EARTHQUAKE PROFESSIONALS TOP TEN ACTIONS FOR NORTHERN CALIFORNIA
(Condensed Version by NESC)

Develop a Culture of Preparedness
- Know your risks
- Prepare to be self sufficient
- Care for the most vulnerable
- Collaborate for regional response

Invest in Reducing Losses
- Focus on the most dangerous buildings
- Ensure essential facility function
- Invest in critical infrastructure

Ensure Resiliency in Recovery
- Plan for regional housing
- Protect your financial recovery
- Plan for regional economic recovery

USSC ACTION PLAN 2004-2005 (PLAN MATRIX)

Learning from Earthquakes
- Improve student-level curriculum
- Teacher workshops
- HAZUS
- Earthquake danger perceptions

Building for Earthquakes
- International Existing Buildings Code
- Lifelines national standards
- Unreinforced masonry buildings program
- Retrofit projects endorsement
- Prorities and triggers (seismic evaluation and assistance program)
- Private residences

Living with Earthquakes
- WSSPC National Conference awards
- Geologic hazards ordinance assistance
- Institutional seismic safety checklists

Earthquake Professionals' Top Ten Actions for Northern California

The people, businesses and government agencies in Northern California risk suffering life, structural and financial losses when major earthquakes strike. Scientists, engineers and emergency management experts gathering for the 100th Anniversary Earthquake Conference call on the region's citizens, businesses, and policymakers to take the following actions to increase safety, reduce losses, and ensure a speedier recovery from the next major earthquake.

Develop a Culture of Preparedness

1. Every household, government agency, and business must know the seismic risks of the buildings they occupy, the transportation systems they use, and the utilities that serve them, as well as the actions they can take to protect themselves.

2. Every household, government agency, and business needs to be prepared to be self-sufficient for at least three days (72 hours) following a disaster.

3. Citizens and governments need to take steps to ensure adequate response care for special needs and vulnerable populations.

4. Government agencies, the region's major industries, and earthquake professionals have to work together to prepare the region to respond to and recover from major earthquakes. This can be done through region-wide, multi-organizational plans, training, exercises and coordination assessments, as well as continuing improvements in our collective understanding of seismic risks.

Invest in Reducing Losses

5. Building owners, governments, and the earth science and engineering professions must target potential collapse-hazard buildings for seismic mitigation, through retrofit, reduced occupancy, or reconstruction.

6. Governments and other relevant agencies must retrofit or replace all facilities essential for emergency response to ensure that they function following earthquakes. These facilities include fire and police stations, emergency communications centers, medical facilities, schools, shelters, and other community-serving facilities.

7. Governments and other relevant agencies must set priorities and retrofit or replace vulnerable response- and community-serving infrastructure, including cellular communications, airports, ports, roads and bridges, transportation, water, dams and levees, sewage and energy supplies, to ensure that functions can be resumed rapidly after earthquakes.

Ensure Resiliency in Recovery

8. Government agencies, the region's major industries, and earthquake professionals have to plan collaboratively for the housing, both short- and long-term, of residents displaced by potential fires, large numbers of uninhabitable buildings, and widespread economic and infrastructure disruption following a major earthquake.

9. Every household, government agency, and business has to assess and plan for financing the likely repair and recovery costs following a major earthquake.

10. Federal, state and local governments, the insurance industry, and the region's major industries have to collaborate to ensure adequate post-event funding to provide economic relief to individuals and communities after a major earthquake, when resources are most scarce yet crucial for recovery and reconstruction.

In conclusion, the earthquake professionals of the 100th Anniversary Earthquake Conference believe that, based on our current understanding of the hazards, local planning, stronger building codes, and ongoing mitigation have substantially reduced the potential loss of life and property that a major Northern California earthquake could cause. Many areas are better prepared than ever before, yet the region is still not sufficiently ready for the next major earthquake. The social and economic consequences could prove to be long-lasting and ruinous to communities. With these actions and a renewed emphasis on safety, Northern California can safeguard its extraordinary cultural and economic vitality and rebound quickly following the next major earthquake.

Action Plan for USSC 2004 - 2005

The April 2004 USSC meeting culminated in a discussion about the Commission's priorities for the upcoming year. Guided by our Strategic Plan(s) and the adoption of "The Plan Matrix" developed by the California Seismic Safety Commission, the following targeted areas were suggested. The format is duplicated from the California plan. Although the categories: Benefits, Costs, and Incentives were not specifically discussed during our meeting, they are included to help complete our consideration of rankings and emphasis for the coming year(s).

Learning About Earthquakes

Concern/Program	Objective(s)	Strategies	Benefits	Responsibilities	Costs	Incentives
A. Improve Student Level Curriculum (Teaching the Next Generation)	Making earth science part of core curriculum.	Strengthen K-12 and higher grade earthquake programs by working with science education decision-makers.	Increase knowledge about Utah's earthquakes. Educated public makes better policy decisions.	Superintendent of Schools State Science Advisor (Mike Keene)	State = minimal Local = none User = none	Strengthen state policies. Increase public demand.
B. Teacher Workshops	Provide resources for educators in earth science.	Build strong, independent connection with educators.	Increase contact with state educators.	USG (Sandy Eldredge) DES (Bob Carey)	State = none Local = none Participant = minimal	Continuing education credit for educators.
C. HAZUS (FEMA Hazard U.S. software program)	Use tool to educate commission, public officials, design professionals and the public.	Create framework for evaluation "reports." Develop resources to refine data.	Increased understanding of the earthquake danger in Utah.	DES (Bob Carey)	State = minimal Local = none User = none	Implementing a national tool for evaluation of earthquake losses in the state.
D. Earthquake Danger Perceptions	Clearer explanation of earthquake danger. Better understanding of the likelihood of potentially damaging earthquakes. Improve building seismic design perception.	Develop "reality" based explanations of risk. Separate time-based risk from consequence-based risk. Provide decision-makers and affected people with useable information	Increase knowledge about Utah's earthquakes. Educated public officials and informed public leads to better policy decisions.	UGS U of U Seismograph Stations (Walter Arabasz) SEAU (Barry Welliver)	State = none Local = none User = none	Strengthen state policies. Increase public demand.

Building for Earthquakes

Concern/Program	Objective(s)	Strategies	Benefits	Responsibilities	Costs	Incentives
E. International Existing Building Code (IEBC)	Upgrade vulnerable buildings.	Endorse IEBC to state building code authorities. Design Professional endorsement.	Reduce loss of life. Reduce property damage. Design Professional consensus	SEAU (Barry Welliver) AIA (Barry Smith) State Building Code Commission.	State = minimal Local = minimal User = varies	Economic and regulatory.
F. Lifelines National Standards	Identify national standards programs. Protect life, limit property damage, resume functions.	Encourage completion of national standards. Provide exposure to state agencies and organizations addressing lifelines.	Economic viability of the region and state	ASCE (Peter McDonough) Utah League of Cities and Towns (Carl Eriksson) System owners	State = minimal Local = none Utility = varies	Economic and regulatory.
G. Unreinforced Masonry Buildings Program (URM)	Increase knowledge about URM's. Address retrofit issues of vulnerable buildings.	Information packets for commercial and residential owners. Study effects of seismic retrofit programs. HAZUS report on vulnerabilities.	Reduce loss of life. Reduce property damage. Quantify the URM problem.	SEAU (Barry Welliver) AIA (Barry Smith) State Building Code commission.	State = minimal Local = minimal User = varies	Economic and regulatory.
H. Retrofit Projects Endorsement	Continue support for ongoing state retrofit projects. Private retrofit success support.	Endorse Capitol Preservation project. Strategize support for Marriott Library and other state retrofit projects forthcoming. Catalogue success stories.	Consistent endorsement objective. Persistent endorsement objective. Show by example.	USSC	State = none Local = none User = none.	Public awareness.
I. Priorities and Triggers (Seismic Evaluation & Assistance Program)	Develop relationships with entities responsible for seismic evaluations and risk analysis.	Attend BB meetings. Attend Regents meetings.	Share expertise. Help prioritize projects.	State Building Board (BB) University Regents USSC	State = varies Local = varies User = varies	Economic and regulatory.
J. Private Residences	Inform affected people. Provide tools for evaluation and mitigation.	Update Homeowners URM manual. Educate level of risk for homes.	Information for decision-making.	Homeowners USSC	State = none Local = none User = varies	Economic. Insurance evaluation.

Living with Earthquakes

Concern/Program	Objective(s)	Strategies	Benefits	Responsibilities	Costs	Incentives
K. Western States Seismic Policy Council / National Conference Awards	Identify programs and projects relating to earthquake safety and exposure.	Annually review and nominate candidates for awards programs.	Ongoing review of potential candidates.	UGS (Rick Allis) DES (Bob Carey)	State = none Local = none USSC = minimal	Regional and national recognition.
L. Geologic Hazards Ordinance (GHO) Assistance	Encourage adoptions of GHO. Provide exposure and forums for discussions.	Develop template for GHO adoptions. Establish "Blue Ribbon" committee to study.	Endorses existing programs. Creates public awareness of geologic hazards.	Utah Geological Survey (Gary Christenson) American Public Works Association (Matt Cassel)	State = none Local = varies User = none	Economic.
M. Institutional Seismic Safety Checklists	Provide information to evaluate non-structural risks. Transfer knowledge between Emergency Managers. CERT Programs awareness.	Develop checklists of desirable mitigation actions. Create forums for dissemination of information.	Learn from existing programs. Increase effective mitigation strategies.	Association of Contingency Planners (Kerry Baum) Public Institutions	State = minimal Local = none Institution = varies	Economic.

Some final thoughts from your Strategic Planning committee:

Decision-makers can be sympathetic to seismic issues or needing education about the value of considering earthquakes in their work. The former type will know our language and can respond without a great deal of hand-holding. These would include agencies such as the Utah Uniform Building Code Commission and others.

The latter type will require the work of finding the language to fit into their deliberations. These include possibly the State Building Board, The University Regents and building and property owners.

Affected people are individuals or groups vulnerable to earthquake impact who generally need understandable information and motivation to take defensive actions. These include homeowners and workers who could have varying degrees of understanding of the earthquake issue and often are decision-makers on their own scale.

Some further last minutes ideas included:

- "Parade of Homes" of retrofit work for builders and homeowners.
- "Sister City" relationship with Portland or Seattle to develop a mutual bond with a region of similar size and exposure. (Formal designation of "Sister City" status usually results from mutual agreement of public officials and hence would require approaching Salt Lake City's mayor and City Council)
- "UDOT" retrofit program endorsement.
- "Partner Commission" involvement with the Nevada Earthquake Safety Council.

PARK CITY
1884

The following statewide codes have been adopted by the Uniform Building Code Commission and are currently in effect for the State of Utah:

- 2006 Edition of the International Building Code
- 2006 Edition of the International Residential Code
- 2006 Edition of the International Plumbing Code
- 2006 Edition of the International Mechanical Code
- 2005 Edition of the National Electrical Code
- 2006 Edition of the International Fuel Gas Code
- 2006 Edition of the International Energy Conservation Code
- 2006 Edition of the International Fire Code

Amendments to these codes can be downloaded from the State of Utah website at www.dopl.utah.gov.

►Click on Programs
►Click on Uniform Building Codes
►Click on Statutes and Rules

- IBC amendments can be found in R156-56-704
- NEC amendments can be found in R156-56-706
- IPC amendments can be found in R156-56-707
- IMC amendments can be found in R156-56-708
- IFGC amendments can be found in R156-56-709
- IECC amendments can be found in R156-56-710
- IRC amendments can be found in R156-56-711

(Please note these rules are subject to change on January 1 and July 1 of each year.)

Code books and amendments can be purchased online through International Code Council (ICC) at www.iccsafe.org or you can stop by the ICC Regional Office at 455 East, 500 South, Suite 202 in Salt Lake City.

Earthquake Engineering Need Reported to House Speaker on June 21, 2006

Seismic Structural-Response Monitoring of State Capitol

Explanation

- Important to structural engineers for evaluating the performance of the seismically retrofit Capitol (enables the effectiveness of the base isolators to be evaluated, even at a low level of seismic shaking)
- If structure is hit by a damaging quake, can pinpoint where damage is—even if hidden
- Best contracted to—and done by—experts of the U.S. Geological Survey's National Strong-Motion Program
- If done, important to do before walls are closed during remodeling process (for access to structural elements in the building)
- For comparison, the cost of instrumenting the Wallace F. Bennett Federal Building in Salt Lake City was approximately $170,000

Cost Estimate

- One-time: $200,000
- Ongoing: Relatively minor; U.S. Geological Survey would have to provide quote (likely about $10,000 per year)

UUSS
university of utah
seismograph stations
www.quake.utah.edu

UTAH SEISMIC SAFETY COMMISSION

Expanding Seismic Instrumentation and Real-time Earthquake Information Products in the St. George-Cedar City Area and Rural Utah

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IN A NUTSHELL

- ❑ Need for improved seismic monitoring and real-time earthquake information products in the dramatically growing St. George-Cedar City area and quake-prone parts of rural Utah
- ❑ Needed for emergency response, earthquake engineering of buildings and lifelines, and risk management
- ❑ For a solid start: 10 new regional and 12 new urban strong-motion seismic stations
- ❑ Cost: $420,000 one-time; $125,000 ongoing

CAPABILITIES FOR REAL-TIME EARTHQUAKE INFORMATION

Wasatch Front

The University of Utah Seismograph Stations (UUSS) plays a critical role in meeting the state of Utah's many needs for earthquake data and information.

UUSS operates a network of 160 urban and regional seismic stations in the Utah region, most of which are in or around the Wasatch Front urban corridor.

Since 2000, UUSS researchers have obtained more than $3 million in federal funds to create and operate a new real-time earthquake information system (sensors, telecommunications, hardware and software) **in the Wasatch Front area** as an element of an Advanced National Seismic System (ANSS):

- Automated earthquake alerts (magnitude and location) to emergency managers and the Web within a few minutes
- "ShakeMaps"—computer maps showing severity and extent of actual ground shaking—within 5 min of a disruptive earthquake
- Digital recordings of strong ground shaking for rapid post-earthquake damage assessment and earthquake engineering design

Need to Extend Capabilities to Southwestern & Rural Utah

Earthquakes in Utah are not just a Wasatch Front problem. But seismic instrumentation in other earthquake-prone parts of the state is sparse, mostly outdated, and generally inadequate to meet growing needs for hazard assessment, emergency mgt., and earthquake engineering. Reasons for improved seismic monitoring:

- Dramatic population growth in southwestern Utah
- Seismic vulnerability and engineering of lifelines (power, water, transportation, communications, fuel pipelines) throughout ~100-mile-wide seismic belt transecting Utah from St. George to the Idaho border
- Energy development (coal, oil, and gas production) in central and NE Utah linked to known and potential induced seismicity

What's Needed?

For a solid start, significant gains can be made with a strategic combination of 10 new regional stations and 12 new urban strong-motion stations:

- 13 stations in and surrounding the St. George-Cedar City area
- 7 stations in other seismically active parts of southwestern Utah (e.g., near Richfield, Beaver, Panguitch, and Kanab)
- 2 stations in Uinta Basin near Vernal and Duchesne

Estimated Cost

For installation, maintenance, and operation of 22 new stations: $420,000 one-time, $125,000 ongoing. State line-item to UUSS is now $424,300 /yr (37% of UUSS budget for monitoring and research in the Utah region).

Benefits

- Real-time earthquake information for emergency response and public awareness
- Automated maps (ShakeMaps) of strong ground shaking for rapid impact and loss estimation
- ShakeMaps can be input to FEMA's HAZUS loss-estimation software to fast-track federal disaster declarations
- Data for cost-effective earthquake engineering of buildings and infrastructure
- Improved understanding of earthquake hazards for science, planning, and insurance

SEISMIC MONITORING SERVES MULTIPLE STATE NEEDS

Seismic monitoring serves diverse government agencies in Utah responsible for emergency services, natural hazards, transportation, dam safety, mine safety, insurance, risk management, trust lands administration, and facilities construction and management, among others.

UUSS and the **Utah Seismic Safety Commission** are jointly committed to improving seismic monitoring in Utah to help safeguard Utah's people, built environment, and economy.

Contact information: Walter Arabasz, Director, Univ. of Utah Seismograph Stations: 801-581-7410; arabasz@seis.utah.edu;
Barry Welliver, Chair, Utah Seismic Safety Commission: 801-553-0162; barrywelliver2@earthlink.net

Strategic Building Blocks for Effective Statewide Seismic Monitoring in Utah

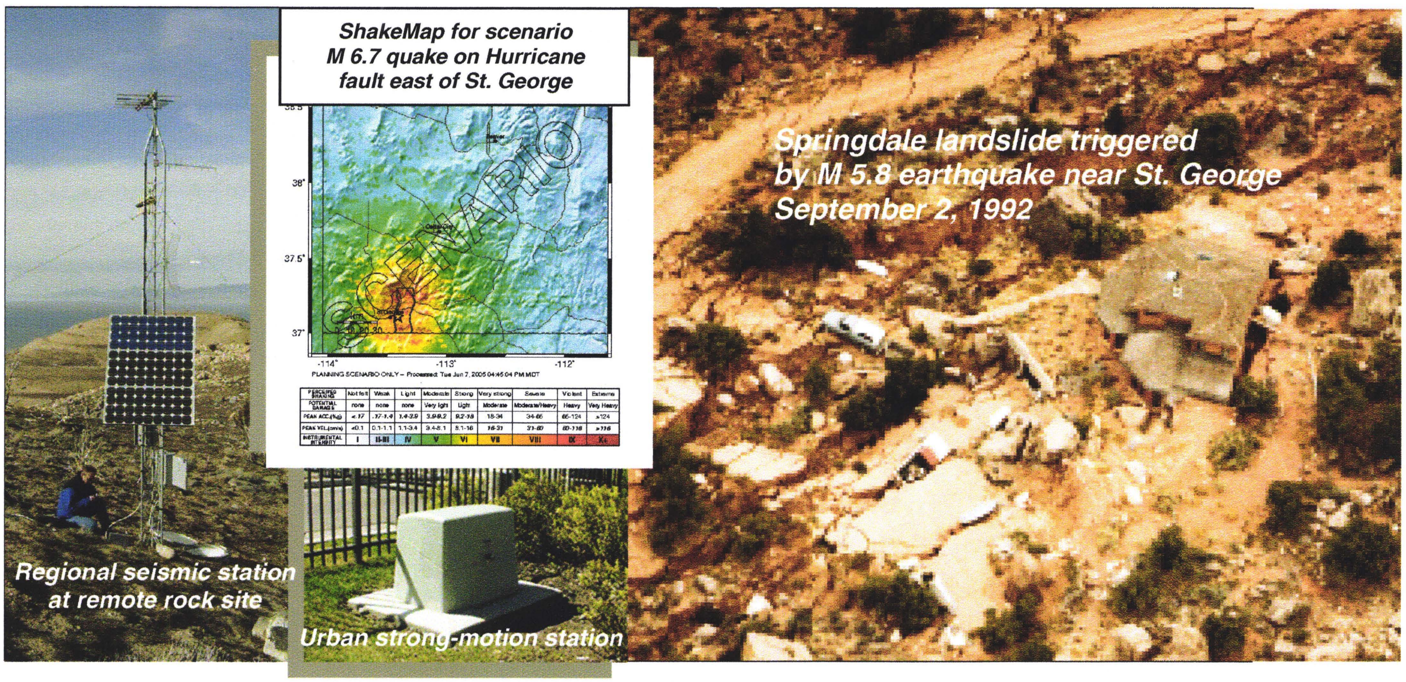
	Building Blocks—Ranked in Priority University of Utah Seismograph Stations (UUSS)	One-time Costs (thousands of dollars)	Ongoing Annual Costs (thousands of dollars)
1.	**Base Proposal for a Solid Start** (10 new regional, 12 new urban seismic stations in St. George-Cedar City area and parts of rural Utah)	420[1]	125[1]
2.	**0.75 FTE Seismologist** (important for effective completion and leveraging of all other building blocks—and to better meet varied state needs for earthquake data and information)		82[2]
3.	**Continuity of Earthquake Monitoring & Reporting in Event of Large Wasatch Front Earthquake** (includes (a) backup systems outside the Wasatch Front area for receiving and processing network data and (b) robust telemetry routing to ensure emergency recording of Utah seismic data by the National Earthquake Information Center in Golden, Colorado)	300	120[3]
4.	**Effective Delivery & Use of Near-Real-Time Earthquake Alerts** (upgraded notification software, video-conferencing connectivity to state Emergency Operations Centers, training workshops for emergency responders throughout quake-prone parts of Utah)	25	----[4]
5.	**20 Additional Urban Strong-Motion Stations** in cities and towns outside the Wasatch Front area (Richfield: 6 stations; Uinta Basin : 4 stations; St. George-Cedar City area: 5 stations; other cities/towns to be determined by engineering advisory board: 5 stations) @ $12.5 K per station	250	74[5]
6.	**7 Additional Regional Stations in Sevier Valley Area** (to be added in region where eight historical earthquakes of magnitude 5 and larger have occurred between Richfield and Marysvale) @ $21K per station	147	20[6]
7.	**Leveraged Addition of 10 Regional Stations to Statewide Network** (conversion of temporary high-quality stations of a "rolling" USArray experiment, funded by the National Science Foundation's EarthScope project to study Earth structure, to permanent stations of Utah's statewide network) @ $30K per station	300	29[7]
	Totals	***1,442***	***450***
	[1] See *Concept Proposal* for detail [2] Salary plus benefits [3] 1.0 FTE computer/communications engineer (salary plus benefits) plus ~$35K/yr telemetry charges [Note: IT engineer important not just for this continuity module but for all network operations] [4] Costs to be absorbed by UUSS in partnership with State Office of Emergency Services [5] 0.50 FTE seismograph engineer/technician (salary plus benefits) plus telemetry, supplies & travel @ $1800/station [6] 0.10 FTE seismograph engineer/technician (salary plus benefits) plus telemetry, supplies & travel @ $1800/station [7] 0.15 FTE seismograph engineer/technician (salary plus benefits) plus telemetry, supplies & travel @ $1800/station		

June 2006; Rev. Dec. 2006

Concept Proposal

Real-time Earthquake Information in Utah Outside the Wasatch Front

A proposal to expand seismic instrumentation and rapid earthquake-information products in the St. George–Cedar City area and rural Utah



UUSS

university of utah
seismograph stations

www.quake.utah.edu

September 2005

revised June 2006

Executive Summary

The University of Utah Seismograph Stations (UUSS) plays a critical role in meeting Utah's basic needs for earthquake data and information—for emergency response, earthquake engineering, and earthquake science. UUSS operates a network of 160 regional and urban seismic stations in the Utah region, most of which are in or surrounding the densely populated Wasatch Front area.

Since 2000, UUSS researchers have gained more than $3 million in federal funds to create and operate a new real-time earthquake information system in the Wasatch Front area as an element of an Advanced National Seismic System (ANSS).

A plan is presented to expand seismic instrumentation and enable real-time earthquake information products and services in the St. George–Cedar City area and rural Utah.

The Problem—and Why State Funding is Needed

Earthquakes in Utah are not just a Wasatch Front problem. But seismic instrumentation in other earthquake-prone parts of the state is sparse, mostly outdated, and generally inadequate to meet growing needs for hazard assessment, emergency management, and earthquake engineering. Factors that inexorably call for improved seismic monitoring outside the Wasatch Front include:

- dramatic population growth in southwestern Utah;
- seismic vulnerability and engineering of lifelines (e.g., power, water, transportation, communications, fuel pipelines) throughout a roughly 100-mile-wide seismic belt that transects Utah from St. George to the Idaho border; and
- energy development (coal, oil, and gas production) in central and northeastern Utah linked to known and potential induced seismicity.

State funding is needed because, for the foreseeable future, available federal monies for enhanced seismic monitoring in the U.S. will continue to be focused on high-risk metropolitan areas like the Wasatch Front.

What is Needed?

For a solid start, significant gains can be made with a strategic combination of 10 new regional and 12 new urban seismic stations:

- 13 stations in and surrounding the St. George–Cedar City area (the most dramatically-growing part of Utah outside the Wasatch Front)
- 7 stations in other seismically active parts of southwestern Utah (including stations in or near Beaver, Kanab, Panguitch, and Richfield)
- 2 stations in the Uinta Basin near Vernal and Duchesne

Estimated Cost

The estimated cost for the installation, maintenance, and operation of the 22 new stations is **$420,000 one-time and $125,000 ongoing**.

The ongoing dollars include $30,000 per year to incrementally add at least one station per year in parts of rural Utah that are inadequately or poorly instrumented. These dollars can be leveraged in 2007, 2008, and 2009 to convert temporary stations from a national experiment to permanent stations of Utah's statewide seismic network.

Benefits (See Appendix)

- Near-real-time earthquake information for emergency response and public awareness
- Automated maps of strong ground shaking for rapid impact assessment (including dam safety), loss estimation, and expedited federal disaster declarations
- Data for cost-effective earthquake engineering of buildings and infrastructure
- Improved understanding of earthquake hazards for science, insurance, and planning

Background on Seismic Monitoring in Utah

Utah's people, built environment, and economy are all exposed to a real and constant earthquake threat. Tragedies accompanying recent catastrophic earthquakes and tsunamis outside the U.S., together with Hurricane Katrina in the U.S. Gulf Coast, emphasize the need to take a long-term view of natural hazards—and they have raised public expectations for government action relating to monitoring, warning, and emergency response.

The University of Utah Seismograph Stations (UUSS) plays a critical role in meeting the state of Utah's basic needs for earthquake data and information—for emergency response, earthquake engineering, and earthquake science. UUSS has ably performed this role since the 1960s, despite great challenges to fund modern instrumentation and implement companion information technologies.

A solid partnership between UUSS, the Utah Geological Survey, and the Utah Division of Emergency Services and Homeland Security has underpinned Utah's state earthquake program since the mid-1980s.

Funding Background

In the late 1980s and early 1990s, attempts to get added state funding to modernize earthquake instrumentation in Utah were minimally successful. A blue-ribbon panel, convened as part of a legislative study in 1989 to objectively evaluate earthquake instrumentation needs in Utah, recommended a "bare bones" package of instrumentation ($2.7 million one-time, $382,000 ongoing). Persistent attempts were made by legislative champions to secure funding. In 1992, the Legislature appropriated a one-time amount of $75,000 to the Utah Geological Survey to begin a state strong-motion program in partnership with UUSS.

In 1992 University of Utah President Arthur Smith advised the governor that UUSS would have to curtail seismic monitoring outside the Wasatch Front area because of inadequate state funding. Thanks to the supportive involvement of the University administration, various state agencies, the Governor's Office of Planning and Budget, and the Office of the Legislative Fiscal Analyst, a temporary fix was found for one year until the 1994 Legislature increased the UUSS line-item budget by $75,000 from the general fund (non-competing with the higher-ed budget).

In the late 1990s, UUSS researchers turned to the national arena and played an active role in planning and advocating congressional funding for an Advanced National Seismic System (ANSS). Thanks to more than $3 million gained from ANSS since 2000, UUSS has successfully built and operated a real-time earthquake information system in the Wasatch Front area, an area whose earthquake hazard and population risk met national guidelines for priority attention in the face of limited available funding.

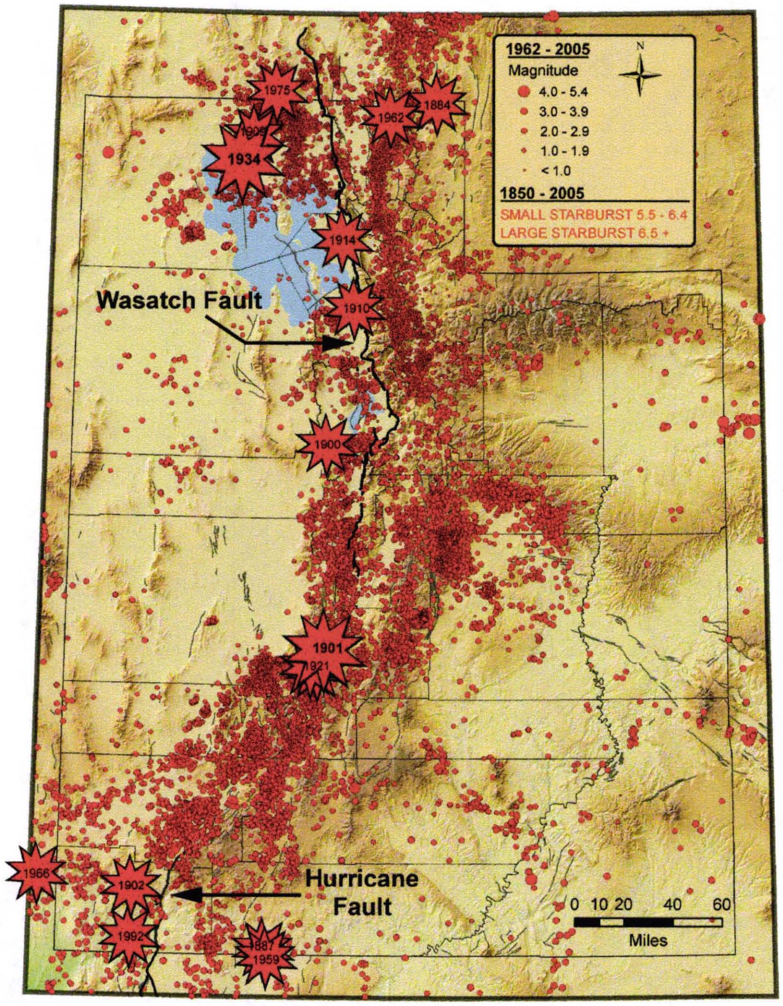
In the Wasatch Front area, earthquake information products and services that were impossible several years ago (see www.quake.utah.edu) are now enabled by a new urban strong-motion network of 85 stations along the urban corridor, expanded seismographic coverage in its immediately surrounding region, real-time data processing capabilities, and new communication systems. These include:

- Earthquake alerts automatically broadcast to emergency managers (and posted on the Web) within a few minutes of a potentially disruptive earthquake, indicating its size and location
- "ShakeMaps"—computer maps broadcast and posted on the Web within 5 minutes of a sizeable earthquake showing the severity and extent of actual ground shaking
- Digital waveforms that enable strong ground shaking to be reliably measured for immediate post-earthquake assessment of likely damage to structures and facilities and for future engineering design

These information products are possible only where adequate seismic instrumentation is in place.

Earthquakes in Utah Are Not Just a Wasatch Front Problem . . .

Historical and Instrumental Seismicity in Utah

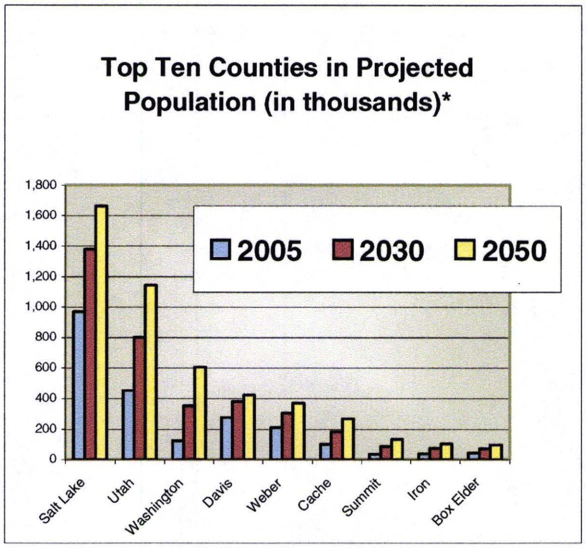


Source: University of Utah Seismograph Stations earthquake catalog

- More than 36,000 earthquakes instrumentally located by UUSS in the Utah region since 1962. Wasatch Front is only <u>part</u> of a regional "Intermountain Seismic Belt."
- Half of the 16 damaging earthquakes in Utah of magnitude 5.5 and larger since 1850 have occurred outside the Wasatch Front area in central and SW Utah, including five in the SW corner of Utah.
- One of the largest historical earthquakes in Utah was a damaging shock of magnitude 6.5 near Richfield in 1901. The Sevier Valley area between Richfield and Marysvale has had eight earthquakes of magnitude 5 and larger.
- More than 10,000 mining-induced earthquakes (up to magnitude 4.2), caused by underground coal mining, have been located by UUSS in Carbon, Emery, and eastern Sevier counties.
- In the Uinta Basin, an earthquake of magnitude 4.5 in 1977 caused minor damage north of Duchesne. Earthquakes up to magnitude 4.9 have been induced both by oil and gas production and deep fluid injection in the Colorado-Utah border region. The Bureau of Land Management predicts that more than 3,000 oil and gas wells could open in the Uinta Basin in the future (*Salt Lake Tribune, July 14, 2005*).

Note: The Wasatch fault and the Hurricane fault are bolded for emphasis in the above figure. Numerous other active faults in Utah are plotted as lighter lines. Many of these active faults (including the Wasatch and Hurricane faults) have the potential to produce large surface-rupturing earthquakes in the magnitude range 7 to 7.5.

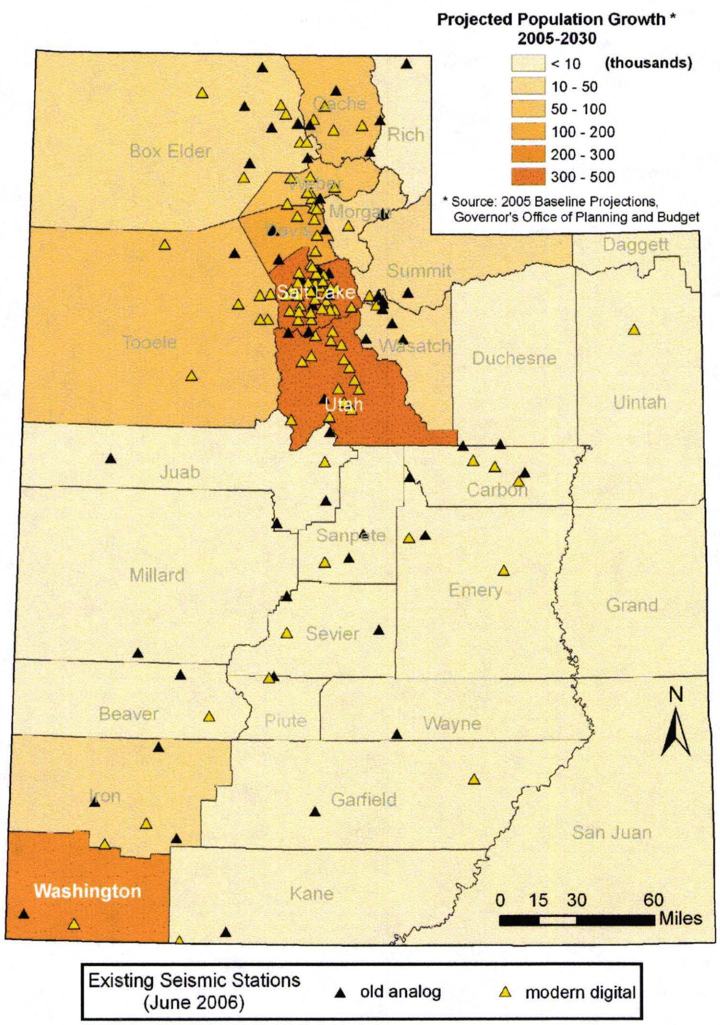
The Most Dramatic Population Growth in Utah Outside the Wasatch Front Is Projected to Be in Southwestern Utah . . .



← According to the Governor's Office of Planning and Budget, Washington County is projected to experience a nearly six-fold increase in population to approximately 600,000 by 2050—which will make it Utah's third most populous county.

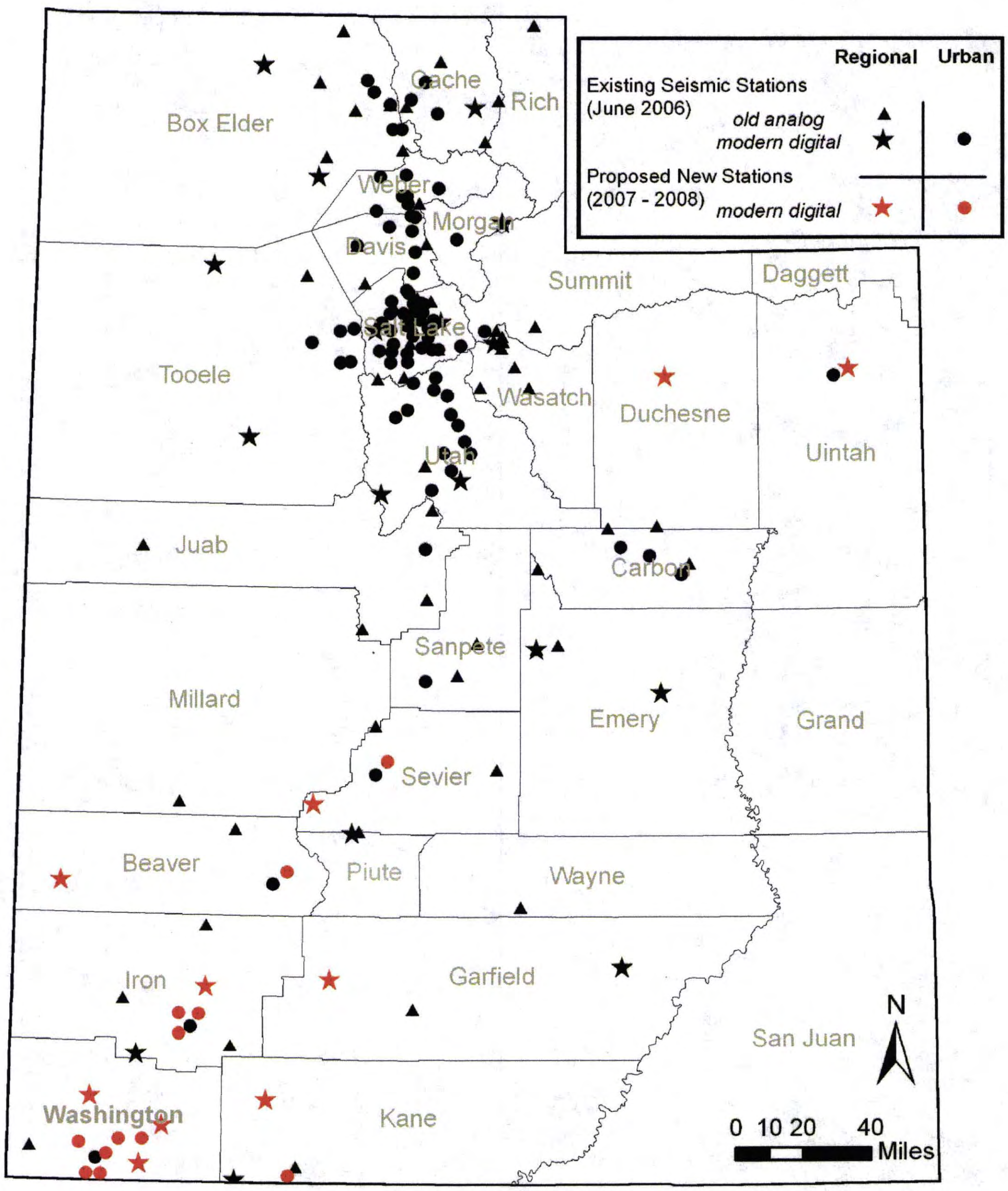
↓ But seismic instrumentation in southwestern Utah is sparse and inadequate to meet growing needs for earthquake engineering and public safety.

Existing Seismic Stations (June 2006) and Projected Population Growth in Utah



How to Begin Improving Earthquake Safety in Southwestern and Rural Utah . . .

Existing and Proposed Seismic Stations

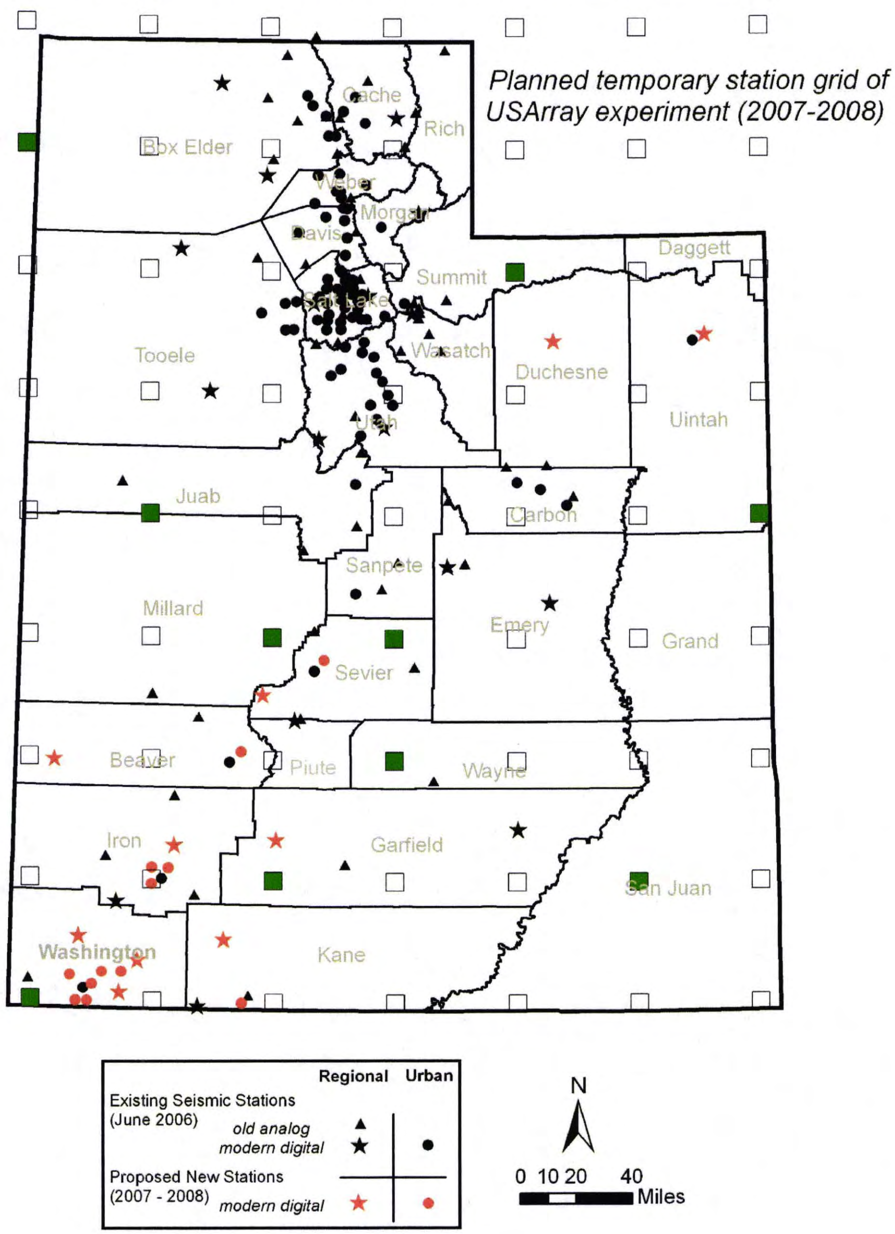


Note: The existing "urban" stations in Carbon County are strong-motion instruments identical to those used in the urban built environment but being used to monitor coal-mining-induced earthquakes.

Leveraging to Augment Statewide Seismic Monitoring in the Future . . .

- Grid squares (below) show sites of temporary high-quality seismic stations to be operated in 2007–2008 as part of a "rolling" USArray experiment, funded by the National Science Foundation's EarthScope project to study Earth structure.
- At a cost of approximately $30,000 per station, a subset of the USArray regional stations can be converted to permanent stations of Utah's statewide seismic network (10 candidate stations shown by GREEN SQUARES below).
- Part of the requested ongoing increase to UUSS line item can be used to acquire at least three candidate stations in 2007, 2008, and 2009; UUSS would try to leverage its state funds with federal and private dollars to acquire 7 more (perhaps up to 20) USArray regional stations in the next few years.

Existing and Proposed Seismic Stations
Plus Acquired Subset of Future USArray Stations



A Start for Improving Earthquake Safety in Southwestern & Rural Utah

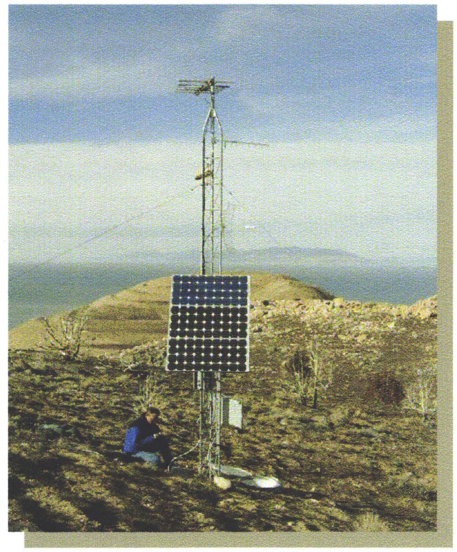
One-time Funding of $420,000

The University of Utah Seismograph Stations estimates a one-time cost of $420,000, including installation costs, to strategically add 22 new digital seismograph stations outside the Wasatch Front area:

- Two high-quality regional stations (broadband/strong-motion) @ $37,500 each—one in southwestern Utah and one in the Uinta Basin
- Eight intermediate-quality regional stations (short-period/strong-motion) @ $21,000 each, including seven in southwestern Utah and one in the Uinta Basin
- Twelve urban (strong-motion) stations @ $12,500 each in St. George (6 stations), Cedar City (3 stations), Kanab (1 station), Richfield (1 station), and Beaver (1 station)

Note: Siting of the urban strong-motion stations would be done under the guidance of the Utah Advisory Committee for Urban Strong-Motion Monitoring, a 12-member subcommittee of the Utah Seismic Safety Commission consisting of ten engineers and representatives from the Utah Geological Survey and the Utah Division of Emergency Services and Homeland Security (see http://www.seis.utah.edu/urban/index.shtml).

(2) regional (broadband/ strong-motion) stations @ $37,500 each	$75,000
(8) regional (short-period/ strong-motion) stations @ $21,000 each	$168,000
(12) urban (strong-motion) stations @ $12,500 each	$150,000
Additional components in Network Operations Center to record/process data from new stations	$27,000
TOTAL	**$420,000**



Example of a **regional seismic station** at a remote rock site (with digital radio telemetry)—designed primarily for the continuous, high-fidelity digital recording and accurate location of earthquakes and other seismic events.

Example of an **urban strong-motion station.** Designed to record strong earthquake ground shaking in the built environment onscale and with high fidelity—chiefly for earthquake engineering and emergency-response applications.

Note: Seismic data from both regional and urban stations are telemetered continuously in real time to the University of Utah's earthquake information center in Salt Lake City via radio, state microwave, telephone, and/or Internet telemetry.

A Start for Improving Earthquake Safety . . . (continued)

Ongoing Funding of $125,000

- Costs for operation and maintenance of 22 new stations (including telemetry).
- Addition of $30,000 per year in equipment monies to augment the existing budget of only $10,000 per year in the state line item, thereby enabling UUSS to incrementally add (and subsequently maintain) at least one station per year during the next decade in parts of rural Utah that are inadequately or poorly instrumented.

Detail of Estimated Ongoing Funding

1. Seismograph Engineer/Technician (0.75 FTE: $56,100 including employee benefits): The state budget now supports a total of 0.45 FTE (0.20 and 0.25) of two Seismograph Engineer/Technicians. Our three UUSS engineer/technicians are stressed to maintain and repair 180 existing regional and urban seismic stations in our entire network together with telecommunications systems and our network operations center. In order to install and maintain the proposed 22 additional stations in distal parts of Utah, a minimum addition of 0.75 FTE would be needed (0.75 FTE of a fourth engineer/ technician that would have to be hired). Market pressures and skill requirements in digital electronics and telecommunications have pushed the salary requirements for seismic field engineer/ technicians up to the $50,000/yr to $70,000/yr level, excluding benefits. A base salary of $55,000/yr is used as the basis for the new hire.

2. Telecommunications ($15,900): Continuous real-time telemetry from remote seismic stations is essential for seismic monitoring, and aggregate costs for a regional-scale network are inherently high. UUSS currently pays approximately $74,000/yr in telecommunications costs for diverse telemetry within Utah, including $34,298/yr to the Utah Department of Information Technology Services (DITS) for use of the state microwave system. The state budget currently supports $21,230/yr for telemetry costs for the 28 state-funded stations. For the 22 proposed regional/urban seismic stations in central, southwestern, and northeastern Utah, an additional $15,900/yr would be required for the necessary telemetry.

3. Supplies ($12,100): Actual costs for field and technical supplies associated with the operation, repair, and recording of the 28 existing state-funded seismic stations in Utah during the past five years have averaged $16,460/yr (or $588/station) vs. state budget support of $10,220/yr for all supply categories. This reflects the erosion of state support due to no increase in non-personnel funds since 1994. For operation and maintenance of the 22 new stations, a conservative amount of $12,100 per year (22 x $550/station) would be needed.

4. Vehicle Expense ($6,700): Our three UUSS field engineer/technicians rely on 4x4 vehicles to travel to seismic stations located both within and remote from urban environments throughout the Utah region. Based on cumulative experience with the repair and maintenance of seismic stations within our network, and accounting for the planned location of the 22 new stations, an amount of $6,700 (rounded) is estimated for 4x4 vehicle usage (15,000 mi per year @ 44.5¢/mi).

5. Travel, In-State ($4,200): Significant expansion of seismic monitoring in southwestern Utah and other parts of rural Utah distant from Salt Lake City would require travel support for the repair and maintenance of those stations. Accounting for the planned location of the 22 new stations and based on our experience with field/telemetry maintenance requirements for the modern digital urban and regional stations that are planned, an amount of $4,200 (rounded) is estimated for travel. Basis: 30 nights lodging @ $60/night; 60 days meals and incidental expenses @ $39/day.

6. Equipment ($30,000): As is evident in the details for the requested one-time funding of $420,000, seismic instrumentation is inherently costly—not only for field instrumentation but also for corresponding components required for data acquisition and real-time processing in our network operations center.

   In order to progressively add at least one seismic station per year in seismically vulnerable parts of Utah that are inadequately or poorly instrumented, $30,000 per year in equipment monies is requested to augment the budget of only $10,000 per year for equipment now in the state line item. (Because the added stations would progressively increase maintenance and telemetry costs, a ten-year timeline is used for adding at least one station per year.)

   We noted on p. 6 that the $30,000 per year can be used in 2007, 2008, and 2009 to convert some temporary high-quality stations from a national experiment to permanent stations of Utah's statewide seismic network. UUSS would try to leverage its state funds with federal and private dollars to acquire seven more (perhaps up to 20) such regional stations in the next few years. Such stations cannot serve the same needs as—and are a lower priority than—the urban and regional stations proposed here for southwestern Utah as part of the $420,000 one-time funding.

Background Information on the UUSS Line-Item Budget

For the calendar year 2006, UUSS's total budget for seismic-network operations, associated earthquake-related research, and earthquake education and outreach—for the Utah region only—amounts to $1.15 million. Of this amount, 37% is from the state line item, 61% is from federal awards, and 2% is from other sources. For the state fiscal year 2006–07, the state line item to UUSS is $424,300.

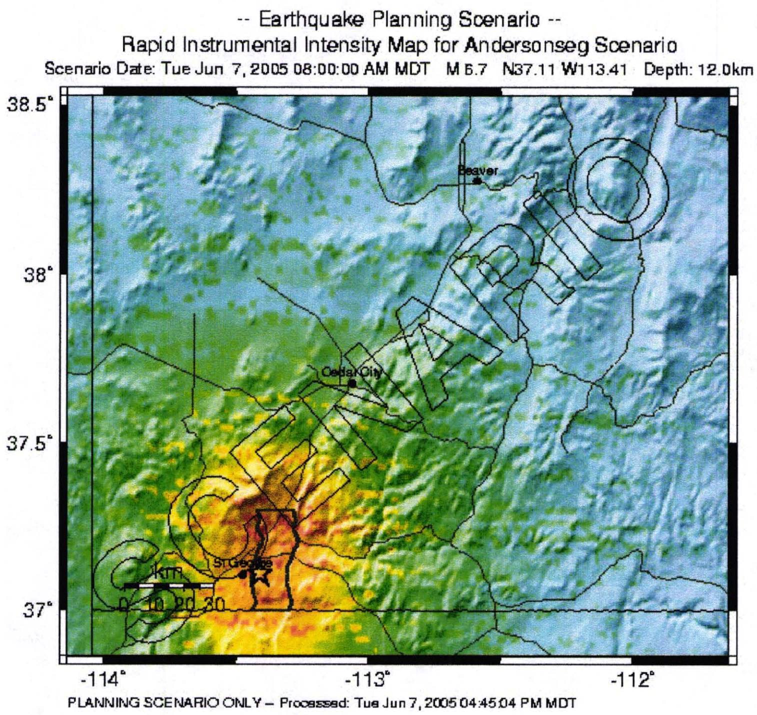
The last increase to the UUSS state line item for operational base support was in 1994, when the Legislature appropriated $75,000 from the general fund to maintain seismic monitoring in Utah outside the Wasatch Front.

Despite (1) past challenges in getting state help for modernizing seismic monitoring in Utah and (2) the erosion of operational base support in its state line item since 1994, UUSS researchers have worked diligently to find funding to modernize and develop seismic monitoring capabilities that provide a great service to the state of Utah.

> The challenge now is to meet Utah's needs for earthquake information and data—for emergency response, earthquake engineering, and earthquake science—in parts of the state outside the Wasatch Front.

Scenario for a Magnitude 6.7 Earthquake (Not the "Big One") on Part of the Hurricane Fault Near St. George . . .

UUSS Scenario "ShakeMap" for M 6.7 Earthquake



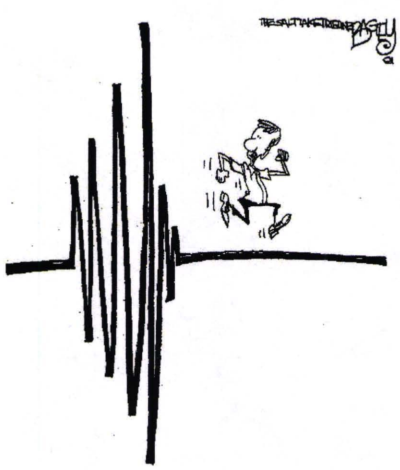
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

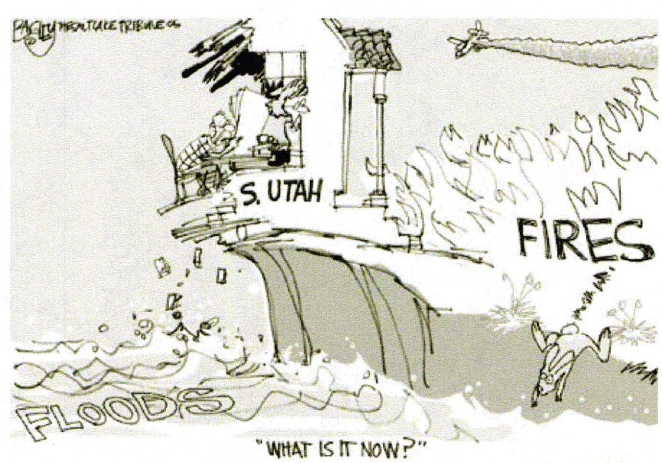
Estimated Earthquake Losses for the Scenario Earthquake *

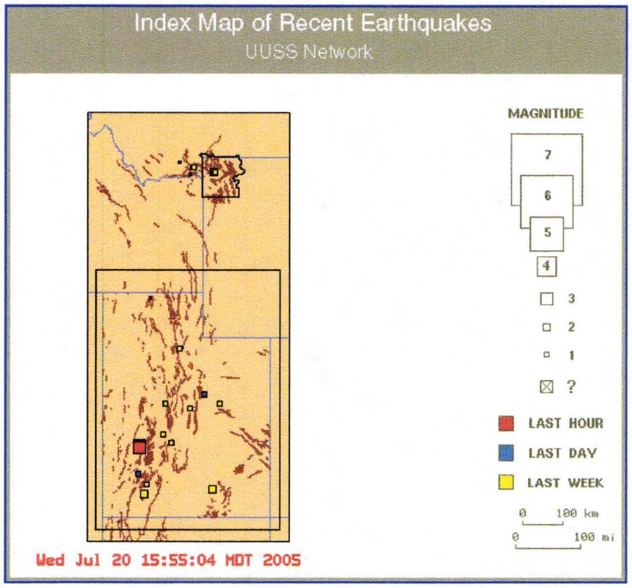
Note: As typical for most loss estimates for a U.S. earthquake of this size, property damage and economic losses loom largest; estimated losses will increase with projected population base.

- Property damage and economic loss — About $232 million, including $199 million in building-related losses and $27 million in utility system losses
- Buildings moderately damaged whose use is restricted — About 3,000
- Buildings severely damaged and unsafe to occupy — About 700
- Buildings destroyed — About 83
- Deaths — 2 to 3
- Injuries — About 85

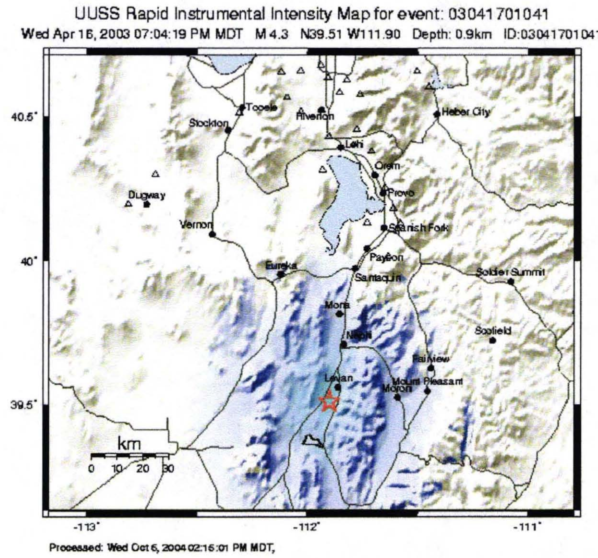
* Source: Utah Division of Emergency Services and Homeland Security; based on linking ShakeMap data with HAZUS loss-estimation software developed by the Federal Emergency Management Agency (FEMA)







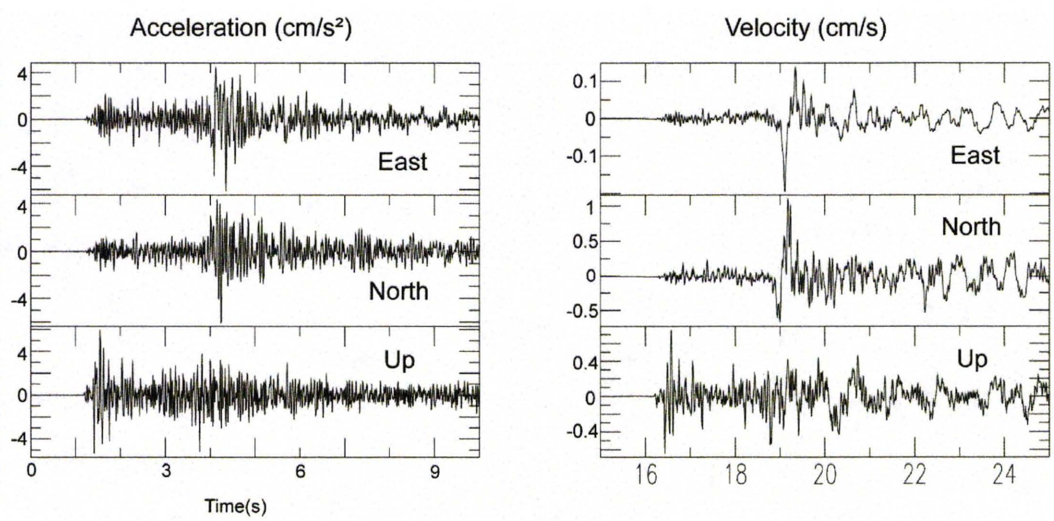
Example of an automated map from the UUSS Web site showing the most recent earthquakes. Users can interactively click for more information.



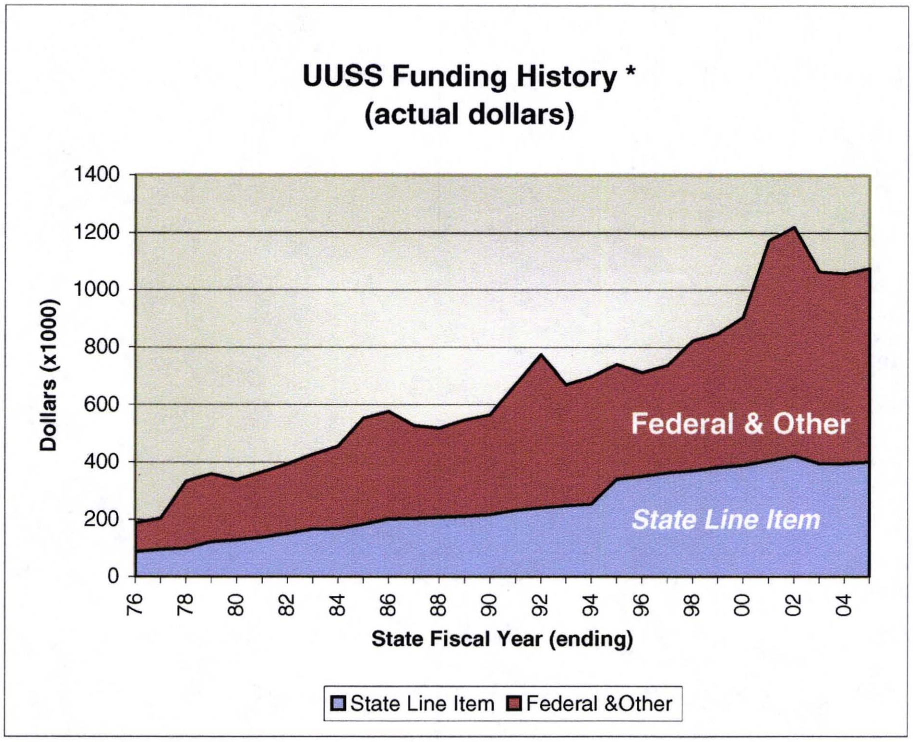
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Moderate/Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<.17	.17-1.4	1.4-3.9	3.9-9.2	9.2-18	18-34	34-65	65-124	>124
PEAK VEL.(cm/s)	<0.1	0.1-1.1	1.1-3.4	3.4-8.1	8.1-16	16-31	31-60	60-116	>116
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Example of an automated ShakeMap from the UUSS Web site showing the intensity of ground shaking from a magnitude 4.3 shock near Levan, Utah, in April 2003 (other available companion maps show measured values of peak ground acceleration and peak ground velocity).

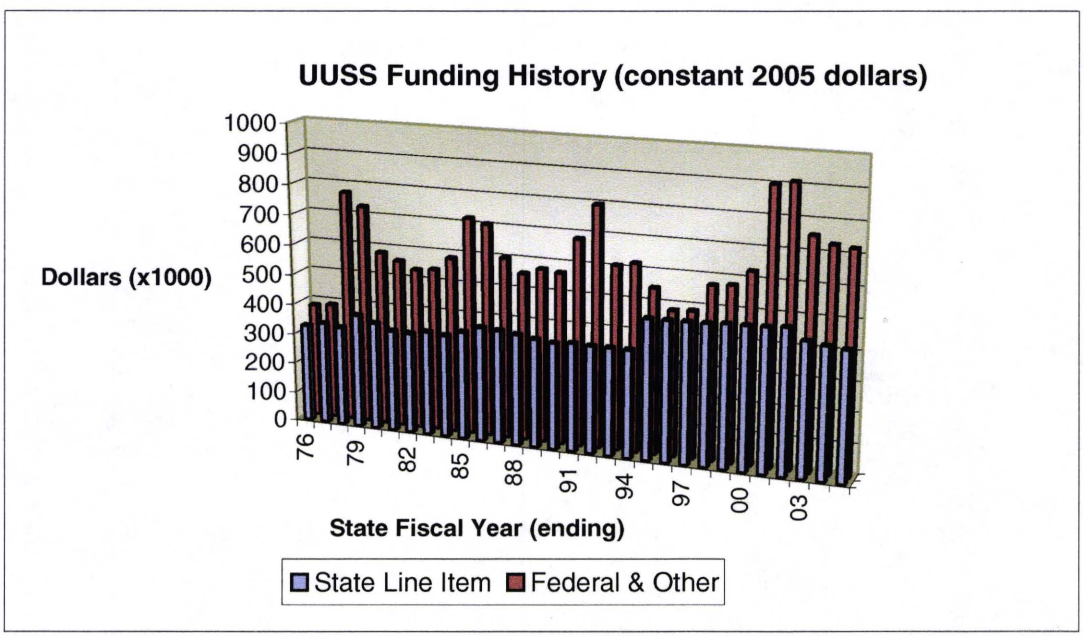
UUSS Earthquake Information Products
www.quake.utah.edu



Examples of digital recordings of ground acceleration and velocity made by a UUSS urban strong-motion instrument at Bates Elementary School in North Ogden, Utah. The ground motion is from a magnitude 3.6 earthquake in January 2003 located eight miles away beneath Pineview Reservoir.



*For Utah Region only—includes funding for seismic-network operations, associated earthquake-related research, and earthquake education and outreach



APPENDIX

Economic Benefits of Improved Seismic Monitoring

The National Research Council has just released a pre-publication version of a report on the economic benefits of improved seismic monitoring. The report can be viewed online at http://books.nap.edu/catalog/11327.html.

Benefits identified by the National Research Council include:

Benefits for emergency response and recovery

- rapid and accurate identification of an earthquake, its location and magnitude, the extent of strong ground shaking (ShakeMaps), and estimates of damage and population impacts
- expedited hazard identification, rapid mobilization at levels appropriate to the emergency, and the rapid identification of buildings that are safe for continued occupation and those that must be evacuated
- a reliable basis (where ShakeMaps are available) for rapid loss estimation and federal disaster declarations

Benefits for earthquake engineering

- seismic monitoring holds the key to understanding how the built environment responds to significant earthquakes
- strong-motion records offer the potential for continued improvement of the design process so that seismic safety requirements are adequately—but not excessively—met
- prediction of expected ground motions leads to new analysis and design techniques to better accommodate those motions

Benefits for improved loss-estimation models

(used by insurers, reinsurers, government agencies, private businesses, the engineering community, and others)

- enhanced accuracy of data underpinning loss estimation models and reduced uncertainties
- increased public knowledge, confidence, and understanding of seismic risk
- better correlation between seismic risk and building codes and land use regulations
- more efficient use of insurance to offset losses from disasters

Potential future benefits

- the feasibility of *earthquake early warning* (when an earthquake is in progress, up to tens of seconds warning before the onset of strong shaking) and the future possibility of *earthquake prediction* both fundamentally depend on seismic monitoring