitment on the part of the research community to incorporate and respond to the concerns of potential users throughout the research process. Szanton (1981: 60-61) discusses the reasons why this collaboration generally does not occur.

> Most faculty members are trained and accustomed to work alone or, at most, in small groups of scholars in their own discipline. But the analysis of a significant policy problem almost always requires several perspectives and a number of disciplines. An academic working alone, or with only

> familiar colleagues, will therefore tend to respond merely to a piece of a problem, and perhaps only a quite small piece. As many have pointed out, moreover, most faculty members are rewarded only as scholars and teachers, especially the former. The approval they seek is that of their peers, and that depends on the quality and number of their scholarly publications; the informal, nondisciplinary, and often verbal communications most useful to a governmental client do not qualify.

Some suggestions have been made to encourage the interaction among researchers and users. Swanson (1966) suggests that these informal, face-to-face interactions can be enhanced by first identifying groups that already engage in information-exchange and then by expanding the selective communication networks within these groups. Yin and Moore (1985) propose four steps that research investigators can take to increase utilization of their results: (1) become active in associations to which both knowledge producers and users belong; (2) when designing a project, identify the specific groups that may use the research results; (3) during the project, be sensitive to ways that the research might be modified to meet emerging user needs or changed problem definitions; and (4) plan to produce at least one product that is aimed directly at a user group.

Besides these interpersonal exchanges during the research process, Glaser and his colleagues (1983) have identified two other situations in which two-way communication can take place to enhance utilization. <u>Conferences</u> provide an opportunity for researchers to present research findings or instances of exemplary practice in depth to potential users. With the possibility to question researchers and clarify practices, practitioners are much more likely to consider using the information presented than they would be if exposed to a one-way flow of information (e.g., a video tape, a movie, or a publication). Site visits allow practitioners to participate in the demonstration of a new procedure or technique to gain some direct experience. Such demonstrations have been found to result in adoption especially when explicit plans have been formulated to provide follow-up services to participating practitioners.

KNOWLEDGE UTILIZATION AS A PROCESS

From the preceding discussion, it should be clear that the perspective taken in this paper is that the application of knowledge is not an event or outcome; rather, utilization is being conceptualized as a process. The successful utilization of research knowledge--whether from the physical, social, or engineering sciences--depends on inputs, decisions, influences, and interactions at crucial stages between the conduct of basic or problem-focused research and the application of that knowledge to reduce earthquake threats to the social and built environments.

Weiss (1979) discusses several different models of knowledge utilization, four of which have some relevance for the purpose of this workshop--the knowledge-driven model, the problem-solving model, the interactive model, and the enlightenment model.

The Knowledge-Driven Model

This model, also referred to as the "research, development, and diffusion (RD&D) theory" (cf. Guba, 1968), is the most widely used in the field of utilization (Figure 2). It derives from the natural sciences, and few examples of its applicability for the social sciences can be found. This linear model assumes

FIGURE 2. KNOWLEDGE-DRIVEN MODEL

Basic Research

↓

Applied Research

↓

Development and Testing

↓

Application

that if basic knowledge exists, its development and utilization will naturally follow. From this perspective, the ultimate user (who is generally not even identified or considered by the researcher) is assumed to be passive during the research process but will actively adopt the resulting innovation or use the information once it is made available.

Yin and Moore (1985) have identified four conditions of this "technology-push" process.

1. Applied research is conducted because of the prior existence of basic research.

2. The need for the research is defined entirely by the research investigator.

3. The research results are further contributions to knowledge, with the major publications being academic (or scholarly) ones.

4. When utilization occurs, the research often leads to the development of a commercializable product.

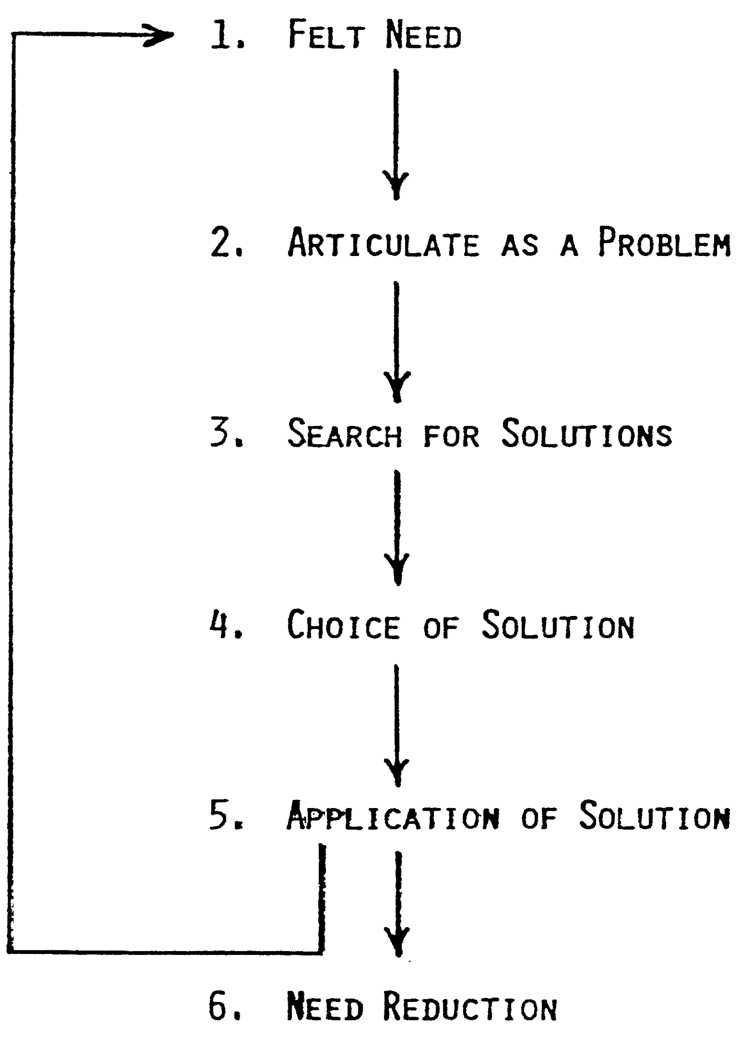
Surely, much of the scholarly research conducted in the areas of seismology, geophysics, geology, and engineering fall within the domain of this model.

The Problem-Solving Model

This model is driven by the need to directly apply the results of a specific study to a user's pending decision. The expectation is that the research will provide empirical evidence and conclusions that will aid in the solution of a policy or technical problem. This linear sequence model (Figure 3) has been characterized by Yin and Moore (1985) as a "demand-pull" model.

In these instances, the user creates the need for the research by proposing the problem that the researcher should be

FIGURE 3. PROBLEM-SOLVER MODEL



addressing and purposefully commissioning research to fill the knowledge gap. The assumption is that because the user is the primary motivator behind the research activity, implementation would naturally occur once the research findings were made available.

The Interactive Model

The emphasis of this model is on diffusion--the movement of messages from person to person and system to system. The importance of informal communication within and across networks is at the heart of this model. Unlike the first two models, this process is not one of linear order, moving from research to an adoption decision. Rather, it is a disorderly set of interconnections and two-way flows of communications and influences that defies a neat, sequential diagram. Figure 1 presents a modified version of this model.

Havelock (1969) developed a model (Figure 4) based on Rogers' (1962) diffusion study findings to explain how various information sources influence the decisions and behaviors of individuals embedded in this complex matrix of relationships. Of these communication influences, Havelock writes:

> In terms of phases of adoption, the following generalizations seem to hold: impersonal sources are most important during the "awareness" phase; during the "interest-information seeking" phase the receiver may turn to an expert, to the mass media, or to personal contacts as sources of information. Personal sources, however, assume greater importance at the evaluation, or "mental trial" stage. Following an actual trial, the individual tends to rely on his own judgment regarding the value of the innovation (10-37).

Two of the seven factors which Havelock (1969) identifies as significantly important in the dissemination/utilization process

FIGURE 4. AWARENESS-ACTIVATED MODEL

1. User Awareness

2. Activated Interest
   Information-Seeking

3. Evaluation of Appropriateness

4. Trial

5. Adoption or Rejection

directly relate to the interactive model and its related communication influences. First, the <u>structure</u> of the relationships is important. The greater the degree of systematic organization and coordination between the resource and user systems, the more likely it is that research knowledge will be utilized. Second, the <u>openness</u> of components of the two systems is also important. If there is a readiness to exchange information between and among members of the research and user systems, utilization becomes more likely. Havelock sees openness as both a prerequisite to the establishment of linkages (discussed above) and a component of a structure that makes utilization more feasible. The concept of openness implies that users are not merely passive receptors of information to which they are exposed (as is their characterization in the knowledge-driven model), but they actively engage in information-seeking and information-exchange activities.

The Enlightenment Model

Enlightenment refers to the unconscious diffusion of general research conclusions that ultimately change the ways the public, decision makers, and practitioners come to define a problem and its alternative solutions. This is the way that most research, especially social science research, enters into the policy arena. Neither information seekers nor decision makers are seen as necessarily active participants in the dissemination/utilization process. Weiss (1979) summarizes the model nicely:

> There is no assumption in this model that decision makers seek out social science research when faced with a policy issue or even that they are receptive to, or aware of, specific research conclusions. The imagery is that of social science generalizations and orientations percolating through informed publics and coming to shape the way in

> which people think about social issues. Social science research diffuses circuitously through manifold channels--professional journals, the mass media, conversations with colleagues--and over time the variables it deals with and the generalizations it offers provide decision makers with ways of making sense out of a complex world (429).

From this perspective, then, research doesn't solve problems. Instead, it provides an intellectual setting of concepts, propositions, orientations, and generalizations that can be used by decision makers, who are likely to be quite distant from the research process and the knowledge producers, to define their problems and evaluate the options for coping with them (Weiss, 1978).

SUMMARY

Throughout the next few days of this workshop, the appropriateness and applicability of these models will be determined by the specification of the utilization components each speaker has chosen. Who is the research producer, and how does that investigator define her/his role with respect to the dissemination or utilization of research findings? Who is the expected user of research knowledge, and what factors will influence whether that user is a passive or active receptor of this new information? What structures or systems exist to enhance knowledge transmission? What are the characteristics of individuals, organizations, systems, and communities which promote or inhibit the transmission and application of information? What is the expected purpose to which the information is to be applied--to change practice, to influence policy making, or to enlighten people's ways of thinking about earthquake threat and how to cope with it?

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APPENDIX B

PARTICIPANT'S LIST
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