Earthquake Engineering Research Institute

Japan and New Zealand RAPIDS and Research Needs Workshop
February 9 and 10th, 2012

PROJECT ABSTRACTS, PIs and SLIDES

By disciplinary grouping:
Geotechnical and Earth Sciences
Oceanography
Structures (Group #1)
Structures (Group #2)
Social Sciences
Information Technology (Group #1)
Information Technology (Group #2)

Collaborative Research: RAPID - Post-Disaster Structural Data Collection Following the 11 March 2011 Tohoku, Japan Tsunami

Program Manager:	Joy Pauschke
	CMMI Division of Civil, Mechanical, and Manufacturing Innovation
	ENG Directorate for Engineering
Investigator(s):	Ian Robertson (Principal Investigator)
	Kwok Fai Cheung (Co-Principal Investigator)
Sponsor:	University of Hawaii
	2530 Dole Street
	HONOLULU, HI 96822 808/956-7800
NSF Program(s):	NEES RESEARCH,
	COLLABORATIVE RESEARCH

ABSTRACT:

The tsunami triggered by the 11 March 2011 magnitude 9.0 earthquake off Tohoku, Japan, created widespread structural damage in cities along the Japanese coastline. Careful documentation of flow depth and structural response resulting from this tsunami will provide data that can be used to validate tsunami inundation models and corresponding methodologies for calculating structural response due to the inundation. The primary objective of this Rapid Response Research (RAPID) award is to collect time sensitive impact data in Japan from this March 2011 tsunami that will soon be lost, as buildings and infrastructure in the affected areas are repaired or demolished. The investigation team includes researchers and students from the University of Hawaii and Oregon State University. This study will focus on collecting detailed, localized data in several of the most severely damaged areas of the coastline in the Miyagi and Iwate Prefectures, rather than a general survey of all of the inundation areas, which has been undertaken by other local and international reconnaissance teams. Through this award, the reconnaissance team will collect high resolution, ground based LIDAR data. The LIDAR data will be used to generate virtual models that can be queried for measurements such as flow depths, observed maximum run-up, and scour depths at key sites. These will be complemented with manual measurements and analysis of videos and photographs. The LIDAR data will also provide detailed dimensional data for the structures to be studied. The focus in specific areas of study will provide the data needed for validation of the tsunami inundation model. Furthermore, the structural properties of both damaged structures and undamaged structures will be used to determine hydrostatic, hydrodynamic, and impact forces applied during the tsunami inundation. This field reconnaissance will help resolve several key questions in the tsunami design provisions regarding flow velocities and momentum of tsunami bores and/or wave surges over land and scouring, as well as gain information on overarching questions on risk-based design criteria and the ultimate capabilities of structures to resist a maximum credible tsunami. This team will coordinate reconnaissance activities with the UNESCO-led International Tsunami Survey Team.

Such data are important for understanding how to design buildings to resist earthquakes and tsunamis for public safety. Many parts of the United States and other places in the world that face similar hazards

will benefit from such discoveries, which will help shape building design codes, which are important for public safety. These new standards, validated by information collected on this project, could also provide data in the near future to assist Japan in the recovery phase of their disaster stricken coastal areas. This project will also enable graduate students to observe sites impacted by tsunamis and learn from this event so that they will be better prepared to lead future generations of engineers in reducing seismic and tsunami risk.

Ian Robertson

Professor
Civil and Environmental Engineering
University of Hawaii at Manoa

ianrob@hawaii.edu
Phone: (808) 956-6536
http://www.cee.hawaii.edu/persons/robertson/robertson.htm

Education:
- Ph.D., Civil Engineering, Rice University, Houston, Texas, 1990
- M.S., Civil Engineering, Rice University, Houston, Texas, 1985
- B.S., Civil Engineering, University of the Witwatersrand, Johannesburg, South Africa, 1978

Research Interests:
- Structural engineering: Structural analysis and design for building and bridge structures of reinforced concrete, prestressed concrete and structural steel
- Seismic and long-term monitoring of structures
- Use of fiber reinforced composites in retrofit of older concrete structures
- Multi-hazard mitigation and structural rehabilitation

Biography:
Dr. Robertson was born and raised in South Africa and received his Bachelor's degree in Civil Engineering from the University of The Witwatersrand (White Waters Ridge) in Johannesburg. After a couple of years working for Ove Arup Inc., an international structural and civil design company, he received a Fulbright Scholarship to attend the Civil Engineering Department at Rice University in Houston, Texas for a Master's degree. At Rice University, he performed an experimental study of the performance of welded wire fabric as shear reinforcement in prestressed concrete T-beams under the guidance of Dr. Ahmad Durrani. The results of this work were subsequently published in the PCI Journal.

On his return to South Africa, he again worked for Ove Arup Inc. on both design and construction projects. In 1986, he decided to accept the offer of a Rice University Research Assistantship for a Doctorate in Civil Engineering. His Doctoral studies focused on the seismic performance of slab-column connections. This work was initiated after the poor performance of waffle-slab structures during the September 1985 Mexico City earthquake. The results of this work were published in two ACI Structural Journal articles.

After completing his Ph.D., he worked for Walter P. Moore and Associates in Houston, Texas from 1989 to 1992. He gained valuable design experience in concrete, prestressed concrete and steel design, and numerous site visits that gave him exposure to current construction practices. In 1992, he accepted a position as Assistant Professor at the University of Hawaii, where he currently teaches design related courses, and performs research in the behavior of structures, particularly those employing concrete and prestressed concrete.

Collaborative Research: RAPID- Post-disaster structural data collection following the 11 March 2011 Tohoku Japan tsunami

US Field Team

Lyle CARDEN, Martin & Chock, Inc./ Univ. of Hawaii

Shawn BUTCHER, Oregon State Univ.

Evon SILVIA, Oregon State Univ.

Gary CHOCK, Martin & Chock, ASCE

Kwok Fai CHEUNG, Univ. of Hawaii

Coordinators

Ian ROBERTSON, Univ. of Hawaii

Michael OLSEN, Oregon State Univ.

Solomon YIM, Oregon State Univ.

Japan Field Team

Yasuo OKUDA, Building Research Inst.

Hiroto KATO, BRI

Toshikazu KABEYASAWA, BRI

Hitomitsu KIKITSU, NILIM

Shinya TACHIBANA, Saitama Univ.

Coordinators

BRI, NILIM

Saitama University

Asia Air Survey Co., Ltd.

Objective - Perform detailed, 3D laser scan topographic surveys of select areas for tsunami inundation models, Collect detailed structural data for specific structures as input for future structure modeling and to verify results. Incorporate these findings into improved building codes and planning in coastal regions with seismic and/or tsunami hazards.

Japan and NZ Earthquakes RAPID and Research Needs Workshop
Arlington, VA   Feb 9 and 10, 2012

Key Findings

- ~100GB of scan data (~4 billion data points) collected for many structures and for a topographic map of Onagawa, which is very flat (0.2% slope)

- Numerical modeling results show reasonable correlation to deformations recorded in LiDAR data for the sites analyzed

- However, modeling of the complete loading time-history using a calibrated tsunami inundation model will provide greater insight into the loading and response of the building.

Opportunities for Future Research
- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- The available scan data provides a virtual time capsule (can visit at any time from any viewpoint). This data will continue to be used by the research team to study select structures and calibrate numerical models.

- What advanced algorithms can be developed to process the large scan dataset and reconstruct a 3D model for FEM analysis?

- What updates need to be made to building codes and planning to design or prepare for these large tsunami forces?

- Study of flow around buildings in built environment?

Award Abstract

US-Japan Collaborative Study on Seismic Damage of Buildings and their Mechanism

Investigator(s):   Hitoshi Shiohara (Principal Investigator), The University of Tokyo

Counter-part: John Wallace (Principal Investigator), University of California, Los Angeles

ABSTRACT:

This research aims at collecting and recording the data of structural damage of engineered buildings and investigating the factor which caused each structural damage. The investigation is carried out jointly by researchers of the US and Japan. The Japanese researchers collect information on location, damage intensity and design documents of damaged buildings and provide them for the US researchers. The US researchers visit the affected area in Japan to confirm the information. The researchers of both countries organize and analyze the information and the results will be published as journal papers on SPECTRA; a journal of EERI. As a result the information will be disseminated in English to the engineering society in the world. The efforts should be dedicated to reduce the damage of the buildings in Japan and the US as well as the countries vulnerable to seismic disaster with high seismic activity.

E-Defense Collaboration (Japan) & Post-Earthquake Reconnaissance (Japan)

- NSF RAPID Projects: Japan (3), Chile (1)
  - E-Defense Shaking Table Tests of RC Buildings (Wallace)
  - U.S. Instrumentation and Data Processing for the Four-Story RC and PT E-Defense Building Tests (Wallace)
  - Post-Earthquake Building Reconnaissance in Japan (EERI)
- Participants:
  - US: J Wallace (PI), W Ghannoum (UT), J Moehle (UCB), R Sause (Lehigh); Students: Z Tuna (UCLA), W Keller (Lehigh), M LeBorgne (UT); M Aschheim (SC)
  - Japan: T Nagae (ED), K Tahara (ED), T Matsumori(ED), H Shiohara (UT), T Kabeyasawa (UT ERI), S Kono (Kyoto), M Nishiyama (Kyoto); K. Kaisai (TiT); M Maeda (TU); M Midorikawa (HU).
- Objectives:
  - Pre-test planning, instrumentation and testing, and post-test analysis of two, full-scale, 4-story RC buildings tested on the NIED
  - Post-earthquake assessment of building performance; researcher exchange

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Key Findings

E-Defense 4-story Building Tests:
- Fundamental issues/concerns related to poor performance of conventional construction
- Data from full-scale, 3D buildings subjected to collapse-level shaking vital for model verification and development

Post-earthquake reconnaissance:
- Performance of retrofitted and unretrofitted school buildings in Fukushima and Sendai
- Potential to assess response of high-performance, instrumented buildings (e.g., with dampers), including the performance of "non-structural" elements

Opportunities for Future Research

Opportunities and Focused Research:

- The performance of conventional reinforced concrete special structural wall and moment frame construction in recent earthquakes (Chile, New Zealand) and tests (e.g., E-Defense, NEES tests) indicates fundamental issues that are not understood.
- The large inventory (~400) of low-rise retrofitted and unretrofitted school buildings in Japan provides an excellent opportunity to assess benefits of retrofitting and performance of poorly-detailed columns.
- The large inventory of instrumented buildings with protective systems provides a unique opportunity to study the effectiveness of these systems (and challenges associated with gaining access to data from private structures).
- Instrumented buildings in Japan, post-earthquake monitoring in Chile and New Zealand, and E-Defense full-scale tests provide a wealth of new data for assessing modeling of 3D systems.
- Ground motion characteristics from very large magnitude subduction events, e.g., long-duration, near-field, spectral characteristics, soil impact, etc.
- Performance of "non-structural" elements
- Potential to conduct loss studies at varies scales

Important Lessons:

- Code performance objectives for typical buildings may result in unacceptably large economic and societal impacts
- Implementation of next-generation, performance-based design and assessment tools is essential

Award Abstract #

Evaluation of the Seismic Performance of Bridges during The Great Eastern Japan Earthquake

Investigator(s):　　　Kazuhiko Kawashima (Principal Investigator), Tokyo Institute of Technology

Counter-part:　　　Ian Buckle (Principal Investigator), University of Nevada, Reno

ABSTRACT:

This joint research aims of investigating damage and damage mechanism of bridges which are key structures of road and railways. An emphasis is provided to investigate 1) effectiveness of recent design practice implemented since 1990.

Project Description/Objective

- **RAPID Title**: Evaluation of the Performance of Bridges During the Great East Japan Earthquake
- **US Researchers**: Ian Buckle, David Frost, Wen-huei (Phillip) Yen, Lee Marsh, Shideh Dashti
- **International counterparts**: Kazuhiko Kawashima, Shigeki Unjoh, Jun-ichi Hoshikuma
- **Objective:** To investigate
  - Effectiveness of design and retrofit procedures implemented since Kobe
  - Vulnerability of bridges to tsunami impacts
  - Linkage between duration and damage

Key Findings

- Bridges built in accordance with revised design specifications (post 1990) and those retrofitted since Kobe, had minimal damage. Older bridges, not yet retrofitted or only partly so, suffered significant damage due to ground shaking.

- Typical bridge damage due to tsunami impact included loss of superstructure and loss of approach fills. Some piers were lost due to scour, but not many. Several bridges with integral superstructures survived almost intact.

Opportunities for Future Research

- **New questions requiring basic research**:
  What are the failure modes of non-integral bridges during tsunami events and how can survival be enabled?
- **New data available as a result of these events**:
  Tsunami performance data for range of different types of highway and rail bridges on Route 45 (coastal highway).
- **Unique aspects requiring focused research:** Multiple disciplines (structural, geotechnical, hydrodynamics…) are required for solution to this very challenging problem.
- **Important lessons from these events for the U.S.**: Develop 'no-collapse' strategies for extreme events, and 'fusing' strategies for catastrophic events.

RAPID: Investigation of Cascading Effects of the 2011 Japan Earthquake to Structural Damages of Bridges

Program Manager:	Kishor Mehta
	CMMI Division of Civil, Mechanical, and Manufacturing Innovation
	ENG Directorate for Engineering
Investigator(s):	George Lee (Principal Investigator)
	Jianwei Song (Co-Principal Investigator)
Sponsor:	SUNY at Buffalo
	501 Capen Hall
	Buffalo, NY 14260 716/645-5000
NSF Program(s):	COLLABORATIVE RESEARCH,
	HAZARD MIT & STRUCTURAL ENG

ABSTRACT:

This Rapid Response Research (RAPID) award provides funding to carry out an exploratory study focused on modeling of structural damages of selected bridges subjected to long duration, high intensity earthquakes (including both mainshock alone and mainshock plus aftershocks), and strong earthquake followed by tsunami wave force by using actual input data of the March 11, 2011 Japan earthquake off the Pacific coast of Tohoku. The PIs will work with their Japanese research partners who are collecting ground motion and tsunami wave force records as well as other useful perishable information; and will identify instrumented and damaged bridges that are suitable for preliminary investigations on the correlations between structural damages and long duration earthquake load effects as well those due to cascading hazard effects. Based on information available, special emphasis for field data collection in this exploratory study will include some or all of: (1) the structures designed according to comparably strict seismic design codes of Japan, but damaged in the mainshock earthquake most likely due to the characteristic of long duration; (2) the bridges survived in mainshock earthquake with minor damages, but damaged more severely or even collapsed in sequential aftershock earthquakes (including earthquake and/or tsunami introduced soil liquefaction effects); (3) damaged or collapsed bridges near coast in hazard region due to combined actions of the mainshock earthquake, tsunami water wave forces associated with the impact forces from floating debris objects, cars and ships to impact the structures; (4) the bridge failure as a result of degradation or loss of function of structural protection systems implemented on the bridge.

The results of this exploratory research will be presented to an NSF workshop for considering future research opportunities related to multiple extreme hazard (including cascading events) mitigation of civil infrastructure systems. The study will also contribute to continued US-Japan cooperative earthquake engineering research and expanding the scope to multiple extreme event engineering. Additionally, this study will provide an opportunity to train post-doctoral and graduate students to understand the complex nature and challenges to develop multi-hazard resilient structures.

George C. Lee

SUNY Distinguished Professor
Department of Civil, Structural and Environmental Engineering
University at Buffalo

gclee@buffalo.edu
Phone: 716-645-2039
http://www.csee.buffalo.edu/people/interactive-people-search/
name:george-c-lee/

Education:
- Ph.D., Civil Engineering, Lehigh University, 1960
- M.S., Civil Engineering, Lehigh University, 1958
- B.S., Civil Engineering, National Taiwan University, 1955

Research Interests:
- Behavior and Design of Metal Structures
- Seismic Design and Retrofit of Buildings and Bridges
- Structural Response Modification Technologies Biomechanics

Biography:
During his 48 years of educational services at UB, Dr. Lee has mentored 20 post-doctoral fellows, supported over 30 international visiting scholars and guided 46 Ph.D. students and 75 M.S. students. He has coauthored four books and published more than 250 papers on structural engineering and mechanics, steel structures and earthquake engineering. In his earlier career, he also made contributions in cold regions structural engineering and in biomechanics of living systems.

Dr. Lee has held leadership positions in numerous professional organizations in which he is a member, including: American Society of Civil Engineers, Structural Stability Research Council, U.S. National Committee on Biomechanics, and Committee on Hazard Mitigation Engineering of the National Research Council. He has served as the editor-in-chief or as a member of editorial boards of several ASCE and international journals. At present, he is the editor-in-chief (U.S.) of *Journal of Earthquake Engineering and Earthquake Vibration*.

Recent Research Projects:
Dr. Lee's currently funded research projects (NSF and FHWA) include Seismic Design of Structures with Added Response Modification and Isolation Systems, Behavior and Design of Segmental Piers for Accelerated Bridge Construction in Seismic Regions, Development of Multi-hazard Design Principles for Highway Bridges and Bridge Damage Monitoring System. In addition, he has been since 1992 supported by NSF to organize annual US-PRC Protocol meetings on cooperative research on earthquake engineering, and supported by the Federal Highway Administration to organize bi-lateral workshops on bridge engineering with Japan and China on an annual basis.

Cascading Effects of 2011 Tohoku Earthquake to Structural Damages of Bridges

George C. Lee, Jianwei Song & Yihui Zhou
MCEER, University at Buffalo

Background and Motivation:

Satellite Photo of the Utatsu O-Hashi after the Earthquake and Tsunami:

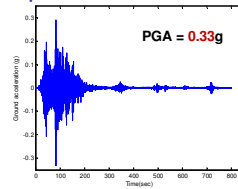**Ground Motion Record Station at Tohoku University:**

Base on Preliminary Investigation Using Simplified Assumption:

- Many research opportunities exist to quantify cascading effects of earthquake and tsunami wave force
- Research efforts should be further expanded to other extreme event combination, such as earthquake + earthquake (long duration earthquakes), earthquake + vessel collision, earthquake + scouring, etc.

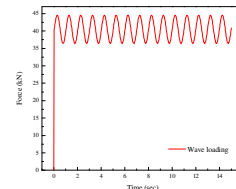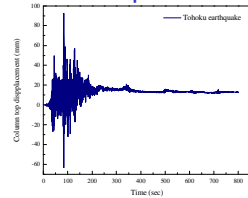MCEER EARTHQUAKE ENGINEERING TO EXTREME EVENTS
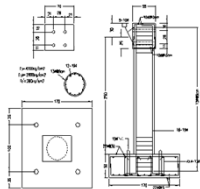
Bridge column model: **Earthquake record from Tohoku Univ.:**   **Wave force simulation:**

PGA = 0.33g
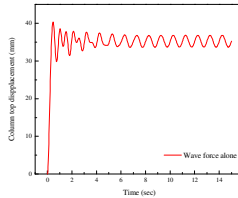
Earthquake   **Wave Attack**   **Earthquake + Wave Attack**
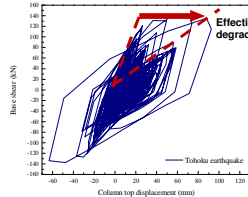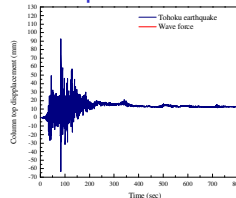
Effective stiffness degradation: 70%

Failure

MCEER EARTHQUAKE ENGINEERING TO EXTREME EVENTS
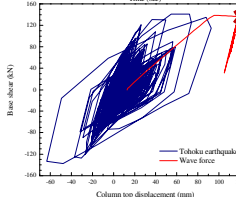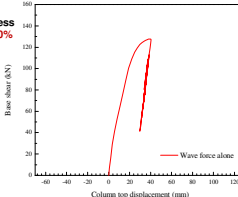
Experimental Study on Long Duration Earthquake Effect--Cyclic loading test carried out in Taiwan:

Loading Protocol

Drift(%)		0.25	0.375	0.5	0.75	1.0	1.5	2.0	3.0	4.0	5.0	6.0
Conventional Protocol	Number of Cycle	2	2	2	2	2	2	2	2	2	2	2
Long Duration Protocol		45	30	30	20	20	15	15	10	3	1	1
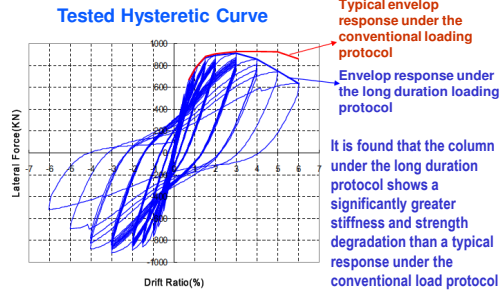
Loading Setup

End of Test

Tested Hysteretic Curve

Lateral Force(KN)

Drift Ratio(%)

Typical envelop response under the conventional loading protocol

Envelop response under the long duration loading protocol

It is found that the column under the long duration protocol shows a significantly greater stiffness and strength degradation than a typical response under the conventional load protocol

MCEER EARTHQUAKE ENGINEERING TO EXTREME EVENTS

RAPID: Workshops to Facilitate Engineering Research Related to 2011 Tohoku-Kanto Earthquake and Tsunami

Program Manager: Kishor Mehta
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s):   Stephen Mahin (Principal Investigator)

Sponsor: University of California-Berkeley
Sponsored Projects Office
BERKELEY, CA 94704 510/642-8109

NSF Program(s):   NEES RESEARCH,
HAZARD MIT & STRUCTURAL ENG,
GEOTECHNICAL ENGINEERING

ABSTRACT:

The Tohoku-Kanto earthquake of March 9, 2011 and the tsunami that followed it, though unfortunately devastating, are very unique events of unparalleled scientific and engineering interest. This earthquake has caused extensive damage to built environment, yet there are examples of structures that have survived the strong shaking. Apparently, Japanese researchers have already collected some information about the damaged and undamaged structures and are willing to share this information with their US counterparts. Much can be learnt from further in-depth analysis of this information to understand the causes of failures and survivals of these structures with the objective of preventing this from happening in future events. This project will support the travel to Japan of a team of researchers to enable them to meet with Japanese engineers and researchers to gather data and information about the damage caused by this earthquake and tsunami that can be shared with US researchers. The team will hold workshops and meetings with Japanese researchers to gather information about what data of research interest is available, and disseminate this information to the wider research community in the US through webcast seminars, Webex-type workshops, and meetings. This is expected to lead to future international research collaborations between the US and Japanese researchers for in-depth scientific investigations about the performance of the built environment during strong earthquakes, with the final objective of mitigating the impact of such mega-events and disasters.

Stephen A. Mahin

Byron L. and Elvira E. Nishkian Professor of Structural Engineering
University of California, Berkeley

Director
Pacific Earthquake Engineering Research Center

mahin@berkeley.edu
Phone: (510) 693-6972
Fax: (510) 643-8928
http://www.ce.berkeley.edu/people/faculty/mahin

Education:
- Ph.D., University of California, Berkeley, Earthquake Engineering
- M.S., University of California, Berkeley, Earthquake Engineering
- B.S., University of California, Berkeley, Civil and Environmental Engineering

Research Interests:
- Behavior of structures
- Earthquake engineering
- Pseudodynamic methods for laboratory testing
- Refined analytical modeling
- Seismic isolation of bridges and buildings

RAPID: Workshops to Facilitate Engineering Research Related to 2011 Tohoku-Kanto Earthquake and Tsunami

Goals:

1. Convene and coordinate a small **expeditionary team** immediately following the earthquake.
2. **Web-cast a seminar** sharing information from the expeditionary team for NSF-funded teams and the general research community, professionals and public.
3. Organize a **web-based workshop** of NSF-funded teams to identify areas of common interest and share ideas.
4. Coordinate regular **web-based meetings** as a forum for sharing lessons learned and research findings by funded researchers studying the earthquakes and tsunami.

Four structural and lifeline engineers, four geotechnical engineers, and two tsunami experts, plus numerous Japanese counterparts

RAPID Award NO 1137811

PI: Stephen Mahin

Outcomes:

- U.S. team visited Japan in early April 2011 to conduct field surveys and discussions with many Japanese organizations investigating the earthquake and tsunami effects.

- Quick report on findings and resources released April 25, 2011
- Webinar was held on April 28, 2011 with over 300 attendees both in-person and online to relay information, especially to those preparing proposals for NSF RAPID grants

  http://peer.berkeley.edu/events/2011/04/prelim-tohoku-briefing/

- RAPID awardees participated in two web-enabled roundtable discussions on July 25 & 29. Positively viewed by participants.

  "[It is] good to know of other scientists working on Fukushima projects"
  "The preparation help me coordinate my work with that of Dr. A. It also will lead to some collaboration with Dr. B."

RAPID Award NO 1137811

Key Engineering Research Issues

Tsunami: Need to benchmark and improve ability to predict tsunami waves, their interaction with costal geometries and structures, and regions of expected flooding. Effectiveness of early warning systems and evacuation procedures should be studied. Improve behavior of structures to tsunami & debris.

Liquefaction and settlement: Improve understanding of the triggering of liquefaction and lateral spreading, the deformations that occur, and the consequences on supported structures.

Nuclear Power Plants & Critical Industrial and Lifeline Facilities: High priority topics include the direct effects of earthquakes and tsunami, inoperability issues for critical lifeline facilities, economic impacts on community, nation and region, and radioactive contamination.

Disruption of business and social systems: In addition to general economic, business and related studies associated with consequences disruption of lifelines and structural damage, investigations are needed on improving the operationally critical lifelines and seismic resistance of nonstructural components and equipment.

Effect of shaking on structures: Study is needed to under-stand the features of ground motions, structures and supporting soil that led to less than expected damage in many cases. Special opportunities exist to study recorded response of modern buildings. Studies are needed on effects of vibrations on occupants and contents.

Award Abstract #

Investigation on the Performance of Buildings with Structural Walls in The Great Eastern Japan Earthquake

Investigator(s):   Masaki Maeda (CoPrincipal Investigator), Tohoku University

Counter-part: Santiago Pujol (Principal Investigator), Purdue University
spujol@purdue.edu

ABSTRACT:

Severe structural failures caused by the Maule, Chile, Earthquake of 2010 (Mw = 8.8) have demonstrated that there are critical missing links in our technology related to earthquake resistance of mid- to high-rise buildings with structural reinforced concrete walls. In Concepción, Chile, where the peak ground acceleration did not exceed 0.4g, nearly 7% of the buildings with structural concrete walls and more than 10 stories were evacuated and scheduled for demolition. In contrast, the intensity of the ground motion caused by The Great Eastern Japan Earthquake was larger (with peak ground accelerations exceeding 2g) but the frequency of building damage was lower. The goal of this investigation is to collect perishable, quantitative field information on the seismic performance of buildings with dominant structural walls in the Tohoku region and compare it with similar information obtained in Chile. The Japanese team will mainly analyze the buildings in Tohoku area, while the US team will mainly analyze the buildings in Chile. The knowledge to be generated by this investigation is essential for the safety of urban populations in seismic regions. The investigation will lead to elimination of massive economic and human losses in future earthquakes.

Investigation on the Performance of Buildings with Structural Walls in the 2011 East Japan Earthquake

Maeda Masaki, Tohoku University, Japan
Counterpart: Prof. Santiago Pujol, Purdue University

Objectives
➤Investigate damage and performance of RC buildings.
  ➤ Damage statistics
  ➤ Analysis of severely damaged RC buildings with structural walls
➤Investigate the reliability and effectiveness of seismic evaluation methods, retrofit measures, and design provisions

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Key Findings

➤ Japanese RC buildings performed very well during the severe ground shaking caused by the East Japan Earthquake (in terms of collapse prevention -life safety-)

Legend:
- Slight or Non
- Minor
- Moderate
- Severe
- Collapse

	Slight or Non	Minor	Moderate	Severe	Collapse
Pre-1971	61	2	1	2	
1971-1981	209	17	4	1	
Post-1981	236	3	3		
total	505	22	8	3	
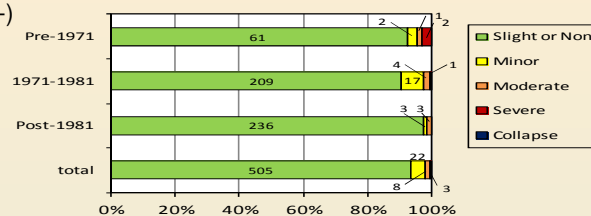
➤ Some retrofitted buildings and buildings believed to be safe had to be evacuated.

Boundary columns of wall in the 3rd floor were crushed

Civil engineering building in Tohoku University

Shear Failure on Coupling Beam with Opening

Electrical engineering building

Opportunities for Future Research

➢ <u>What new data are available?</u>
  Data from buildings (including structural drawings and earthquake records) that had been evaluated and retrofitted were obtained. *Such data will help to improve the reliability of seismic performance evaluation methods.*

➢ <u>What new questions require basic research?</u>
➢ <u>What unique aspects require the development of a focused research program?</u>
  Reasons for relatively infrequent damage to RC Buildings and effectiveness of seismic retrofit measures should be investigated.
  Serviceability and "reparability" limit states for RC buildings need to be defined and better evaluation method should be developed.

Award Abstract # 1138668

RAPID: Impact of Debris Generated from the 11 March 2011 Tohoku, Japan Tsunami

Program Manager:	Joy Pauschke
	CMMI Division of Civil, Mechanical, and Manufacturing Innovation
	ENG Directorate for Engineering
Investigator(s):	Clay Naito (Principal Investigator)
Sponsor:	Lehigh University
	Alumni Building 27
	Bethlehem, PA 18015 610/758-3021
NSF Program(s):	NEES RESEARCH,
	COLLABORATIVE RESEARCH

ABSTRACT:

The objective of this grant for rapid response research (RAPID) is to assess the type of debris generated by tsunami events and quantify the resulting impact damage to structures. To achieve this objective, a field investigation of the northeast coast of Honshu, Japan, inundated by the 11 March 2011 Tohoku tsunami, will be conducted by a team of researchers from Lehigh University, Oregon State University, University of Hawaii, and Japan's Nagoya University. The research team will acquire field data on tsunami generated debris, document cases of impact on structures in Japan, and use this field data to validate results of an ongoing experimental and analytical NSF-supported research project on tsunami generated debris impact. The research will assess the type and size of debris demands typical for coastal communities, assess structural damage patterns generated as a result of impact events, and validate models developed as part of the ongoing NSF-supported study. This research team will also coordinate with the UNESCO-led International Tsunami Survey Team.

The knowledge gained from the proposed research will be used for enhancement of U.S. infrastructure code recommendations and design practice for coastal communities where the threat of a tsunami event exists. Identification of debris type is critical for determination of potential design loads. Video footage and post-event images indicate that the Tohoku event generated a spectrum of debris ranging from wood, vehicles, and shipping containers, to entire houses and ships. Assessment of what size and type of debris is likely in a given region is critical for the development of design recommendations. In addition, the occurrence of impact events may not be associated with all types of debris, and some structural systems may be more sensitive to a type of impact demand. These issues will be quantified with the field studies conducted in Japan.

Clay J. Naito

Associate Professor
Department of Civil and Environmental Engineering
Lehigh University

cjn3@lehigh.edu
Phone: 610-758-3081
Fax: 610-758-5553
http://www.lehigh.edu/~cjn3/

Education:
- Ph.D. University of California Berkeley, Civil Engineering, 2000
- M.S. University of California Berkeley, Civil Engineering, 1994
- B.S. University of Hawaii Manoa, Civil Engineering, 1993

Research Interests:
- Experimental and Analytical Evaluation of Reinforced and Prestressed Concrete Structures Subjected to Extreme Events including Earthquakes, Tsunamis, and Intentional Blast Demands.

Recent Research Projects:
- NSF: Development of a Blast and Ballistic Resistant Precast Concrete Armored Wall System
- NEES-CR: Impact Forces from Tsunami-Driven Debris
- Inspection Methods & Techniques to Determine Non Visible Corrosion of Prestressing Strands in Concrete Bridge Components
- Daniel P. Jenny PCI Fellowship: Analytical Assessment of the Resistance of Precast Structures to Blast Effects
- Development of a Seismic Design Methodology for Precast Diaphragms
- Development of a Welding Procedure Specification for Field Welding of Precast Concrete Connections
- Use of Polyurea for Blast Hardening of Concrete Construction
- Estimation of Concrete Response Under Varying Confinement
- Evaluation of Bond Mechanics in Prestressed Concrete Applications
- Horizontal Shear Capacity of Composite Beams Without Ties
- Lateral Resistance of Plywood and Oriented Strand Board Sheathing After Accelerated Weathering

Project Description/Objective

- NSF Rapid: Impact of Debris Generated from the 2011 Tohoku, Japan Tsunami (CMMI-1138668)
- US Researchers: Clay Naito, Dan Cox, Kent Yu, Ron Riggs and Marcelo Kobayashi
- International counterparts: Daiki Tsujio (Pacific), Prof. Norimi Mizutani (Nagoya University)

Project Objectives

Acquire field data on tsunami generated debris and document cases of impact on structures in Japan. Assess the type and size of debris demands typical for coastal communities. Assess structural damage patterns generated as a result of impact events. Validate models developed as part of an ongoing NEES study.

Key Findings

- Tsunami generated debris can be divided into three categories:
    a) Small disbursed debris which alters the water density
    b) Moderate size/mass debris which can result in localized impact and damage to structures (i.e., containers and vehicles)
    c) Large size debris which can result in significant damage to evacuation shelters (i.e., ships and buoyant buildings)
- Type of debris present in a region is dependent on the coastal region. For example ports and resort communities are subject to different debris demands.
- Structural damage from debris impact is dependent on:
    - The structural configuration of the facility below the inundation depth. For example column supported structure with an open floor plan would see higher flow velocities than a solid box type building and would thus be subject to higher impact velocities and consequently impact force.
    - The debris category likely in the facility region.
- Fuel storage containers located in inundation zones will likely be subject to tie-down failure and lateral movement resulting in fuel contamination of the region. Storage should be constructed on elevated low-drag resilient supports or a tether system should be integrated to prevent the container from becoming debris.

Opportunities for Future Research

- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- What new questions raised by these events require basic research?
  - How do we determine the likely debris category for a region?
  - How do we conservatively estimate the potential impact forces that would be generated from the categories of debris identified?
  - How do we effectively design or protect shelters and critical structures for the categories of debris identified?
- What new data are available as a result of these events?
  - Photos of tsunami generated debris and impact on structures were taken. Measurements of impact damage cases were recorded.
- What unique aspects of these events require the development of a focused research program?
  - Flow of tsunami generated debris in coastal regions should be examined to assess likely impact and speed at impact for different structural configurations.
  - Use of field observations to inform the hydrodynamic testing of tsunami-debris loading for NEES Grant No.1041666
- What are the important lessons from these larger than expected events for the U.S.?
  - Tsunami generated debris can result in impact and damming leading to significant damage to structures in coastal communities.

Collaborative Research: RAPID- Post-disaster structural data collection following the 11 March 2011 Tohoku Japan tsunami

US Field Team

Lyle CARDEN, Martin & Chock, Inc./ Univ. of Hawaii

Shawn BUTCHER, Oregon State Univ.

Evon SILVIA, Oregon State Univ.

Gary CHOCK, Martin & Chock, ASCE

Kwok Fai CHEUNG, Univ. of Hawaii

Coordinators

Ian ROBERTSON, Univ. of Hawaii

Michael OLSEN, Oregon State Univ.

Solomon YIM, Oregon State Univ.

Japan Field Team

Yasuo OKUDA, Building Research Inst.

Hiroto KATO, BRI

Toshikazu KABEYASAWA, BRI

Hitomitsu KIKITSU, NILIM

Shinya TACHIBANA, Saitama Univ.

Coordinators

BRI, NILIM

Saitama University

Asia Air Survey Co., Ltd.

Objective - Perform detailed, 3D laser scan topographic surveys of select areas for tsunami inundation models, Collect detailed structural data for specific structures as input for future structure modeling and to verify results. Incorporate these findings into improved building codes and planning in coastal regions with seismic and/or tsunami hazards.

Japan and NZ Earthquakes RAPID and Research Needs Workshop
Arlington, VA   Feb 9 and 10, 2012

Key Findings

- ~100GB of scan data (~4 billion data points) collected for many structures and for a topographic map of Onagawa, which is very flat (0.2% slope)

- Numerical modeling results show reasonable correlation to deformations recorded in LiDAR data for the sites analyzed

- However, modeling of the complete loading time-history using a calibrated tsunami inundation model will provide greater insight into the loading and response of the building.

Opportunities for Future Research
- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- The available scan data provides a virtual time capsule (can visit at any time from any viewpoint). This data will continue to be used by the research team to study select structures and calibrate numerical models.

- What advanced algorithms can be developed to process the large scan dataset and reconstruct a 3D model for FEM analysis?

- What updates need to be made to building codes and planning to design or prepare for these large tsunami forces?

- Study of flow around buildings in built environment?

Award Abstract # 1139364

RAPID/IUCRC: An International University Collaborative Research Program between the Center for Friction Stir Processing (an NSF I/UCRC) and Tohoku University

Program Manager: Rita V. Rodriguez
CNS Division of Computer and Network Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Tracy Nelson (Principal Investigator)

Sponsor: Brigham Young University
A-285 ASB
Provo, UT 84602 801/422-6177

NSF Program(s):   INTERNATIONAL RES NET CONNECT,
COLLABORATIVE RESEARCH,
GRANT OPP FOR ACAD LIA W/INDUS

ABSTRACT:

This RAPID project, enabling graduate students from the Kokawa Laboratory from Tohoku University in Japan to go to Brigham Young University (BYU) to use the facilities and equipment available within the CFSP (Center for Friction Stir Processing, an NSF ENG I/UCRC) to continue performing essential research for short periods of time (2-6 weeks), responds to the disaster in the labs caused by the March 11 earthquake in Japan. Sensitive Optical and electron microscopy equipment were rendered unusable and are currently not on the priority list for immediate repair. Thus, the project aims to satisfy the following objectives:

- Enable students to continue their research;

- Engage graduate, undergraduate, and underrepresented students and faculty from five different countries in an international collaborative effort;

- Expose students to a wider breadth of research and development in FSW&P;

- Expand international networking opportunities; and

- Enlarge the international database of Friction Stir Welding (FSW) processes and practices.

The research work at both universities has a long history of producing outstanding intellectual results, as evidenced by more than 60 publications in Tohoku and more than 30 at BYU in this area in recent years. While at BYU, the students will be performing joint research in:

- FSW of steels, stainless steels, and titanium alloys,

- Tooling for FRW&P, and

- Grain boundary engineering.

The USA researchers collaborate with the Japanese investigators from Tohuku University, Dr. Hiroyuki Kokawa and Dr. Yutaka Sato. The former has co-authored a relevant book in the area, while the latter has spent a sabbatical year at BYU. Thus, a useful collaboration already exists. A letter of support and biographical sketch of the Japanese collaborator is included in the supplementary document.

Broader Impacts:

Students representing five different countries, along with faculty from Japan and USA will be engaged in this international collaborative research effort. Both undergraduate and graduate students will be invited to present their work to more than 20 industrial sponsors from around the world during annual and semi-annual CFSP meetings. The research will be broadly disseminated in the technical community in the form of journal papers and technical presentations.

Obviously, contributing equipment to help in the completion of on-going research should enhance the USA students while enabling the exchange of ideas. In general, the project also contributes to train graduate and undergraduate students exposing them to high-impact application areas.

Tracy Nelson

Professor
Department of Mechanical Engineering
Brigham Young University

nelsontw@byu.edu
Phone: (801)422-6233
http://me.byu.edu/faculty/tracynelson

Education:
- Ph.D., The Ohio State University, Welding Engineering, 1998
- MS, The Ohio State University, Welding Engineering, 1993
- BS, The Ohio State University, Bachelor of Science, Welding Engineering, 1991
- Assoc., Ricks College, Associates Degree, Welding Engineering Technology, 1990

Research Interests:
- Welding
- Welding Metallurgy
- Friction Stir Welding
- Materials Characterization
- Fracture and Failure Characterization
- Fracture Mechanics

Biography:
Dr. Tracy Nelson is an Assistant Professor of Mechanical Engineering. He received his Ph.D. in Welding and Materials Engineering from The Ohio State University. Prior to joining BYU, he worked at Edison Welding Institute from 1989 to 1993 and Westinghouse-Power Generation from 1993-1994. At BYU his research focus includes materials and failure related issues involving welding. During the past four years Dr. Nelson's research focus has been in the area of Friction Stir Welding, a relatively new solid state joining process. During this time Dr. Nelson has authored and co-authored numerous papers, proceedings and patents in friction stir welding. Dr. Nelson also serves on two AWS handbook chapter committees and as an advisor to the AWS D17-Friction Stir Welding specification committee.

Collaborative Research Program between the Center for Friction Stir Processing (an NSF I/UCRC) and Tohoku University

Dr. H. Kokawa, Dr. Y. Sato, Tohoku University, Sendai, Japan

Dr. T. W. Nelson, Brigham Young University, Provo, UT

Objectives:

1. Enable students in the Kokawa Lab at Tohoku University the ability to continue their research,

2. Engage graduate, undergraduate and underrepresented students and faculty from five different countries in an international collaborative research effort,

3. Expose students to a wider breadth of research and development in FSW&P.

Key Findings

- **Research topic:** Microstructure and mechanical properties of friction stir welded high-strength steels
- **Student name:** Sangchul Lee, Ph.D. candidate
- **Visiting period:** July 17 to August 6, October 17 to November 4
- **Progress:** Friction stir welding produced defect-free welds at various welding parameters in the high-strength steels. Although the stir zone exhibited higher hardness than the base material, the hardness value of the stir zone depended on the welding parameters, i.e., with decreasing the rotational speed, the hardness increased up to 500 rpm and then decreased. To examine effect of parameter on hardness of the stir zone with microstructure, the microstructure data was precisely obtained through EBSD analysis at BYU.

- **Research topic:** Microstructure evolution of Ti-6Al-4V alloy during friction stir welding
- **Student name:** Yoshito Nagahama, Master student
- **Visiting period:** September 12 to October 14
- **Progress:** EBSD map of wide region including the stir zone, thermo-mechanically affected zone and base material region on the cross section perpendicular to the welding direction was obtained at BYU. Precise examination of the EBSD data revealed that equiaxed fine grains were formed through discontinuous recrystallization in the stir zone.

- **Research topic:** Effect of cobalt on microstructure and properties of friction stir welded steels
- **Student name:** Masahiro Miyake, Ph.D. candidate
- **Visiting period:** November 7 to November 25, January 23-February 10
- **Progress:** The microstructure examinations of the friction stir welded steels were conducted by chemical composition analysis and SEM at BYU. Chemical analysis revealed that the cobalt was uniformly distributed in the stir zone. Any reaction phases could not be found through SEM observation. From these results, the cobalt tools hardly affect the weld properties in steels, even if they experience the severe wear during friction stir welding.
- During January 2012, Mr. Miyake performed experiments with specialized equipment available at BYU

- This collaboration helped us in continuing our research. Our students could continue their own research projects using BYU facilities, and the projects were better with inputs from BYU professors. Dr. Y. Sato

Opportunities for Future Research

RAPID program has provide new opportunity for collaboration
between BYU and Tohoku University
The CFSP plans to invite Dr. Sato to is Spring IAB meeting to present
results
Anticipate preparing joint proposal in near future

RAPID: Collaborative Research: Using Lessons from the Disaster in Japan to Develop Communications for Emergency Situations

Program Manager: Sajal Das
CNS Division of Computer and Network Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Arjan Durresi (Principal Investigator)

Sponsor: Indiana University
P O Box 1847
Bloomington, IN 47402 812/855-0516

NSF Program(s):   COLLABORATIVE RESEARCH,
INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

During disasters, the telecommunication infrastructure are usually heavily damaged or overloaded, which leads to serious disruptions in the warning and rescue operations. Similarly, part of the Japanese cellular Early Earthquake Warning (EEW) system were damaged during the March 11th earthquake and tsunami. This collaborative project proposes to study the disruption of emergency communications during the last disaster in Japan and investigate corresponding solutions. In particular, the project has the following three integrated objectives: 1) To study the cellular EEW system of Japan and its use in the March 11th earthquake in Japan; 2) To study the communication problems that were encountered leading to disruptions in warning and rescue operations; and 3) To explore tower-less phone-to-phone direct communication mode that can make the cellular phone communications much more resilient during disasters.

This project supports collection of data about communication disruptions in Japan; treatment of such data to better understand the impact of telecommunication failures; and finally, solutions how to enhance the cellular system with ad hoc communications. The project is a close collaboration among PIs inthe US, their collaborators in Japanese universities and cellular service providers in Japan.

The outcome of this project will lead to a deeper understanding of tradeoffs among robustness, simplicity, scalability, self-organization and adaptivity in designing a cellular emergency broadcast system for USA and beyond. The results of this project will have a direct and practical impact on developing an effective emergency warning system using the latest communication devices.

Award Abstract # 1138665

RAPID: Collaborative Research: Using Lessons from the Disaster in Japan to Develop Communications for Emergency Situations

Program Manager:	Sajal Das
	CNS Division of Computer and Network Systems
	CSE Directorate for Computer & Information Science & Engineering
Investigator(s):	Raj Jain (Principal Investigator)
Sponsor:	Washington University
	ONE BROOKINGS DRIVE, CAMPUS BOX
	SAINT LOUIS, MO 63130 314/889-5100
NSF Program(s):	COLLABORATIVE RESEARCH,
	INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

During disasters, the telecommunication infrastructure are usually heavily damaged or overloaded, which leads to serious disruptions in the warning and rescue operations. Similarly, part of the Japanese cellular Early Earthquake Warning (EEW) system were damaged during the March 11th earthquake and tsunami. This collaborative project proposes to study the disruption of emergency communications during the last disaster in Japan and investigate corresponding solutions. In particular, the project has the following three integrated objectives: 1) To study the cellular EEW system of Japan and its use in the March 11th earthquake in Japan; 2) To study the communication problems that were encountered leading to disruptions in warning and rescue operations; and 3) To explore tower-less phone-to-phone direct communication mode that can make the cellular phone communications much more resilient during disasters.

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Raj Jain

Professor
Washington University in St. Louis

jain@wustl.edu
Phone: (314) 935-4963
Fax: (314) 935-7302
http://engineering.wustl.edu/facultybio.aspx?faculty=125

Education:
- PhD, Harvard University, 1978
- ME, Indian Institute of Science, 1974
- BS, A.P.S. University, 1972

Research Interests:
- Wireless networks
- Network security
- Next generation Internet
- Sensor networks
- Telecommunications networks
- Performance analysis
- Computer networks
- Optical networks
- Broadband access
- Traffic management
- Datacenter networks
- TCP/IP, ATM, WiMAX, and Gigabit Ethernet.

Biography:
Professor Jain is a Fellow of IEEE, a Fellow of ACM and is on the Editorial Boards of Computer Communications (UK), Journal of High Speed Networks (USA), Mobile Networks and Nomadic Applications, International Journal of Virtual Technology and Multimedia (UK) and International Journal of Wireless and Optical Communications (Singapore).

His book, "Art of Computer Systems Performance Analysis" won the 1991 "Best-Advanced How-to Book, Systems" Award. His fourth book entitled, "High-Performance TCP/IP: Concepts, Issues, and Solutions" was published by Prentice Hall in November 2003.

He was also a Co-founder and Chief Technology Officer of Nayna Networks, Inc., a next generation telecommunications systems company in San Jose, CA.

Arjan Durresi

Associate Professor
Department of Computer and Information Science
Indiana University Purdue University Indianapolis

durresi@cs.iupui.edu
Phone: (317) 274-8942,
Fax: (317) 274-9742
http://www.cs.iupui.edu/~durresi/

Education:
- Ph.D., Computer Science, Tokyo Denki University, Tokyo, Japan 2006
- Ph.D., Electronic-Telecommunication Engineering, Polytechnic University of Tirana 1993
- Post-Graduate Degree, Italian Telecommunication Institute, La Sapienza University, Italy 1991
- M.E., Electronic-Telecommunication Engineering, Polytechnic University of Tirana 1990
- B.E., Electronic Engineering, Polytechnic University of Tirana, 1986

Research Interests:
Dr. Durresi's research focuses on networking and security. He is particularly interested in new network architectures as response to the changing challenges and needs of users in various environments and applications, such as Internet, wireless, optical, multimedia, and so on. Important design goals for such systems include scalability, security, robustness, reliability, economic viability, manageability. His research explores the design space among various goals and constrains and tries to find desirable tradeoffs, which would enable the practical use of new solutions.

Recent Research Projects:
Dr. Durresi's research has influenced the directions of Testing working group of ATM Forum, an International Consortium of Computer and Telecommunications companies. Many of the metrics and procedures developed by him have been adopted by ATM Forum and will be used throughout the networking industry. He is an active participant and has written contributions to several other industry forums including Internet Engineering Task Force (IETF), American National Institute (ANSI), Telecommunications Institute of America (TIA) and International Telecommunication Union (ITU).

He was one of the founding partners of ITEC-Ohio effort. Itec-Ohio has been selected to develop and test the only Internet2 Test and Evaluation Center in the country. Dr. Durresi has continued to work closely on several projects with ITEC-Ohio, which is a catalyst for network research in Ohio.
For his "outstanding Research Accomplishments", Dr. Durresi received the 2002 Lumley Research Award from the College of Engineering at the Ohio State University.
Dr. Durresi holds a patent on measuring the quality of signal in optical networks. In the last years he has obtained research funding for more than **$ 1 Million** from NSF, the States of Ohio and Louisiana, OAI, TRW and Honeywell. He has collaborated for more than eleven years with Professor Raj Jain in many research projects in networking area funded by NSF and NASA.

Project Description/Objective

Disaster Area

Cellular
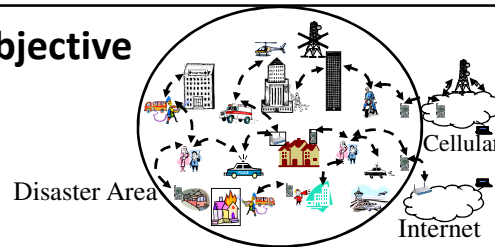
Internet

- Title: Using Lessons from the Disaster in Japan to Develop Communications for Emergency Situations
- US Researchers: Arjan Durresi (Indiana University Purdue University Indianapolis) and Raj Jain (Washington University in St. Louis)
- International counterparts from Japan
  - Leonard Barolli (Fukuoka Institute of Technology), Makoto Takizawa (Seikei University), Shibata Yoshitaka (Iwate Prefectural University), Akio Koyama (Yamagata University)
- VERY short objective of RAPID: Study and propose solutions for emergency communications in the United States

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Key Findings

- Japan has a very sophisticated EEW system but does not use the latest capabilities of smart phones. US has no cellular warning system. [WUSTL MS project report]
- When cellular infrastructure is broken, Wi-Fi capabilities of the phones and private WiFi networks can be used to communicate warning in a trustworthy manner [IUPUI tech report]
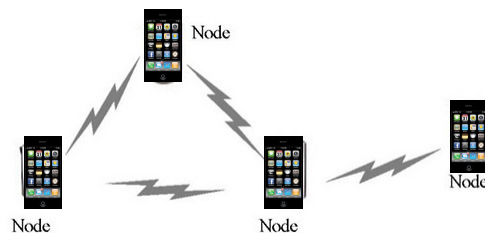
Opportunities for Future Research

- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- What new questions raised by these events require basic research?
    - Develop communication protocols suitable for emergency

- What new data are available as a result of these events?
    - Data about communication failure

- What unique aspects of these events require the development of a focused research program?
    - The interplay between technical and social aspects

- What are the important lessons from these larger than expected events for the U.S.?
    - Develop standards, regulations, and systems for cellular based emergency communications

RAPID: Population Protection and Monitoring in Response to Radiological Incidents

Program Manager:	Sajal Das
	CNS Division of Computer and Network Systems
	CSE Directorate for Computer & Information Science & Engineering
Investigator(s):	Eva Lee (Principal Investigator)
Sponsor:	Georgia Tech Research Corporation
	Office of Sponsored Programs
	Atlanta, GA 30332 404/894-4819
NSF Program(s):	COLLABORATIVE RESEARCH,
	INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

This RAPID project, collecting rare and real-life data pertaining to radiological emergency response in Japan, builds on previous work that collects and processes a large amount of time-motion study data in the public health emergency response system planning and usage at Georgia Tech. The team will work with Japanese collaborators in their efforts in performing assessment of the recent series of disasters in Japan, as well as in assisting in the recovery. This team is experienced in using a real-time information-decision support system for emergency preparedness. The collection and the analysis of scarce data in the so-called Knowledge Data Bank for Radiological Responses, speaks to the importance and uniqueness of the proposed system. The Japanese-USA academic research team will be engaged in some of the following activities:

- Establish a knowledge data bank for radiological response: emergency data collection and resource assessment.

- Process mapping and time motion study.

- Interview individuals (emergency workers, affected individuals, etc.)

- Incorporate the radiological knowledge data bank into a real-time simulator and decision support system.

- Analyze and assess the effects of the disaster in collaboration with NanZan University.

The final system will facilitate assessment of current operations performance versus pre-disaster preparedness. It will allow for the study, training, and enhancement of emergency response, as well as future planning for radiological incidents. The work provides a unique opportunity to collect on-the-ground emergency response data.

The researchers collaborate with the Japanese investigators from NanZam University, Dr. Suzuki and Dr. Sasaki, whose work is funded by the Japan Society of Promotion of Science. The Japanese team will arrange trips for the US team to visit the various shelters, distribution, medical, and/or health-

registering sites where they will conduct the time-motion studies, interviews, and operations/performance observations, and evaluations. A letter of support and biographical sketches of the Japanese collaborators are included in the supplementary document.

Broader Impacts:

This project promises an immediate benefit to society by supporting economic recovery efforts in Japan through a participatory research paradigm. The data bank is critical to our national medical preparedness, emergency response, and homeland security. Moreover, the work is urgent for population protection from nuclear plant accidents. Long-term benefits for future disasters are in evidence. Obviously, the emergency response and disaster mitigation research will be enabled with the developed simulation and decision support system along with the knowledge data base. In general, the project also contributes to train graduate students exposing them to high-impact application areas.

Eva K. Lee

Professor
H. Milton Stewart School of Industrial and Systems Engineering
Georgia Institute of Technology

Director
Center for Operations Research in Medicine and HealthCare

eva.lee@isye.gatech.edu
Phone: (404) 894-4962
Fax: (404) 894-2301
http://www2.isye.gatech.edu/~evakylee/

Education:
- Ph.D. at Rice University in the Department of Computational and Applied Mathematics
- Undergraduate Degree in Mathematics from Hong Kong Baptist University

Research Interests:
- **Mathematical theory and modeling** - complex/systems modeling, optimization and logistics theory, machine learning and predictive algorithms, decision theory and risk analysis.
- **High-performance computing** - information technology, software enterprise design for industrial, biomedicine, and healthcare applications.
- **Large-scale optimization** - linear/nonlinear mixed integer programming, combinatorial optimization, parallel algorithms.
- **Biomedicine and clinical research** - biomedical modeling, informatics and algorithmic strategies for genomic analysis, health risk prediction, early disease prediction and diagnosis, optimal treatment strategies and drug delivery, healthcare outcome analysis and treatment prediction.
- **Healthcare policy, management, and decision analysis** - systems modeling, quality improvement, operations efficiency, organizational transformation.
- **Public health and medical preparedness** - emergency response, large-scale dispensing, disease propagation analysis, and economic impact.
- **Homeland security and defense** - surveillance and detection, biodefense, radiological emergency preparedness, medical countermeasures, large-scale response and disaster relief logistics, population protection, design of resilient critical infrastructure.
- **Industrial applications** - efficiency and quality of services; portfolio optimization, organizational transformation.

Project Description/Objective
Population Protection and Monitoring in Response to Radiological Incidents

- **Researchers**
  - Eva K Lee, PI, Georgia Institute of Technology
  - Atsuo Suzuki, collaborator, NanZan University, Japan
- **Objectives:** Design and advance information – decision support system for population protection and emergency response, and establish a national knowledge databank
  - identifying people in immediate danger; those who need medical treatment for contamination or exposure; recommending and facilitating practical steps to minimize risk, rapid screening and decontamination, registering people for long-term health monitoring, and servicing the displaced population on day-to-day needs.

Key Findings

- On-the-ground:
  - Lack of strategies and emergency guidelines for rapid screening and decontamination for both workers and citizens
  - Lack of knowledge of radiation safety and emergency response processes, even for those live very close to nuclear plants
- Advances:
  - Collected some critical data related to radiological emergency response processes
  - Information-decision support system developed helps with large-scale radiological emergency response (social, logistics, policies)
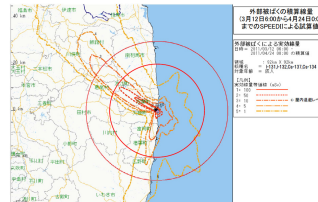
Opportunities for Future Research

- What new questions raised by these events require basic research?
  - Large-scale mathematical modeling, decision analysis and real-time systems for emergency response.

- What new data are available as a result of these events?
  - Timeline on evacuation, sociological information regarding citizen knowledge and after-event psychological and medical burden

- What unique aspects of these events require the development of a focused research program? What are the important lessons from these larger than expected events for the U.S. (and beyond)?
  - Strategic planning and operations capabilities for emergency response and medical preparedness for radiological incidents is one of the critical cornerstones for US Homeland Security, along with biological and chemical incidents. The Japan incident *underscores* its paramount importance. Such needs are wide-spread as many nations employ nuclear plants for energy generation.

Award Abstract # 1138666

RAPID: Automating Emergency Data and Metadata Management to Support Effective Short Term and Long Term Disaster Recovery Efforts

Program Manager: Sajal Das
CNS Division of Computer and Network Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Calton Pu (Principal Investigator)

Sponsor: Georgia Tech Research Corporation
Office of Sponsored Programs
Atlanta, GA 30332 404/894-4819

NSF Program(s):   INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

This RAPID project, collecting, processing, and disseminating appropriate sensor data, aims to contribute to an effective recovery. The work addresses the challenges of sensor data flood during an emergency, through integration, evaluation, and enhancement of current data management tools, particularly with respect to meta-data. Automation of data and meta-data collection, processing, and dissemination are expected to alleviate the time pressure on human operators. The fundamental tools support quality information dimensions such as provenance, timeliness, security, privacy, and confidentiality, enabling an appropriate interpretation of the sensor data in the long term. For the short term, the tools are expected to help relief the workers as data producers and consumers; for the long term, they will provide high quality information for disaster recovery decision support systems. Additionally, the cloud-based system architecture and implementation of the CERCS cluster of Open Cirrus provide high availability and ease of access for recovery efforts in Japan as well as for researchers worldwide. The integration of techniques from several information dimensions (e.g., data provenance, surety, and privacy) and the application of code generation techniques to automate the data and metadata management tools constitute the intellectual merit of the proposed research. New challenges will be encountered in the potential interferences among the quality of information dimensions. It is also a new challenge to apply code generation techniques in the adaptation of software tools to accommodate changes imposed by environmental damages and contextual as well as cultural differences among countries.

The investigator collaborates with Prof. Masaru Kitsuregawa from the University of Tokyo, Japan, a leading researcher in data management. He is the first database researcher from Asia to win the ACM SOGMOD Innovation Award (2009). In addition to a letter of support and biographical sketches of the Japanese collaborator, a support letter has been submitted by Intel to OISE, CISE and Engineering. Intel has offered access to the Intel Open Cirrus cluster to conduct the research.

Broader Impacts:

The proposed tools should contribute to improve both the quantity and quality of data being collected by a variety of sensors, thus improving the effectiveness of short and long term decision making. For example, measured radiation levels in agricultural products can serve as an indication of spreading radioactive contaminations that complement the direct readings of radiation in soil samples. The project enables informed decisions based on precise interpretation of real sensor data that may improve the quality of life at both human and social levels, while reducing costs. The project will also contribute in graduate student education.

Calton Pu

Professor and John P. Imlay, Jr. Chair in Software
Georgia Institute of Technology

Co-Director
Center for Experimental Research in Computer Systems (CERCS)

calton.pu@cc.gatech.edu
Phone: (404)385-1106
Fax: (404)385-2295
http://www.cc.gatech.edu/~calton/

Education:
- University of Washington, 1980 – 1986
- B.S., Computer Science at Universidade de São Paulo, 1976 – 1979
- B.S., Physics Universidade de São Paulo, 1975 – 1978

Research Interests:
Calton's research interests are in the areas of distributed computing, Internet data management, and operating systems. In distributed systems, his focus is on extended transaction processing, system survivability, and Internet applications. In operating systems, he is applying the idea of *specialization.* Comparing with usual centralized systems, distributed and parallel systems softwares display unique characteristics in distance, complexity, extensibility, concurrency and availability. Making software handle these problems in a reliable and efficient way is the emphasis of Calton Pu's work. In the Infosphere project, he is developing concepts and software for Internet-scale applications driven by information flow such as real-time decision support, digital libraries, and electronic commerce. The sponsors for Calton Pu's research include both government funding agencies such as DARPA, NSF, and companies from industry such as IBM, Intel, and HP. He is an affiliated faculty of Center for Experimental Research in Computer Systems (CERCS), Georgia Tech Information Security Center (GTISC), and Tennenbaum Institute. Currently, he is mainly involved in three projects, in addition to several other collaborations around the world. Positions available: Georgia Tech is recruiting good graduate students.

Recent Research Projects:
- Elba Project: Automated N-Tier Application Deployment
- Denial of Information project: Research on Deceptive and Misleading Information
- The Enterprise Computing Initiative at CoC, in cooperation with the Tennenbaum Institute for Enterprise Transformation.

Project Description/Objective

- RAPID Title: Automating Emergency Data and Metadata Management to Support Effective Short-Term and Long-Term Disaster Recovery Efforts
- US Researchers: Prof. Calton Pu, Georgia Institute of Technology, PI
- International counterparts: Prof. Masaru Kitsuregawa, University of Tokyo, Japan, Collaborator
- Objective: Development of a generic tool that supports centralized sensor data collection, metadata management, and information retrieval in a timely, scalable and practical manner
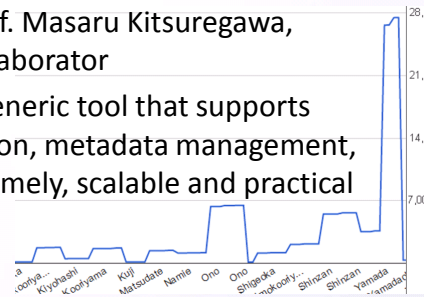
Key Findings

- There are many sensor data sources that are used mainly for recovery purposes, but they can become invaluable resources for research if sufficient metadata can be collected for their appropriate interpretation by researchers.
- Existing data and metadata management tools for sensors are not appropriate for high volume sensor data from numerous and diverse data sources. Furthermore, the proliferation of new sensors that generate more data (both in quantity and variety) may actually aggravate the problem by overloading the limited capabilities of current data management tools.

Opportunities for Future Research

- Unlike typical mission-critical systems that achieve reliability and availability through refinement for well known workloads and scenarios, disaster recovery systems by definition need to adapt to unforeseen circumstances.
- New data generated by general purpose sensors such as smart phones that combine GPS-location, accelerometer, and gyroscopic sensors could become invaluable in the research towards better practices in disaster recovery and serving as communication tools.
- There is a significant amount of unique data such as web and twitter data created and shared during each disaster. Systematic collection, management, and analysis of these data sources requires the development of a focused research program.
- Short-term: shared sensor infrastructure must be available for research groups (InfaaI). Medium-term: sensor data must be accessible in the raw form and at a higher level of abstraction (IaaP). Long-term: sensor data must be accessible in various forms for analysis and visualization (InfaaS).

Award Abstract # 1138642

RAPID: Mobile Augmented Reality to Improve Rapid Assessments in Disasters

Program Manager: Sylvia J. Spengler
IIS Division of Information & Intelligent Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Jeannie Stamberger (Principal Investigator)
Ian Lane (Co-Principal Investigator)
Semiha Ergan (Co-Principal Investigator)

Sponsor: Carnegie-Mellon University
5000 Forbes Avenue
PITTSBURGH, PA 15213 412/268-1161

NSF Program(s):   INFO INTEGRATION & INFORMATICS

ABSTRACT:

Following an earthquake, or similar natural disaster, a key problem is rapid and accurate on-site damage assessment to support local first responders; however, trained experts are typically remote from the disaster and it can be time consuming and expensive to bring them onsite. Accessing remote experts to improve the accuracy of rapid assessments is a promising method to streamline provisioning of emergency shelters and other resources. This project focuses on new methods for improved rapid assessment of earthquake damaged building structures in Christchurch, New Zealand. The methods are based on collaboration using augmented-reality (AR) imagery, mobile phone based sensor technologies and crowdsourcing techniques for guided remote data collection. A key element of the system is intuitive remote collaboration. Our mobile AR system can be used to connect a user in the disaster zone to a remote expert via audio and shared still images and/or video, helping them to rapidly collect data on building structural integrity. A user evaluation will be performed to compare the performance between the prototype and more traditional approaches (e.g., waiting for an expert to arrive on the ground), and assessment based on imagery recorded from an untrained and unguided user. Two hypotheses will be tested: 1) a collaborative mobile AR system can improve the quality and type of data collected for structural assessment 2) the time to provide data from non-experts assisted by experts to decision makers in a digestible format is dramatically reduced as compared to traditional methods.

The approach will enable rapid post-event damage assessment, streamline emergency provisioning of shelters by allowing people to stay in safe dwellings, and speed up emergency response and reconstruction. The resulting valuable dataset will assist development of rapid assessment forms, contribute to earthquake structural damage case studies, provide key baseline to test several computer science research projects on improved disaster response, and provide key data for development of life-saving tools. The international collaboration also provides engagement of underrepresented groups in this computing research.

Jeannie Stamberger
Note: Her co-PI may be attending instead.
unct Faculty
Carnegie Mellon University Silicon Valley Campus

Associate Director - Strategic Projects and Funding, Disaster Management Initiative

jeannie.stamberger@sv.cmu.edu
Phone: 650-380-1158
http://www.cmu.edu/silicon-valley/faculty-staff/stamberger-jeannie.html

Education:
- Ph.D. in Biological Sciences from Stanford University in 2006
- Undergraduate degree from Illinois Wesleyan University

Recent Research Projects:
She brings a unique perspective to disaster management, by integrating her experience developing technology for extreme environments and analytical skills (modeling and custom statistical analyses for patchy data), that results in award winning designs such as "Tweak the Tweet" (a Twitter hashtag syntax for disaster reporting; Random Hacks of Kindness, November 2009). She has been the CrisisCamp lead for Silicon Valley since early 2010. Within the DMI her research interests include social media, user-centered design, technology to reduce violence against women, and the 'human sensor'.

Project Description/Objective

Mobile Augmented Reality to Improve Rapid Assessment in Disasters

J. Stamberger, I. Lane, S. Ergan (CMU, USA), M. Billinghurst (University of Canterbury, NZ)

Collaborative Augmented Reality Tools

Remote experts

Rapid building assessment

Non-experts in earthquake hit region

Objective: Evaluate the use of mobile augmented reality for rapid, large-scale damage assessments of buildings by facilitating remote collaborative expert/non-expert interactions

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Expected Findings[1]

For response planning following an earthquake or similar natural disaster, rapid assessment of infrastructure damage is critical

Expected Findings:
➔ **Collaborative augmented reality systems** coupled with **remote experts** and **on-site citizens** can assist in rapidly and accurately assessing infrastructure damage
➔ Identification of methods for evaluating remote collaborative augmented reality (AR) systems for rapid damage assessment
➔ Evaluation of collaborative AR systems for remote damage assessment

[1] Onsite data collection in Christchurch originally planned for summer 2011 (July 14-30th, 2011). Due to delay of award funding, collection will now be performed in Feb 27th – Mar 7th, 2012

Opportunities for Future Research

- **What new questions raised by these events require basic research?**
    - Can building information models be leveraged to assist during rapid damage assessment?
    - Will collaborative crowdsourcing coupled with consumer level mobile devices obtain expert quality assessments?
    - Can interactive dialog agents assist in this process?
    - What are the communication cues necessary for remote collaboration and shared situational awareness?
- **What new data are available as a result of these events?**
    - Annotated and geo-located images and videos of earthquake damaged buildings
    - Recorded collaborative dialogs of the damage assessment process
    - Detailed damage assessment reports for buildings used in this exercise
    - A complete 3-D model of inner-city Christchurch with immersive panoramic images
- **What unique aspects of these events require the development of a focused research program?**
    - Crowdsourcing has been successfully used during planning for sheltering and aiding in earthquake hit regions and has a potential to access to structural experts to increase the speed of rapid assessments
- **What are the important lessons from these larger than expected events for the U.S.?**
    - Rapid assessment of infrastructure damage is critical for response agencies to plan for sheltering displaced people
    - Crowd sourcing played an important supporting role in providing information to response agencies in both Japan and NZ

RAPID: Flow Dynamics/Morphological Impacts of March 11 Tohuku Tsunami, Japan

Program Manager:	Thomas Torgersen
	EAR Division of Earth Sciences
	GEO Directorate for Geosciences
Investigator(s):	Victor Baker (Principal Investigator)
	Jon Pelletier (Co-Principal Investigator)
Sponsor:	University of Arizona
	888 N Euclid Ave
	TUCSON, AZ 85721 520/626-6000
NSF Program(s):	GEOMORPHOLOGY & LAND USE DYNAM,
	HYDROLOGIC SCIENCES

ABSTRACT:

The devastating tsunami waves of March 11, 2011, along the northeastern coast of Japan caused severe damages to coastal communities. The unusual, very high-energy conditions achieved by the March 11, 2011, Tohuku Tsunami afford a unique opportunity to greatly advance our understanding of the geological effects of tsunamis in coastal areas. While much of the immediate post-tsunami research is focused on damage assessment, this particular project aims to understand the dynamics of tsunami waves and their impacts on natural landscapes. Prompt access to the field areas is crucial for this effort in order to obtain evidence of the tsunami wave effects. Current disaster response reconstruction efforts are quickly erasing the traces of the event in developed areas. Natural, undeveloped areas of interest in this project will also quickly lose evidence of high-water indicators and subtle sediment layers because of rainstorms, human disturbance, and other post-tsunami processes. This project will integrate numerical modeling with field measurements and remote sensing. A large group of collaborating Japanese scientists, unfunded by this project, will facilitate the operations in the field areas, and the quantitative modeling efforts by the U.S. team will be supplemented by collaborator from Finland, who will be funded by his own sources independent of the project funds.

Results obtained from this study will contribute to tsunami hazard assessment by greatly advancing the scientific capability to recognize and understand the effects of high-energy tsunami waves that may be preserved as geological evidence of ancient tsunamis on potentially hazardous coastlines around the world. This new understanding will prove particularly relevant to hazardous coastlines in the western U.S. In particular, the potential earthquake zone off coastal Washington and Oregon has many similarities to northeastern Japan in regard to tsunami hazards. Tsunami-vulnerable areas also occur in California, Alaska and Hawaii.

Victor R. Baker

Regents' Professor and Professor of Geosciences and Professor of Planetary Sciences, University of Florida

baker@hwr.arizona.edu
Phone: (520) 621-7875
http://chubasco.hwr.arizona.edu/hwr-drupal/?q=node/30

Faculty Introduction:

Dr. Baker's research interests are very broadly concerned with paleohydrology and related aspects of geomorphology, but a particular focus is on flood processes. He also works in the area of planetary geomorphology, and on issues that involve Earth science in relation to public policy, the environment, and philosophy of science. Dr. Baker is a Foreign Member of the Polish Academy of Sciences and an Honorary Fellow of the European Geosciences Union. He is also a Fellow of the American Geophysical Union, of the American Association for the Advancement of Science, and of The Geological Society of America. He is a past President of the latter Society and a recipient of the Distinguished Scientist Award from that society's Quaternary Geology and Geomorphology Division. He received the David Linton Award of the British Society for Geomorphology. He has served on numerous panels and committees of the National Research Council including its Committee on Hydrologic Sciences.

Research Summary:

Paleoflood Hydrology of the Southwestern United States. This is a continuation of more than 30 years of research on Holocene paleoflood records from bedrock stream channels in Arizona, Western Texas, and Southern Utah (reviewed in the journal*Geomorphology*, v. 101, p. 1-13, 2008). Current work is focused on interpreting the hydroclimatological causes of extremely large floods and their clustering in time and space. An application of this research, supported by the United States Bureau of Reclamation, considers flood risk to high-hazard dams in the Western United States.

Debris Flow Flooding in Southern Arizona. This work concerns the spectacular southern Arizona debris flows of late July 2006, including those associated with the aftermath of wildfires.

Cataclysmic Pleistocene Megaflooding, Northwestern, U.S. Studies include field investigations of the Late Pleistocene Missoula Floods (reviewed in *Annual Reviews of Earth and Planetary Sciences*, v. 37, p. 6.1-6.19, 2009) and 2-D computational modelling of the flooding processes. Work also involves the application of both TCN and OSL geochronological techniques in order to understand the timing of the megaflood events, including their relationship to ground-water recharge.

Paleohydrology and Paleoclimatology of Mars. Geological studies of long-term paleoenvironmental change on Mars are focused on understanding, past epochs of surface-water flow, glaciation, and related paleohydrological phenomena. The relevant geomorphological features are interpreted in relation to the planet's history of volcanic, tectonic, and atmospheric processes, including their astrobiological implications.

History and Philosophy of the Earth and Environmental Sciences. This work concerns the role of science education in relation to modern society, the appropriate role for models and predictions in relation to science and technology policy, the nature of scientific reasoning in the Earth Sciences, and the history and development of scientific thought in relation to geomorphology.
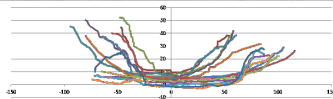
Flow Dynamics/Morphological Impacts of March 11 Tohoku Tsunami, Japan

USA: Victor R. Baker, Jon Pelletier, Luke Mcguire, Univ. of Arizona
JAPAN: Takashi Oguchi, Yuichi S. Hayakawa, Hitoshi Saito, Akitoshi Kobayashi, Univ. Tokyo

Objective: Understand the catastrophic geomorphic effects of the March 11 Tohoku-Oki Tsunami on the Sanriku Coast, Japan, using 2-d Hydraulic Modeling and Terrestrial Laser Scanning
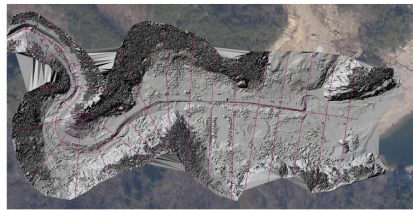
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Flow Dynamics/Morphological Impacts of March 11 Tohoku Tsunami, Japan: **Key Findings**

- Distinctive Valley and Slope Morphologies are Generated by the Erosive Effects of Repeated, Century-Scale Tsunami Since Mid-Holocene Along the Sanriku Coast, Northeast Honshu, Japan.

- There is an apparent threshold effect whereby the energy expenditures by the incidence tsunami waves must be high enough to exceed resistance factors imposed by vegetation-stabilized regolith on hillsides. When the threshold is exceeded, on approximate century time scales, catastrophic erosion and deposition are generated in the local zone of tsunami impact.

Flow Dynamics/Morphological Impacts of March 11 Tohoku Tsunami, Japan
Opportunities for Future Research

What new questions raised by these events require basic research?

The newly discovered tsunami erosion effects are all remarkably similar to what is observed for catastrophic fluvial erosion in bedrock channels.

What new data are available as a result of these events?

Inverse hydraulic modeling associates the causative tsunami velocities and unit stream powers with the observed Tohoku-Oki tsunami erosion features.

What unique aspects of these events require the development of a focused research program?

The distinctive high-energy erosion/deposition features constitute definitive signs of the highest energy tsunami events. Their high potential for long-term preservation affords an opportunity to reconstruct the physics of those events through the application of hydraulic modeling codes.

What are the important lessons from these larger than expected events for the U.S.?

Preservation of distinctive tsunami erosion features in other high-energy tsunami settings, such as those landward of the Cascadia Subduction Zone, may afford an opportunity to estimate tsunami magnitudes via the inverse modeling noted above.

Collaborative Research: The Japan March 11 Earthquake, Tsunami Inundation, and Initial Spread of Fukushima Dai-ichi Radionuclides into the Pacific Ocean: Model Assessment

Program Manager: Eric C. Itsweire
                                         OCE Division of Ocean Sciences
                                         GEO Directorate for Geosciences

Investigator(s):   Changsheng Chen (Principal Investigator)

Sponsor: University of Massachusetts, Dartmouth
                                         285 Old Westport Road
                                         North Dartmouth, MA 02747 508/999-8953

NSF Program(s):   PHYSICAL OCEANOGRAPHY

ABSTRACT:

This project is a comprehensive interdisciplinary study of the March 11 initial M=9 and M=7.9 earthquakes, the resulting tsunami wave generation, propagation and coastal inundation along northern Honshu Island, and the initial pathways and changes in Cs-237 concentrations as it enters the coastal waters at the Fukushima Daiichi nuclear facility and spreads across the shelf to deeper water. The approach is to use a combination of advanced seismic and nested coupled atmospheric/3-D ocean circulation numerical models plus available field measurements to simulate these processes starting with the initial March 11 M=9 earthquake bottom movement through April 12. During this 33-day simulation, the Cs-137 source concentration levels peaked and decreased towards the increasing coastal and off-shelf concentration levels, indicative of cross-shelf transport and shelf-ocean exchange processes, with a potential sedimentation loss and biological accumulation in the near-shore region. Detailed descriptions of the different model simulations, the resulting ocean circulation and water property output fields and initial analysis will be uploaded to a project website on a frequent basis for use by others interested in coastal physical and bio/chemical processes in the study area and as initial conditions for studies of the long-term spread of Cs-137 and other radionuclides in the Pacific Ocean.

Intellectual Merit:

The March 11 earthquakes, tsunami waves, coastal inundation, and initial release of Cs-137 into the ocean cover a wide range of time (from seconds to a month) and space (meters to 100's of km) scales. The multi-scale modeling approach with advanced models should produce a comprehensive and integrated description and understanding of the key physical processes involved and an independent assessment of the initial fate and spread of Cs-137 and its impact on the coastal ecosystem within the RAPID grant period.

Broader Impacts:

This study will foster U.S-Japanese collaboration in several areas of ocean sciences (marine geophysics, physical oceanography, and bio-chemistry related to Cs-137 and other released radionuclides). The team includes one Japanese PhD student, and it is anticipated that the models and model results posted on a website will be used by researchers, students, and others as the study progresses. One outcome of this

study will be a tested new combined earthquake/3-D ocean model system that can be used by researchers and coastal planners for assessing potential tsunami flooding from future earthquakes in the megathrust zones east of Japan. This system can be applied to other earthquake and or tsunami-prone areas.

Changsheng Chen

Professor
Department of Fisheries Oceanography
University of Massachusetts Dartmouth

Adjunct Scientist
Department of Physical Oceanography
Woods Hole Oceanographic Institution (WHOI)

c1chen@umassd.edu / cchen@whoi.edu
Phone: (508)910-6388
Fax: (508)910-6371
http://fvcom.smast.umassd.edu/People/chen.html

Education:
- Ph.D. Physical Oceanography, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution Joint Program, 1992
- M.S. Physical Oceanography, Massachusetts Institute of Technology and Woods Hole Oceanographic Institution Joint Program, 1989
- M.S. Marine Meteorology, Ocean University of Qingdao, P. R. China, 1983

Research Interests:
Chen is a coastal oceanographer who is interested in modeling and observational exploration of coastal ocean circulation, oceanic frontal processes, turbulent mixing/bottom boundary layer dynamics, chaotic mixing, western boundary current, internal waves and tides, and biological/physical interaction. His recent research is mainly focused on ecosystem dynamics in the US eastern continental shelf. He is leader of the Marine Ecosystem Dynamics Modeling Research Laboratory, School for Marine Science and Technology, UMASSD. Chen and his co-workers have developed an innovative unstructured grid, Finite-Volume Community Ocean Model (FVCOM) for the ocean community.

Recent Research Projects:
- NSF. Collaborative research: Inter-annual variability of coastal phytoplankton bloom and their relationship to large-scale forcings: A model study in the Gulf of Maine.
- NSF. Collaborative research: Effects of a warming climate on Arctic shelf and basin calacus populations: Implications for Pan-Arctic ecosystem dynamics.
- NSF. Collaborative research: Development of a high-resolution, unstructured grid, finite-volume coupled ice-ocean model for the Arctic Ocean.
- MIT-Sea Grant: Development and validation of a water quality model system for Massachusetts coastal waters.
- Massachusetts Ocean Partnership (MOP). Development of an ocean circulation hindcast database and specific products for coastal ocean management.
- NOAA. Tropical and extra-tropical inundation mode evaluation.

Award Abstract # 1141785

Collaborative Research: The Japan March 11 Earthquake, Tsunami Inundation, and Initial Spread of Fukushima Dai-ichi Radionuclides into the Pacific Ocean: Model Assessment

Program Manager: Eric C. Itsweire
OCE Division of Ocean Sciences
GEO Directorate for Geosciences

Investigator(s): Robert Beardsley (Principal Investigator)
Jian Lin (Co-Principal Investigator)
Rubao Ji (Co-Principal Investigator)

Sponsor: Woods Hole Oceanographic Institution
183 OYSTER POND ROAD
WOODS HOLE, MA 02543 508/289-2462

NSF Program(s): PHYSICAL OCEANOGRAPHY

ABSTRACT:

This project is a comprehensive interdisciplinary study of the March 11 initial M=9 and M=7.9 earthquakes, the resulting tsunami wave generation, propagation and coastal inundation along northern Honshu Island, and the initial pathways and changes in Cs-237 concentrations as it enters the coastal waters at the Fukushima Daiichi nuclear facility and spreads across the shelf to deeper water. The approach is to use a combination of advanced seismic and nested coupled atmospheric/3-D ocean circulation numerical models plus available field measurements to simulate these processes starting with the initial March 11 M=9 earthquake bottom movement through April 12. During this 33-day simulation, the Cs-137 source concentration levels peaked and decreased towards the increasing coastal and off-shelf concentration levels, indicative of cross-shelf transport and shelf-ocean exchange processes, with a potential sedimentation loss and biological accumulation in the near-shore region. Detailed descriptions of the different model simulations, the resulting ocean circulation and water property output fields and initial analysis will be uploaded to a project website on a frequent basis for use by others interested in coastal physical and bio/chemical processes in the study area and as initial conditions for studies of the long-term spread of Cs-137 and other radionuclides in the Pacific Ocean.

Intellectual Merit:

The March 11 earthquakes, tsunami waves, coastal inundation, and initial release of Cs-137 into the ocean cover a wide range of time (from seconds to a month) and space (meters to 100's of km) scales. The multi-scale modeling approach with advanced models should produce a comprehensive and integrated description and understanding of the key physical processes involved and an independent assessment of the initial fate and spread of Cs-137 and its impact on the coastal ecosystem within the RAPID grant period.

Broader Impacts:

This study will foster U.S-Japanese collaboration in several areas of ocean sciences (marine geophysics, physical oceanography, and bio-chemistry related to Cs-137 and other released radionuclides). The team

includes one Japanese PhD student, and it is anticipated that the models and model results posted on a website will be used by researchers, students, and others as the study progresses. One outcome of this study will be a tested new combined earthquake/3-D ocean model system that can be used by researchers and coastal planners for assessing potential tsunami flooding from future earthquakes in the megathrust zones east of Japan. This system can be applied to other earthquake and or tsunami-prone areas.

Robert Beardsley

Scientist Emeritus
Physical Oceanography
Woods Hole Oceanographic Institution

rbeardsley@whoi.edu
Phone: (508)289-2536
Fax: (508) 457-2181
http://www.whoi.edu/page.do?pid=26736
&tid=241&id=rbeardsley

Education:
- B.S. Massachusetts Institute of Technology, 1964, Nuclear Physics
- Ph.D. Massachusetts Institute of Technology, 1968, Physical Oceanography

Research Interests:
- Observational and numerical model studies of wind-, tidal-, and buoyancy-driven currents, mixing, and air-sea forcing on the continental shelf and marginal seas
- Impact of physical processes on biological processes and ecosystem dynamics.

Recent Research Projects:
Bob Beardsley investigates the circulation and other physical processes at work on the continental shelf—including currents, tides, air-sea interaction—and the effects of such processes on plankton ecology. He has been deeply involved in the Global Ocean Ecosystems Dynamics Northwest Atlantic on Georges Bank program, which conducted an extensive set of physical and biological measurements on Georges Bank and surrounding waters during 1995-1999.

YNU
SMAST-UMASSD

Collaborative Research: The Japan March 11 2011 Earthquake, Tsunami Inundation and Initial Spread of Fukushima Dai-ichi Radionuclides on the Pacific Ocean: Model Assessment

Team:
  Changsheng Chen, Zhigang Lai, Huichan Lin
    University of Massachusetts-Dartmouth (UMASS-D), USA
  Robert Beardsley, Jian Lin, Rubao Ji
    Woods Hole Oceanographic Institution (WHOI), USA
  Jun Sasaki
    Yokohama National University, Japan
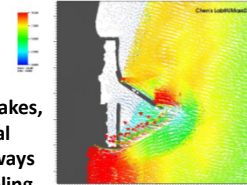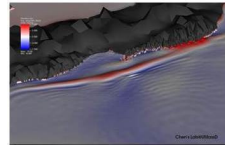
Objective:
  Model assessment of March 11 initial M=9 and M=7.9 earthquakes, the resulting tsunami wave generation, propagation and coastal inundation along northern Honshu Island, and the initial pathways and changes in Cs-237 concentrations as the contaminated cooling waters enter the coastal waters at the Fukushima Daiichi nuclear facility and spread across the shelf to deeper water.

Key Findings

- **Model-simulated tsunami height, shape of dikes and harbor in front of NNP structure, and surrounding topography combined to cause significant flooding of NNP from the back (land) side.**

- **Model-simulated distribution and dispersal of Cs-137 strongly dependent of grid resolution of the local NNP geometry.**
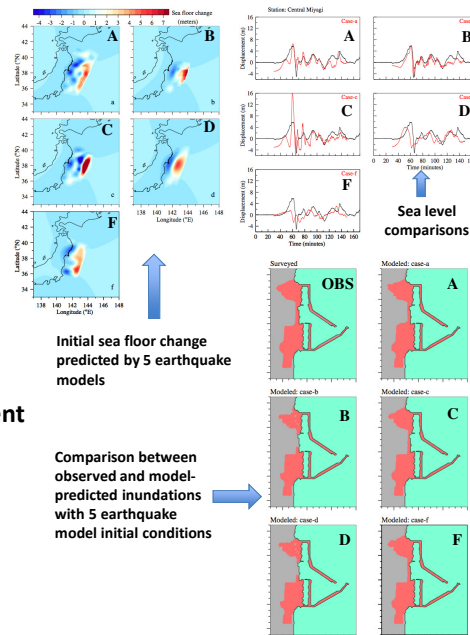
Sea level comparisons

Initial sea floor change predicted by 5 earthquake models

Comparison between observed and model-predicted inundations with 5 earthquake model initial conditions

Opportunities for Future Research

- **What new questions raised by these events require basic research?**
1. Improve design of NNP sea wall/harbor to protect/reduce damage from future tsunamis.
2. Nested model system can be used to simulate ocean response to past and potential (idealized?) earthquakes near Japan.
3. Can tsunami warning system be improved using nested model approach

- **What new data are available as a result of these events?**
1. Hindcast of March 11 earthquake-tsunami simulation can be used to test new NNP site configuration, other coastal marine structures.

- **What unique aspects of these events require the development of a focused research program?**

- **What are the important lessons from these larger than expected events for the U.S.?**
1. Add earthquake ocean bottom movement into Global FVCOM operation in order to drive operational inundation forecast model systems along US coast.

Award Abstract # 1138944

RAPID - Collaborative Research - Offshore impacts of the Tohoku-Oki earthquake: Seafloor deformation, sedimentation, erosion, tsunamigenesis

Program Manager: Richard L. Carlson
OCE Division of Ocean Sciences
GEO Directorate for Geosciences

Investigator(s):   Marie-Helene Cormier (Principal Investigator)

Sponsor: University of Missouri-Columbia
310 JESSE HALL
COLUMBIA, MO 65211 573/882-7560

NSF Program(s):   MARINE GEOLOGY AND GEOPHYSICS

ABSTRACT:

Great megathrust earthquakes and the tsunamis they generate are among are the greatest threats to populated coastlines worldwide, such as Chile, Sumatra, Alaska, and Cascadia (the regions extending from southern British Columbia into northern California). The risk of catastrophic consequences and the acute need for improved understanding of these events are underscored by the devastation caused by the 11 March 2011 Tohoku-Oki earthquake off northern Japan. While the destruction from these events is acute, they also offer important opportunities to gain new insights into the processes that spawn them. In the wake of the earthquake in Japan, the proponents of this project have been invited to collaborate with Japanese scientists at JAMSTEC (Japan Agency for Marine Earth-science and Technology) to investigate and document the effects of the earthquake offshore. The broader impacts of this program include enhanced international collaboration, and a contribution to instruction at the investigators' respective institutions, but by far the greatest broader impact of this activity is the very high societal relevance of studying these catastrophic events.

Marie-Helene Cormier

Assistant Professor
Department of Geological Sciences
University of Missouri

CormierM@missouri.edu
Phone: (573)882-8608
Fax: (573)882-5458
http://web.missouri.edu/~cormierm/

Education:
- PhD, University of California Santa Barbara, 1994
- Doctorat de 3eme Cycle, University Paris 7, 1984
- MS, University of Rhode Island, 1983
- Engineering degree, E.N.S.E.M., Nancy, France, 1980

Research Interests:
- Marine geophysics
- Seafloor imaging
- Mid-ocean ridges
- Offshore seismotectonics
- Shelf processes
- Natural hazards

Recent Research Projects:
My research focuses on the study of the processes that shape the seafloor. I apply a wide variety of marine geophysical methods to investigate volcanic and earthquake events, seafloor deformation, gas and fluid seepages, landslides, and anthropogenic impacts.

"RAPID - Offshore impacts of the Tohoku-Oki earthquake:
Seafloor deformation, sedimentation, erosion, tsunamigenesis"

Marie-Helene Cormier (U. Missouri), Leonardo Seeber & Cecilia McHugh (Columbia U.)
Toshiya Fujiwara (JAMSTEC) & Kenji Hirata (Meteorological Research Institute – JMA)

- **What are the impacts of the 2011 earthquake near the trench?**
- **How did it contribute to the building of the accretionary prism?**
- **Do sediments preserve evidence for similar prior earthquakes?**
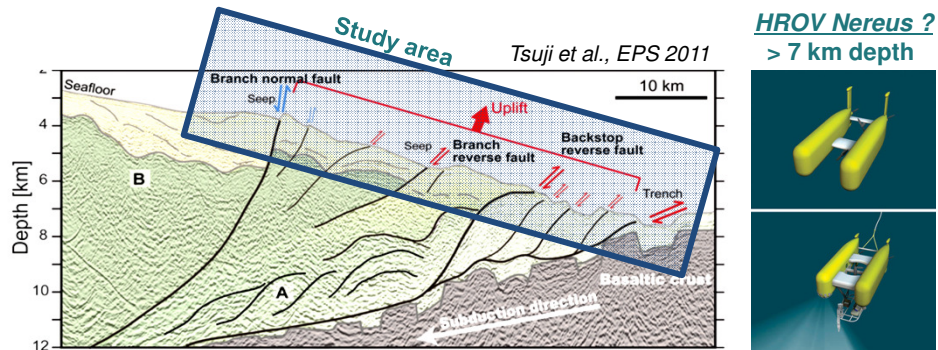
Key Findings

- The field component of this project has not yet started: American and Japanese co-PIs met twice but a cruise opportunity has not yet materialized. A proposal will be submitted this month for a joint research cruise.

- Expected findings:

  1) Confirm (or not) whether significant slip occurred in 2011 on the normal fault that occurs about 50 km landward of the trench axis.
  2) Document the sedimentary processes that accompanied the 2011 earthquake and quantify the approximate recurrence interval of similar large earthquakes from the sedimentary record.

Opportunities for Future Research

- What new questions raised by these events require basic research?

What factors control a "rupture-to-the-toe" during megathrust event?

- What new data are available as a result of these events?

Japanese scientists have collected a wealth of high quality, diverse data, and more continue to be collected. These should provide vastly more information that what was available from the 2004 Sumatra earthquake.

- What unique aspects of these events require the development of a focused research program?

The great water depths at subduction trenches pose a technological challenge to the international community with regards to the collection of high-resolution marine geophysical / geological data.

- What are the important lessons from these larger than expected events for the U.S.?

A megathrust earthquake similar to the 2011 Japan earthquake is expected to occur at the Cascadia Trench.

Award Abstract # 1135768

RAPID: Reconnaissance of the 11 March 2011 Tohoku, Japan Tsunami

Program Manager: Joy Pauschke
                         CMMI Division of Civil, Mechanical, and Manufacturing Innovation
                         ENG Directorate for Engineering

Investigator(s):   Hermann Fritz (Principal Investigator)
                         Harry Yeh (Co-Principal Investigator)
                         Costas Synolakis (Co-Principal Investigator)

Sponsor: Georgia Tech Research Corporation
                         Office of Sponsored Programs
                         Atlanta, GA 30332 404/894-4819

NSF Program(s):   COLLABORATIVE RESEARCH,
   GEOTECHNICAL ENGINEERING

ABSTRACT:

The 11 March 2011 magnitude 9.0 earthquake off Tohoku in Japan triggered a transpacific tsunami that had basin-wide impact of varying severity. Both the earthquake and tsunami magnitudes are unprecedented in Japan's long historical records of over 1,000 years. This award supports a reconnaissance survey team to investigate the effects of this tsunami along coastlines in Japan, the Pacific Islands, and the western United States. The team will conduct the reconnaissance with Japanese researchers from Tohoku University in Sendai, the University of Tokyo, and the Port and Airport Research Institute, and coordinate with the UNESCO-organized International Tsunami Survey Team. The 2011 event in Japan presents a unique research opportunity since there are now three historic tsunamis with significant impact on the same Sanriku coastline, which may allow differentiating between tectonic and potentially superimposed landslide tsunami sources. The tsunami sources and magnitudes of historic and geologic events inferred from tsunami deposits such as the 869 event need to be revisited. The tsunami survey team supported on this award will collect high quality inundation measurements that will allow the research community to infer the predictive capability of different tsunami models. Tsunami eyewitness videos will be calibrated in situ to extract time series of flow depth and velocity. The obtained field data will be analyzed closely with the existing laboratory data collected by past experimental projects. The primary project deliverable will be a comprehensive multi-scale, geo-referenced database of tsunami damage and flood zone characteristics combined with numerical model results. Education and outreach lectures and briefings will be given at villages surveyed and to eyewitnesses interviewed. The reconnaissance team will coordinate with the UNESCO-led International Tsunami Survey Team.

Tsunami reconnaissance of an estimated 1,000-year event will transform tsunami modeling and mitigation with broad implications beyond engineering. Post-disaster reconnaissance following major natural events has yielded significant new insights into both the characteristics of the events as well as the behavior of landforms and performance of infrastructure subjected to these catastrophic events. Through such research into the Tohoku tsunami, researchers may be able to understand the causes of the significant death toll that resulted from this disaster. The measurements and observations will also

provide important information that will be used to influence both evacuation and building procedures for the prevention of loss of life and property damage in Japan and in other areas of the world susceptible to tsunamis, such as the impact of a tsunami generated on the Cascadia subduction zone on communities along the U.S. Pacific Northwest and northern California coastlines.
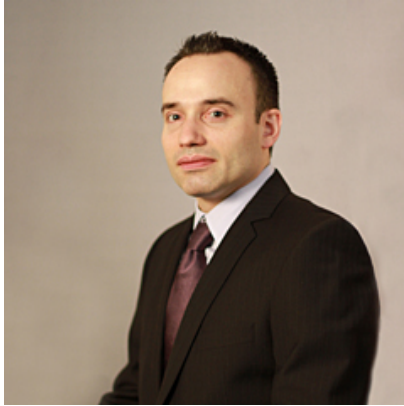
Hermann Fritz, Ph.D.
Associate Professor, Civil and Environmental Engineering, GeorgiaTech Savannah,

hermann.fritz@gtsav.gatech.edu
Phone: (912) 966-7947
Fax: (912) 966-7928
http://savannah.gatech.edu/offices-departments/people/hermann-fritz-ph-d

Education:

- Ph.D., Hydraulic Engineering, ETH (Swiss Federal Institute of Technology), 2002.
- M.S.C.E., Civil Engineering, ETH (Swiss Federal Institute of Technology), 1997.

Research Interests:

- Tsunamis, bores, non-linear and breaking waves
- Subaerial and submarine landslides and oceanic volcano island collapses
- Hurricane storm surges and coastal flooding Hydropower
- Wave and tidal energy Hydraulic, coastal, marine and offshore structures
- River engineering
- Sediment transport and morphologic processes
- Advanced whole field multi-dimensional laser measurement techniques
- Numerical simulation of multiphase flows
- Natural hazard mitigation and risk analysis
- Natural and man-made hazards

Biography:

Dr. Fritz started his dual-appointment in March 2003 as Assistant Professor at the Georgia Tech Regional Engineering Program in Savannah and the School of Civil and Environmental Engineering in Atlanta. His research centers on fluid dynamic aspects of natural hazards such as tsunamis, hurricane storm surges and landslides as well as their mitigation and coastal protection. Dr. Fritz obtained his Doctorate degree (Dr. Sc. Techn. ETH Ph.D. equivalent) in 2002 from the Swiss Federal Institute of Technology in Zurich (Switzerland) better known under the German acronym ETH. He graduated from ETH as Civil Engineer in 1997 and received a diploma (dipl.-Bau Ing. ETH considered equivalent to a MSCE). He was licensed as Civil Engineer in Switzerland. 1st Lieutenant Fritz served in the Swiss Air Force and Army Corps of Engineers from 1994 until 2002. Dr. Fritz is a Swiss citizen and was born in Zurich, Switzerland on May 20, 1972.

## RAPID: Reconnaissance of the 11 March 2011 Tohoku, Japan Tsunami

J-RAPID: Investigation on the 2011 Tohoku earthquake tsunami propagation, nearshore effects and mitigation by coastal structures

US: Hermann M. Fritz[1], Harry Yeh[2], Costas E. Synolakis[3,4], David A. Phillips[5 (subaward)],
JP: Shinji Sato[6], Y. Tajima[6], H. Liu[6], T. Takagawa[6], A. Okayasu[7], T. Shimozono[7]

[1]Georgia Institute of Technology, [2]Oregon State University, [3]University of Southern California, [4]HCMR, [5]UNAVCO
[5]University of Tokyo, Japan, [3] Tokyo University of Marine Science and Technology, Japan

Objectives:

- Initial rapid survey to document perishable tsunami characteristics as part of Tohoku Earthquake Tsunami Joint Survey Group (~300 participants).
- Specifying the failure mechanisms of various coastal structures and proposing efficient countermeasures.
- Extract tsunami hydrographs and current velocities from eyewitness videos calibrated with detailed terrestrial LiDAR based topography.
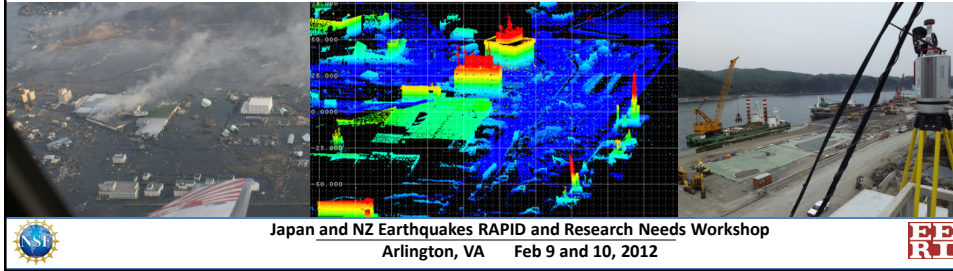
Key Findings

- 2011 Tohoku tsunami characteristics

  Tsunami height and inundation distance measurements in joint database (TETJSG); Runup height distributions for several historical events and numerical simulations were compared.

- Coastal Structure Failure mechanisms

  Combined Field, laboratory and numerical studies on coastal seawall failure mechanisms and tsunami block and boulder transport.

- Tsunami Hydrograph and Current velocities

  Detailed LiDAR topography at several sites, eyewitness video analysis resulted in tsunami hydrograph and current velocity measurements (Fritz et al., 2012, GRL-special section, published)
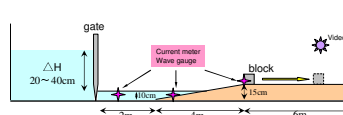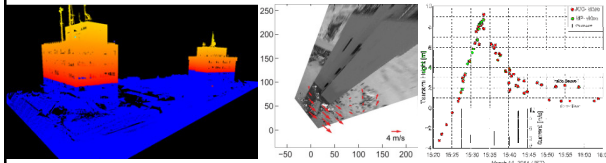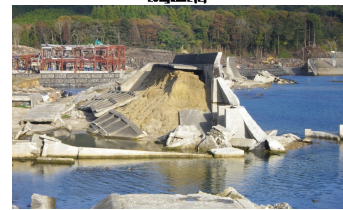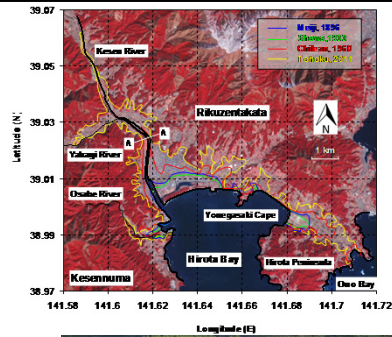
Opportunities for Future Research

What new questions raised by these events require basic research?
- Historic tsunami runup distributions and potential submarine landslides
- Tsunami characteristics for various event types including tsunami earthquakes
- Effectiveness and failure of various coastal tsunami mitigation structures
- Tsunami flooding velocities, boulder transport and sediment deposit records

What new data are available as a result of these events?
- Intermediate water depth GPS-buoy tsunami wave profiles
- High-density tsunami characteristics database for 5 overlapping historic events
- High-density LiDAR coastal flood zone and damage topography
- Video-derived temporal and spatially resolved tsunami hydrograph and currents
- Post-tsunami coastal structures and tsunami forest performance and failure data

What unique aspects of these events require the development of a focused research program?
- Link between advanced inundation data modeling, sedimentology and boulders
- Construction mitigation standards for various coastal structures against tsunamis

What are the important lessons from these larger than expected events for the U.S.?
- Revaluation of tsunami flood zones, evacuation maps, expected impact on navigation and coastal structures in case of design exceedence.

RAPID: Time Series Sampling for Radionuclide and Biogeochemical Fluxes at F1 Time-series Station, Offshore Fukushima Dai-ichi Nuclear Power Facility

ABSTRACT:

The 2011 Tohoku earthquake off Japan resulted in a tsunami that severely damaged the Fukushima Dai-ichi nuclear power facility. Emergency cooling using seawater, in response to overheating of the facility's reactor units 1, 2 and 3 and uncontained spent fuel pools, has led to run-off of contaminated waters to the adjacent Pacific Ocean that, cumulatively, measure > 10,000 higher than pre-tsunami levels and exceed the release of radionuclides to the marine environment from Chernobyl accident.

With funding through this Grant for Rapid Response Research (RAPID), a research team at the Woods Hole Oceanographic Institution will participate in a JAMSTEC-led cruise in June-July 2011, and deploy a time-series sediment trap mooring at a station 80km off the coast of Japan. The specific goal will be to collect settling particulate radionuclide matter over the coming weeks and months through to an already-scheduled cruise to recover the moorings in May, 2012. By deploying traps at 500m and 1000m, the team will intercept particle-attached radionuclide settling out of the upper ocean and assess their fluxes into the deep ocean interior. They will collect fresh samples approximately every 2 weeks at each depth throughout the sampling period to complement snap-shot sampling that will be conducted aboard the JAMSTEC cruise at the start and end of the deployment period.

The team will also collaborate closely with Dr. Ken Buesseler at WHOI (already funded separately, including a complementary NSF-RAPID project) who will be responsible for radionuclide analyses of particulate samples at no additional cost to this proposal. This project will handle preparation, deployment and recovery of the time-series sediment trap mooring as well as preliminary sample splitting, characterization of samples for biogeochemical properties and sample archiving. Radionuclides of primary interest at this time include 137Cs, 134Cs, 106Ru, 144Ce and 147Pm; other species (e.g. Pu isotopes) may also prove to be of interest within the lifetime of the deployment. Thus an important part of the project will also be to stand ready to provide further splits of these well characterized samples to US, Japanese and other interested international research groups in the future, as need arises.

Broader Impacts: As learned in the aftermath of Chernobyl, establishing the distributions and activities of radionuclides present in the environment as soon as possible post-release is important to understanding the severity of the releases that have occurred, their implications for public health, and

to establish "time zero" conditions against which the wider oceanographic community can subsequently track the fate of long-lived (conservative and biogeochemically-active) radionuclides. In addition to the strong international (WHOI-JAMSTEC) collaboration that has already been developed for this project, the team will share all data (banked with BCO-DMO at Woods Hole) and samples collected by this work with the wider national and international science community and public.

Chris R. German

Senior Scientist
Chief Scientist for Deep Submergence
Geology & Geophysics

cgerman@whoi.edu
Phone: (508)289-2853
Fax: (508) 457-2150
http://www.whoi.edu/profile/cgerman/

Education:
- Sc.D., Earth Sciences, 2006, University of Cambridge, UK
- Ph.D., Marine Geochemistry, 1988, University of Cambridge, UK
- B.A., Natural Sciences (Chemistry & Geology), 1984, University of Cambridge, UK

Research Interests:
- Geologic controls on hydrothermal activity
- Impact of hydrothermal activity on ocean budgets
- Chemosynthetic Ecosystems
- New Technologies for Deep Ocean Exploration

Recent Research Projects:
Dr. German has won national and international recognition by demonstrating that hydrothermal vents can, indeed, occur in all the world's ocean basins—even along the least volcanically active chains. He was also part of a research team that, while working last year in the South Atlantic, discovered the hottest known hydrothermal vent plumes: 407°C! Most recently, working with WHOI colleague Jian Lin and a team of Chinese oceanographers, German helped discover the first vents ever found on the ultraslow-spreading Southwest Indian Ridge. German's recent successes are largely a result of his pioneering use of WHOI's free-swimming robotic vehicle named *ABE* (Autonomous Benthic Explorer) to "sniff" out vents on the seafloor, allowing researchers to make more targeted use of more intensive samplers and submarine vehicles. Next up for German is a search for vents along the East Scotia Ridge, Antarctica—perhaps the most isolated ridge on Earth. That work is scheduled for January 2009.

In his continuing search for vents, German has become well acquainted with deep-sea technology. Soon after he joined WHOI as a senior scientist in 2005, he was named Chief Scientist for Deep Submergence for the National Deep Submergence Facility, which operates the *Alvin* submersible, the *Jason* remotely operated vehicle (ROV), and *ABE*. His expertise has also brought him to the co-chairmanship of the *InterRidge* program—which promotes international, cooperative studies of mid-ocean ridges—and that of the *ChEss Project*, a part of the *Census of Marine Life.* German truly has his finger on the pulse of vent research around the world.

Project Description/Objective

- **RAPID title**

  Time Series Sampling for Radionuclide and Biogeochemical Fluxes at F1 Time-series Station, Offshore Fukushima Dai-ichi Nuclear Power Facility

- **US Researchers**

  German, C., Manganini, S., Buesseler, K.

  (Woods Hole Oceanographic Institution)

- **International counterparts**

  Honda, M. C., Kawakami, H., Kitamura, M.

  (Japan Agency for Marine-Earth Science and Technology)

- **Objective of RAPID**

  To verify vertical transport of Fukushima artificial radionuclides by settling particles in the western North Pacific

- **Tactics**

  Collection of time-series settling particles by sediment traps deployed at stations F1, S1 and K2 in the western North Pacific

Key Findings

Deployment of sediment traps
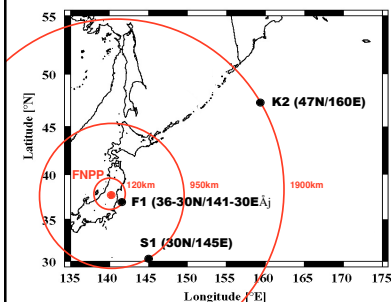
^{134}Cs in settling particles at 4810 m of stations K2 and S1
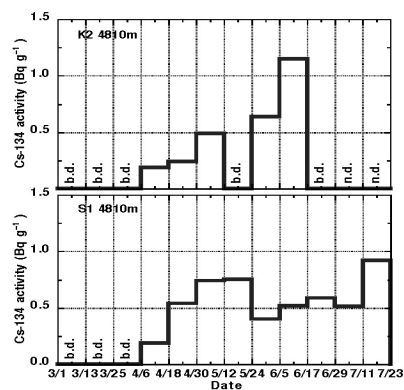
Detection of ^{134}Cs from sample collected after 6 April

（Detail is shown on poster.）

Broader Impacts

As learned in the aftermath of Chernobyl, establishing the distributions and activities of radionuclides present in the environment as soon as possible post-release is important to understanding the severity of the releases that have occurred, their implications for public health, and to establish "time zero" conditions against which the wider oceanographic community can subsequently track the fate of long-lived (conservative and bio-geochemically-active) radionuclides. In addition to the strong international (WHOI-JAMSTEC) collaboration that has already been developed for this project, we will strive to share all data (to be banked with BCO-DMO) and samples collected by this work with the wider national and international science community and public. But the single greatest contribution we anticipate will be to provide timely, quantitative data, from which well-informed policy decisions can subsequently be made.

RAPID Response to Tohoku Earthquake: Participation in Marine Geophysical Surveys of the Quake Rupture Zone

Program Manager: Thomas Janecek
OCE Division of Ocean Sciences
GEO Directorate for Geosciences

Investigator(s):   Gregory Moore (Principal Investigator)

Sponsor: University of Hawaii
2530 Dole Street
HONOLULU, HI 96822 808/956-7800

NSF Program(s):   OCEAN DRILLING PROGRAM,
MARINE GEOLOGY AND GEOPHYSICS

ABSTRACT:

We propose to participate in one or two marine geophysical surveys covering the rupture zone of the March 2011 great earthquake off Tohoku, Honshu, Japan during summer, 2011. In response to this great earthquake, the Institute For Research on Earth Evolution (IFREE) of the Japan Agency for Marine-Earth Science and Technology (JAMSTEC) has undertaken a program of marine geophysical surveys to try to detect seafloor and subsurface structures associated with the quake's rupture. One cruise will include multibeam bathymetric mapping during OBS recovery and redeployment in June-July. A more extensive MCS survey is planned for August. Coupled with the extensive on-land seismograph and GPS network, the offshore data set presents an unprecedented opportunity to study deformation associated with rupture during a great earthquake. Moore and his students have been invited to participate in the offshore to help with data acquisition and on-board data processing and to participate in the structural interpretation and synthesis of the offshore data sets. The main advantage of participating in the cruises is that we will also be able to participate in the data analysis phase. We will be able to combine the new data sets with seismic reflection and bathymetric data collected previously by IFREE. The seismic reflection data to be collected in the earthquake rupture zone will be used as a site survey for a proposal to IODP for Rapid Response Drilling off Tohoku. The seismic data will be essential for defining drilling targets. We note that the older seismic lines in this area, while excellent for interpreting the regional tectonics, do not image any potential drill sites, so high-quality images will be required in advance of any drilling. The main reason why this work needs to be funded quickly is because the Japanese will be carrying out the work as already scheduled, whether or not we are able to participate. If we have to go through the 'standard' proposal process, with the next proposal deadline being in August, the work will have already been completed by the time funding decisions could be made. We would thus lose out on this opportunity for U.S. scientists to have early access to this large data set at relatively low cost.

Broader impacts:

One product of this project will be a seismic reflection and multibeam bathymetry data set that will help characterize the Earth's best documented great earthquake. Although this data set will exist within Japan, it will not be released to non-Japanese researchers for many months (or years). Our participation

will ensure that US scientists will be able to help interpret the data. The seismic reflection data will be used as a site survey to determine whether or not a rapid-response drilling program will have suitable drill targets. This project will also provide valuable sea-going experience for two graduate students.

Gregory F. Moore

Professor
Dept. of Geology & Geophysics
University of Hawaii

gmoore@hawaii.edu
Phone: (808) 956-6854
Fax: (808) 956-5512
http://www.soest.hawaii.edu/moore/

Education:
- Ph.D., Cornell University, 1977
- M.A., The Johns Hopkins University, 1974
- B.A., University of California, Santa Barbara, 1973

Research Interests:
- Marine Geophysics
- Tectonics

Biography:
While at U.H., Dr. Moore has participated in several oceanographic expeditions, including four cruises for the Ocean Drilling Program (one as co-chief scientist). He is a fellow of the Geological Society of America, and a member of the American Geophysical Union, the Society of Exploration Geophysicists, and the American Association of Petroleum Geologists.   During 2006-2008, Greg worked at JAMSTEC in Yokohama, Japan as Advisor to Asahiko Taira, Director General of the Center for Deep Earth Exploration (CDEX). In November, 2007, he completed the first expedition of IODP drilling with D/V *Chikyu* in the NanTroSEIZE area south of Honshu, Japan. Stage 2 of NanTroSEIZE took place during June-October, 2009, and Stage 3 began in 2010 and is scheduled to continue in 2012.

Recent Research Projects:
Greg's main research interest is in the highly deformed belts of rock that develop along convergent plate margins. This is, in large part, a study of the processes responsible for mountain building and for the generation of continental crust. Because most convergent plate margins are expressed as trench-arc systems in which the zones of active deformation are beneath very deep water, marine geological and geophysical remote sensing techniques must be relied on. These have included seismic reflection profiling, high-resolution multibeam bathymetric mapping, and ocean drilling. He is also interested in giant landslides off the Hawaiian Islands.

During April-May, 2006, he conducted a 3D seismic reflection cruise to the new IODP drilling transect in the Nankai Trough. The data set was collected by PGS using the *Nordic Explorer* with 4 x 4500m streamers. A full 3D pre-stack depth migration (PSDM) was completed by IFREE/JAMSTEC in November, 2007. An initial results paper appeared in Science in November, 2007. A second paper that defines the regional tectonic setting of the NanTro transect was published in the IODP Expedition 314/5/6 Initial Report Volume.

Participation in Marine Geophysical Surveys of the Tohoku Quake Rupture Zone

- University of Hawai`i
  G. Moore, J. Barnes,
  B. Boston

- IFREE/JAMSTEC
  S. Kodaira, T. Fujiwara,
  T. No, Y. Nakamura,
  Y. Kaiho, G. Fujie,
  N. Takahashi, Y. Kaneda
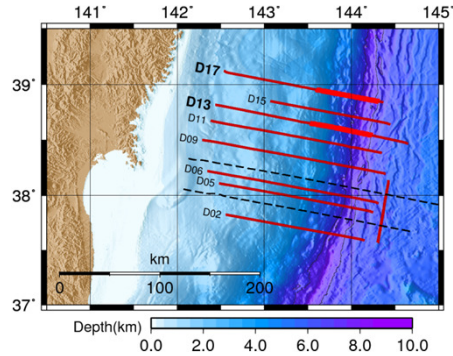
  Objective: Image the geologic structure of the Tohoku quake epicentral region

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Key Findings

- Repeat bathymetry surveys show evidence for landslide at base of trench slope with accumulation of debris in the trench
  - Frontal region shifted 50 m seaward
  - Causes effective 10 m uplift to generate tsunami
- Seismic reflection images show potential propagation along a décollement interface at the base of the frontal accretionary prism
  - Co-seismic rupture may have propagated all the way to the trench

Opportunities for Future Research

- We need to determine whether or not the rupture propagated all the way to the trench
  - IODP drilling in April, 2012 will help
  - Future seismic/bathymetric surveys will be necessary

- The new bathymetry and seismic reflection data will allow much more precise measurements of possible fault slip after additional data processing

- An important lesson for the U.S. is that co-seismic slip may be able to propagate all the way to the trench axis
  - We need to evaluate whether this may mean that potential quakes in the Aleutian or Cascadia regions could result in larger tsunami events than previously thought

RAPID: Performance of the Base-Isolated Christchurch Women's Hospital during the Sequence of Strong Earthquakes and Aftershocks in New Zealand from September 2010 through 2011

Program Manager: Joy Pauschke
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s):   Henri Gavin (Principal Investigator)

Sponsor: Duke University
2200 W. Main St, Suite 710
Durham, NC 27705 919/684-3030

NSF Program(s):   NEES RESEARCH

ABSTRACT:
The objective of this Rapid Research Response (RAPID) award is to collect perishable data on the seismic response of the base-isolated Christchurch Women's Hospital during the sequence of strong earthquakes and aftershocks in Canterbury, New Zealand from September 2010 through 2011. The relatively high probability of additional strong aftershocks in 2011 presents a unique opportunity to capture high-fidelity data on the performance of a modern seismically-isolated structure. This project involves collaboration among researchers at Duke University and the University of Canterbury. The project team will travel to Christchurch to temporarily instrument the isolation galley and the top level of the Christchurch Women's Hospital with accelerometers, displacement transducers, and data recorders loaned from the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) facility at the University of California, Los Angeles. This instrumentation is capable of enabling near real-time observation of the building response measurements. Aftershock responses will be recorded automatically over a period of months and ambient vibrations will be recorded periodically. These records will be used to assess the behavior and to develop mathematical models of this seismically-isolated structure, including soil-foundation-structure interaction effects and the effects of inter-structural coupling.

Understanding soil-foundation-structure interactions and coupled-structure interactions in base-isolated buildings is needed for advancing knowledge and future implementation of this method of seismic hazard mitigation. Visual inspection of the seismic isolators following the New Zealand earthquakes of 4 September 2010 and 22 February 2011, and the first-person accounts of motions felt within the hospital during these events, indicate that the isolation system deformed less than may have been expected given local ground motion records. High-fidelity response measurements of this structure to strong aftershocks will provide the basic quantitative information required to assess the mechanisms at play in this and many similar base-isolated structures. Future implementation of base isolation as a seismic mitigation strategy will therefore benefit from the knowledge gained from examining the performance of a modern base-isolated facility responding to strong ground motions. Collaboration among researchers in the United States and New Zealand in this project will advance the development of seismic isolation internationally. Knowledge generated from this project will be used to illustrate soil-foundation-structure interaction effects in an interactive web-based educational tool, and will provide opportunities for undergraduate research.

Henri P Gavin

W. H. Gardner Jr. Associate Professor
Civil and Environmental Engineering
Duke Pratt School of Engineering

henri.gavin@duke.edu
Phone: (919) 660-5201
http://www.cee.duke.edu/faculty/henri-p-gavin

Education:
- PhD at University of Michigan, 1994
- MS at University of Michigan, 1988
- BS at Princeton University, 1986

Specialties:
- Earthquake Engineering, adaptive structures
- Structural Engineering
- Alternative Energy
- Adaptive Structures
- Vibration
- Nonlinear Dynamics

Research Interests:
Structural dynamics, structural control, and related applications of controllable materials, especially the use of electrorheological and magnetorheological dampers for structural vibration suppression. This work encompasses rheology, non-Newtonian fluid mechanics, visco-elasticity, non-linear structural dynamics, and multivariable control.

Recent Research Projects:
Henri's work encompasses rheology, non-Newtonian fluid mechanics, visco-elasticity, non-linear structural dynamics, and multivariable control. His research is sponsored primarily by NSF (Earthquake Hazard Mitigation Program), the Oak Ridge Associated Universities, and the North Carolina Space Grant Consortium. His experimental facilities include a high capacity load frame and a high-fidelity seismic simulator. He also has strong professional interests in structural behavior and structural integrity assessment techniques involving non-destructive evaluation.

Seismic Behavior of the
Christchurch Women's Hospital

- Henri Gavin (Duke), Bob Nigbor (UCLA),
  - Wayne Lawson (CDHB NZ),
- Greg MacRae, Geoff Chase, Geoff Rodgers, Stefanie Gutschmidt (Canterbury NZ)

- The objective of this project is to collect perishable seismic response data from the base-isolated Christchurch Women's Hospital. The strong and continuing sequence of aftershocks presents a unique opportunity to capture high-fidelity data from a modern base-isolated facility. These measurements will provide quantitative information required to assess the mechanisms at play in this and in many other seismically-isolated structures.
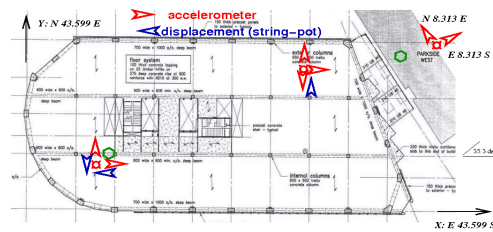
Key Findings

- The deformations within the isolation system were generally smaller than would have been anticipated for the M6 @10 km event of Dec 23 2011. Free-field records from these events had PGA ~ 0.2g and PGV ~ 15 cm/s (comparable to the Feb 22 2011 M6.3 motions at the site). Nonetheless, measured accelerations below the isolation system were half of the free-field levels this level (0.1 g) and isolator displacements were on the order of 2-5 cm. (Accelerations at the top level of the adjacent fixed-base structure were on the order of 0.4 g.)

- Long period accelerations and liquefaction debris observed in the isolation galley suggest that soft soils may have contributed to this behavior.

Opportunities for Future Research

- How do interactions with locally soft/weak soils and with adjacent/coupled structures affect the performance of seismically isolated structures, and how do these interactions scale with shaking intensity?

- This project has developed well over 200 triggered events (and counting) from M 3.5 to a M6 event (10 km from the building site).
- Up to 48 channels of processed data per event. Records are rotated, detrended and synchronized with nearby GeoNet (NZ) records.

- These records provide a unique opportunity to examine the effects coupled-building interactions with a seismically-isolated structure, SFSI interaction in an isolated structure, soil liquefaction and re-consolidation over time (months) and throughout an earthquake swarm.
- Many sites in the US share seismic risks that are qualitatively similar to those in Christchurch NZ: aluvial basins and liquefiable soil. Moreover, this data set will enable important insights into the performance of a structure with the kind of seismic-isolation used to protect many structures in the US.

RAPID: Forensic Analysis of Eccentrically Braced Frame Fracture during the February 2011 Christchurch, New Zealand Earthquake

Program Manager: Joy Pauschke
                         CMMI Division of Civil, Mechanical, and Manufacturing Innovation
                         ENG Directorate for Engineering

Investigator(s):   Amit Kanvinde (Principal Investigator)

Sponsor: University of California-Davis
                         OR/Sponsored Programs
                         Davis, CA 95618 530/754-7000

NSF Program(s):   HAZARD MIT & STRUCTURAL ENG

ABSTRACT:

The principal research objective of this Rapid Response Research (RAPID) award is to identify and understand the conditions that could cause an earthquake-induced fracture in eccentrically braced frame (EBF) steel buildings. For this purpose, multi-scale forensic analysis of the first earthquake failure worldwide of an EBF structure will be conducted. Such a failure occurred in the Christchurch Hospital during the February 2011 Christchurch, New Zealand earthquake. The perishable data to be collected under this RAPID are material specimens from the failed frame before repairs begin. The forensic analysis involves simulations encompassing several scales (from building scale to micromechanical fracture), and will feature mechanical and chemical material tests from the failed frame. The research, if successful, will result in the discovery of new failure modes of EBFs with direct implications for design safety.

The broad significance of this research will include the discovery of new failure modes and the consequent enhancement of design considerations, resulting in safer buildings. Outside the immediate discipline of structural engineering, a significant impact is the modeling of a comprehensive end-to-end simulation (encompassing several scales) of an observed field failure. In addition to revealing deficiencies in such end-to-end simulation methodologies, and thus spawning new research, this will have high educational and training value across various levels of academic accomplishment, including technology transfer to industry.

Amit Kanvinde

Associate Professor
Department of Civil and Environmental Engineering
University of California

kanvinde@ucdavis.edu
Phone: 530-752-2605
Fax: 530-752-7872
http://cee.engr.ucdavis.edu/faculty/kanvinde/

Education:
- Ph.D. (2004), MS (2000), Stanford University
- B.Tech (1999) Indian Institute of Technology, Bombay

Research Interests:
Amit Kanvinde's research interests focus on the seismic response and design of steel structures, with an emphasis on fracture and fatigue.

Recent Research Projects:
His research combines large and small-scale experiments with model-based simulation to develop a more fundamental understanding of the response of structural systems. His ongoing projects address (1) The seismic response of column base connections (2) The development of continuum models for low-triaxiality fracture and fatigue in steel (3) The seismic performance of column splices and (4) Forensic analysis of earthquake induced fracture in eccentrically braced frames.

Some of Professor Kanvinde's recent projects have addressed (1) Ultra low cycle fatigue in steel structures (2) Inelastic buckling and fracture of cyclically loaded steel braces and (3) Strength and ductility of transversely loaded fillet weld connections.

Forensic Analysis of Eccentrically Braced Frame Fracture during the 2/22/11, Christchurch, NZ, Earthquake

US Researcher: Amit Kanvinde, UC Davis

NZ Counterpart: Chris Allington, Holmes Consulting, New Zealand; Thanks to, Wayne Lawson, Canterbury Health Board

Objective: Examine factors influencing first ever fractures of EBF links observed in the field, by conducting material tests and 3-d scans on failed frames
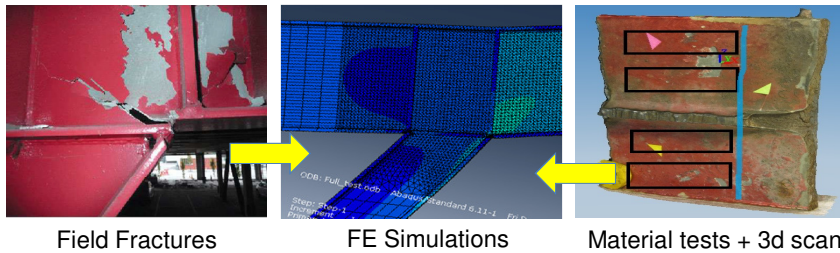
Field Fractures   FE Simulations   Material tests + 3d scans

Key Findings

- Material weakness, or overall deformation demand does not appear to be the factor responsible for fracture, as evidenced by material (CVN and fracture) tests, and by 3-d scans, indicating very large local deformation prior to fracture
- Poor stiffener detailing appears to be the major factor, and enhancement of provisions to preclude such details (and rigorous inspection) will mitigate similar issues in the US

Opportunities for Future Research

- What new questions raised by these events require basic research? (I am answering in the specific context of my RAPID, although they may be interpreted in a broader context)

Large structural fracture with dollar/life repercussions is sensitive to minor variations in local details (perhaps more so than typically assumed). Systematic study of these sensitivities and incorporation into reliability analyses may significantly overall system reliability of several (especially steel) structures

- What new data are available as a result of these events?

Unexpected failure modes in steel, concrete and wood buildings. Important because design philosophies/standards in NZ and the US are similar

- What unique aspects of these events require the development of a focused research program?

A general issue is that reconnaissance, forensic analyses are often done in an ad-hoc way. The development of earthquake-specific forensic analysis methodologies (in the presence of incomplete material, configurational, soil, ground motion data) to rigorously quantify *a posteriori* probabilities of the factors affecting failure is important.

- What are the important lessons from these larger than expected events for the U.S.?

Award Abstract # 1138609

RAPID: Collection of Data on the Performance of Wood Diaphragms in Buildings during the February 2011 Christchurch, New Zealand Earthquake

Program Manager: Joy Pauschke
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s):   Roberto Leon (Principal Investigator)

Sponsor: Georgia Tech Research Corporation
Office of Sponsored Programs
Atlanta, GA 30332 404/894-4819

NSF Program(s):   NEES RESEARCH,
COLLABORATIVE RESEARCH

ABSTRACT:

This Rapid Response Research (RAPID) award will collect data to document the performance of unreinforced masonry (URM) construction during the February 2011 Christchurch, New Zealand earthquake. Specifically, this award will document the ability of originally constructed and retrofitted floor and roof diaphragms to efficiently distribute loads to all walls and other lateral-load resisting elements. NZ URM construction from 1880 to about 1970 typically used timber joists, rafters, and trusses, very similar to U.S. construction from the same era. The project will catalog seismic performance at both the qualitative and quantitative levels. At the qualitative level, the project will identify weak or poor detailing typical in URMs and effective mitigating technologies. At the quantitative level, the project will develop guidelines for the type and detailing of retrofit measures to be used in strengthening projects in the United States. These guidelines will be developed in close collaboration with the U.S. masonry industry and practitioners to ensure that results from this research will be transferred quickly to American practice.

Building stock in large parts of the United States, including most of the east coast and the Midwest, consists of URM construction. This type of building is known to be very susceptible to collapse under earthquake loading; therefore, effective and economical retrofit techniques are needed to mitigate damage and ensure human safety. The Christchurch event provides unique and exceptional data to calibrate current U.S. practices for seismic evaluation and retrofit of these systems, including retrofits that did not bring the structures to 100% of the strength required by current codes. This latter data is important for the case where seismic retrofits will not be carried as a single project, but rather as a series of smaller projects spread over a number of years as other improvements are made to existing URM buildings. This staged approach has been proposed to spread the cost over a longer period and make the retrofits more feasible. The NZ experience will clarify which vulnerabilities need to be addressed first and which techniques should be used.

Roberto T. Leon

Professor
School of Civil & Environmental Engineering
Department of Structural Engineering, Mechanics and Materials
Georgia Institute of Technology

roberto.leon@ce.gatech.edu / rleon@vt.edu
Phone: (404)894-2220
http://www.ce.gatech.edu/node/921

Education:

- Ph.D., Civil Engineering, University of Texas at Austin, 1983.
- M.S.C.E., Structural Engineering, Stanford University, 1979.
- B.S.C.E., Civil Engineering, University of Massachusetts, Amherst, 1978.

Biography:

From 1983 to 1994 Roberto was assistant and associate professor in the Department of Civil and Mineral Engineering at the University of Minnesota, and became professor in the School of Civil and Environmental Engineering at the Georgia Institute of Technology in 1995. He served as interim Chair of the School in 2002-2003. He is a member of the AISC Committee on Specification, the BSSC Provisions Update Committee, and of several technical committees on steel and composite construction. He is a member of the Board of Governors of the Structural Engineering Institute (SEI/ASCE) and incoming president of the Network for Earthquake Engineering Simulation (NEES). He is a registered professional engineer in Minnesota, the co-author of a book on composite construction, a non-technical book on bridges and tunnels, and is the author and co-author of over 60 articles in refereed journals.

Research Interests:

- Behavior and design of steel and composite connections
- Seismic design of steel-braced frames and frames with partially restrained connections
- Seismic behavior of bridges
- Serviceability of composite floors
- High performance materials

Performance of Retrofitted Wood Diaphragms

Jazalyn Dukes and Stephanie German , Ph.D. Students (field reconnaissance), Julie Dykas, M.S. (data processing) and Roberto T. Leon, Professor (*)

CEE, Georgia Tech, Atlanta, GA

Objective: collect data on the performance of diaphragms, and reevaluate/propose changes to current USA strengthening practices

(*) Collaborators: J. Ingham, Professor, *U. of Auckland, NZ;* L. Moon, Ph.D. Student, *U. of Adelaide, AU*; A. Schultz, Professor, *U. of Minnesota, and* D.Biggs, Consultant, *Troy, New York*

Key Findings

- Most damage due to inadequate anchorage of roof and floor diaphragms to walls due to improper installation or selection of anchor.
- Many partial retrofits (either in terms of overall base shear or local diaphragm forces) do not seem to have worked well

The Malthouse – successful retrofit by The Holmes Group (J. Hare, SE)

Opportunities for Future Research

- Cyclic performance of interface zone in post-installed anchorages into weak mortars and brick needs urgent and careful reexamination from both analytical and experimental standpoints for older USA materials.
- Determine correlation between high level of damage for URMs and local ground motions/soil conditions, particularly with respect to cumulative damage from several earthquakes.
- Partial retrofit strategies may not work as envisioned; selective strengthening and stiffening of diaphragms requires careful consideration of overloading of other critical structural elements.
- Reconsider USA (HAZUS – type) damage models for URM structures; NZ earthquake clearly points out vulnerability of cities such as Memphis and St. Louis, as well as military facilities throughout the USA.

"Well considered, conceived and implemented seismic retrofits of URM buildings performed well, even when the building experienced ground motion that was well in excess of the design level for Christchurch."
(J. M. Ingham and R.M. Griffin, The Performance of Unreinforced Masonry Buildings in the 2010/2011 Canterbury Earthquake Swarm, Rep[ort to Royal Commission of Inquiry, August 2011)

NEES@UCLA AS A RESOURCE FOR RAPID PROJECTS IN CHRISTCHURCH

Bob Nigbor, Erica Eskes, Steve Keowen, Alberto Salamanca, John Wallace (NEES@UCLA)

collaborating with:

Geoff Chase, Stephanie Gutschmidt, Greg MacRae,
Stefano Pampanin, Geoff Rodgers (University of Canterbury)
Henri Gavin (Duke RAPID)
Jose Restrepo, Matt Schoettler (UCSD RAPID)

Advanced Dynamic Field Measurements of Structural Response
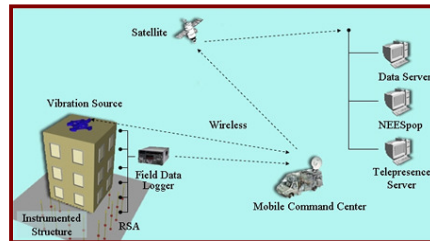
Japan and NZ RAPID and Research Needs Workshop
February 9 and 10, 2012

NEES Instrumentation In Christchurch July 2011 - Present

Servo Accelero-meters
- sub-micro-g to 4g
- DC – 200Hz
- 24 channels

Other Sensors
- Displacement (string pots)
- Environmental
- *Others as needed*

Data Acquisition Units
- 24-bit digital
- A/D for each channel
- up to 2000 sps/ch
- GPS timing
- Battery power

Software/ Firmware
- Continuous recording
- Triggered recording
- Remote access
- Real-time data
- Modal analysis
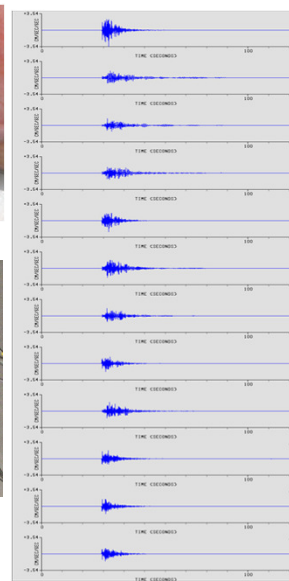
Japan and NZ RAPID and Research Needs Workshop
February 9 and 10, 2012

NEES@UCLA AS A RESOURCE FOR
RAPID PROJECTS IN CHRISTCHURCH

Bob Nigbor, Erica Eskes, Steve Keowen, Alberto Salamanca, John Wallace (NEES@UCLA)

Restrepo et al. RAPID
- July-September 2011
- Damaged 5-level Parking Structure
- Damaged 8-story hotel in CBD
- Extensive ambient vibration data for both
- Triggered earthquakes for both
- Demolition vibrations (nearby) for hotel
- NEES personnel brought equipment and worked with UC and UCSD researchers

Gavin RAPID
- September 2011 - present
- Base isolated hospital building
- Connected conventional building
- Extensive ambient vibration data for both
- Triggered earthquakes for both
- 100's of aftershocks
- NEES personnel installed equipment in collaboration with UC and Duke researchers
- Remote operation of instrumentation via hospital VPN

RAPID and Research Needs Workshop
February 9 and 10, 2012

RAPID: Mapping of Damage in Precast Concrete Buildings from the February 2011 Christchurch, New Zealand Earthquake

Program Manager: Joy Pauschke
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s):   Jose Restrepo (Principal Investigator)

Sponsor: University of California-San Diego
Office of Contract & Grant Admin
La Jolla, CA 92093 858/534-4896

NSF Program(s):   NEES RESEARCH,
COLLABORATIVE RESEARCH

ABSTRACT:
The objective of this Rapid Research Response (RAPID) award is to gather perishable data on the damage to two precast concrete buildings during the February 2011 magnitude 6.3 Christchurch, New Zealand, earthquake. This project is a collaboration among researchers from the University of California-San Diego, University of Arizona, and University of Canterbury. Project team members will travel to Christchurch and catalog earthquake damage (foundation, structural and non-structural) through visual observation. The post-earthquake structural state will be determined by means of collecting ambient vibration and potential aftershock dynamic response. An array of accelerometers loaned from the NEES facility at the University of California, Los Angeles will be temporarily deployed to monitor and record these vibrations. Sensors will be strategically distributed to capture the predominant modes of vibration and concentrated at the foundation to capture soil-structure interaction. This data will be post-processed for a first-level system identification and characterization of the damaged buildings.

Cataloging post-earthquake damage is an established practice for the benefit of seismic design. Forensic engineering is an essential catalyst of modern building codes. The technique advances the field of earthquake engineering leading to better designs, seismic details, and construction methods. These two buildings are important to the earthquake engineering research community and the precast concrete industry in the United States because of relevant construction and designs. With state-of-the-art seismic design guidelines in place, the two buildings performed as intended, well beyond the life-safety minimum of seismic design philosophy in New Zealand and the United States. Structural damage was sustained as expected, with the buildings' structural integrity remaining intact. To replicate this desirable performance in future buildings, the damage needs documenting to advance the earthquake engineering practice before repairs eliminate the opportunity. Participation by researchers at three universities in two countries will strengthen the infrastructure for research on an international level. Educational outreach is leveraged by introducing an undergraduate student to international collaborative research, forensic engineering, sensors, data acquisition, and seismic resilience with an NSF-supported Research Experiences for Undergraduates site through the Pacific Earthquake Engineering Research Center at the University of California, Berkeley.

Jose I. Restrepo

Note: Matthew Schoettler will be representing the project instead.

Professor for Structural Engineering
University of California, San Diego

jrestrepo@ucsd.edu
Phone: 858-822-3392
http://www.jacobsschool.ucsd.edu/faculty/faculty_bios/index.sfe?fmp_recid=9

Education:
- Ph.D., Civil Engineering, University of Canterbury, Christchurch, New Zealand, (1993)
- C.E., Universidad de Medellín, Medellín, Colombia (1983)

Research Interests:
- Seismic design of buildings for improved response during earthquakes.

Recent Research Projects:

Professor Restrepo focuses on the discovery of construction alternatives for state-of-the-art, performance-based designs. This involves the conceptual design of reinforced, prestressed and precast concrete structures, reinforcement detailing and strut-and-tie models. By using shake table tests on buildings and buildings components, Restrepo evaluates their non-linear dynamic reponse.

Currently, Restrepo is developing "articulated" buildings with linked components that form a moveable whole. This flexibility provides damage free response, externally and internally. Concrete or steel columns are linked together with braided strands of steel that run through internal ducts and are anchored to the ground. The strands will not yield during a quake and will reposition the building when it is displaced. Vibration dampeners in the floor act like shock absorbers to minimize movement and eliminate damage.

RAPID: Mapping of Earthquake Damage in Precast Buildings in Christchurch, New Zealand

US Researchers

José Restrepo, UCSD (P.I.)

Robert Fleischman, Univ. of Arizona (Co-P.I.)

Matthew Schoettler, UC Berkeley

Robert Nigbor, UCLA

David Deutsch, USC (PEER intern)

International collaborators

Stefano Pampanin, Univ. of Canterbury

Sahin Tasligedik, Univ. of Canterbury

Umut Akguzel, Univ. of Canterbury

Patricio Quintana Gallo, Univ. of Canterbury

John Marshall, Precast NZ

Hannah Clarke, Powell Fenwick Consultants

The project objective was to gather perishable data on two precast concrete buildings damaged by the events in Christchurch, New Zealand. Damage patterns were collected and archived for future numerical model verification. This information is bolstered by the concurrent deployment of high quality sensors to record data for system identification.

5-story Parking Garage
Partially precast concrete helical ramp structure
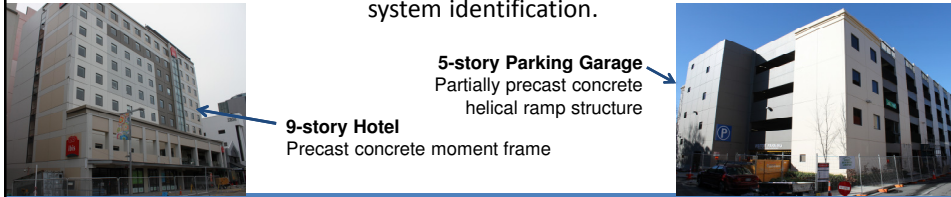
9-story Hotel
Precast concrete moment frame

Key Findings

- Damage patterns were consistent with current NZ seismic design philosophy. Plastic deformations concentrated in regions especially detailed for seismic energy dissipation, but both structures had regions that experienced excessive damage.
- Deployed sensors identified significant soil-structure interaction. Damping ratios of the damaged structures ranged between 1 and 4%.

Opportunities for Future Research
- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- What new questions raised by these events require basic research?
  - Are the hazards being adequately estimated and how can the consequences of unforeseen catastrophic events be reduced?
  - Is the seismic performance currently provided adequate for societal needs?
- What new data are available as a result of these events?
  - Unprecedented vertical acceleration demands.
  - Performance of structures for verification/evaluation of PBEE.
- What unique aspects of these events require the development of a focused research program?
  - Vertical accelerations and load combinations.
  - The development of a more refined analysis tool that incorporates soil-structure interaction (SSI) and is integrated into PBEE. Without SSI, building periods are estimated shorter than actuality and analysis fails to capture the much larger interstory drift demands.
- What are the important lessons from these larger than expected events for the U.S.?
  - Aftershocks pose a long term threat to the recovery process.

Award Abstract # 1138614

RAPID: Data Collection on the Performance of Adhesive Anchor Retrofits in Unreinforced Masonry Buildings during the February 2011 Christchurch, New Zealand Earthquake

Program Manager: Kishor Mehta
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s):   Arturo Schultz (Principal Investigator)

Sponsor: University of Minnesota-Twin Cities
200 OAK ST SE
MINNEAPOLIS, MN 55455 612/624-5599

NSF Program(s):   COLLABORATIVE RESEARCH,
HAZARD MIT & STRUCTURAL ENG

ABSTRACT:

The objective of this Rapid Response Research (RAPID) award is to collect perishable data from the February 2011 Christchurch, New Zealand earthquake on the performance of unreinforced masonry (URM) structures that had been retrofitted with adhesive anchors. Such anchors are used to connect floor or roof diaphragms to masonry walls or parapets. Wall-to-diaphragm connection retrofit using these anchors is the most common seismic rehabilitation technique used in both the U.S. and New Zealand. The URM building stocks in the United States and New Zealand, including both unretrofitted and retrofitted buildings, share many similarities. Perishable data will be collected from as many of the 59 retrofitted URM buildings in the Christchurch area, as well as from comparable unretrofitted buildings, as is possible during the 28-day duration of the field work. This data will be used for follow-on research of this retrofit strategy for the URM building inventory in the United States.

This activity will expand current understanding of URM building vulnerabilities to earthquake effects. By focusing on the observed performance of URM buildings with adhesive anchor retrofits, the data collected and its analysis will provide enhanced assessment methods for evaluating seismic rehabilitation techniques for URM buildings. The goal is to advance the seismic safety of URM buildings, which are widely constructed in the U.S. and one of the most seismically vulnerable building types. The results of this research will be widely distributed to the earthquake engineering community, including organizations responsible for updating and improving national seismic design provisions.

Arturo E. Schultz

Professor
Department of Civil Engineering
University of Minnesota

aeschultz@umn.edu / schul088@umn.edu
Phone: (612)626-1540
Fax: (612)626-7750
http://www.ce.umn.edu/directory/faculty/schultz.html

Education:
- B.S. in Civil Engineering, summa cum laude, Southern Methodist University, Dallas, Texas, 1980
- M.S. in Civil Engineering, University of Illinois, Urbana-Champaign, 1982
- Ph.D. in Civil Engineering, University of Illinois, Urbana-Champaign, 1986

Research Interests:
Analysis, design and performance of masonry, concrete and steel structures including analysis, laboratory testing, field monitoring and numerical simulation with a focus on gravity and lateral loads, extreme loading events and long- term effects. Research interests can be classified into three broad categories:

- *Stability of slender concrete and masonry structures* including masonry walls, precast concrete spandrel beams and prestressed concrete girders under the combined action of vertical and lateral loads.
- *Seismic behavior of structural systems* including the study of the seismic resistance characteristics of masonry, precast concrete, and steel-concrete wall structures emphasizing the role of connectors and reinforcement details.
- *Performance of transportation structures* including structural health monitoring of bridges, response modification for extending bridge service life, assessment of distortional fatigue in steel girder bridges and evaluation of bridge deck condition.

Data collection on the field performance of adhesive anchors

GOALS AND OBJECTIVES
1) Performance of adhesive anchors in existing masonry
2) Buildings with masonry of various grades
3) Load anchors in tension only
4) Record loads and displacements
5) Observe failure modes

University of Minnesota: PI Art Schultz, Chris Nobach.
University of Auckland: Jason Ingham, Dmytro Dizhur and Najif Ismail.
Georgia Tech University: Stephanie German and Jazalyn Dukes.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

NSF-EERI Rapid Workshop
8-9 Feb. 2012

Anchor Test 066 / Building B / Adhesive 2 / Unsleeved

OBSERVATIONS AND CONCLUSIONS
1) For lower strength adhesives, anchor failure was usually by pullout as the masonry sheared along interface with the adhesive.
2) For the embedment depths tested, anchors failing by pullout exhibited ample deformation capacity.
3) For the higher strength adhesive, failure was usually by ductile fracture of the anchor.
4) A 22.5° anchor inclination in many cases improved performance, but foil tubes had no marked effect on anchor capacity.
5) Best practices (manufacturers' recommendations and accepted details) make installation time-consuming and labor-intensive.

THE UNIVERSITY OF AUCKLAND
NEW ZEALAND

NSF-EERI Rapid Workshop
8-9 Feb. 2012

Award Abstract # 1138655

RAPID: Impact of Earthquakes on the Electricity Infrastructure

Program Manager:	Paul Werbos
	ECCS Division of Electrical, Communications and Cyber Systems
	ENG Directorate for Engineering
Investigator(s):	Ganesh Venayagamoorthy (Principal Investigator)
Sponsor:	Missouri University of Science and Technology
	300 W 12th Street
	Rolla, MO 65409 573/341-4134
NSF Program(s):	ENERGY,POWER,ADAPTIVE SYS,
	COLLABORATIVE RESEARCH,
	INFRAST MGMT & EXTREME EVENTS,
	SPECIAL STUDIES AND ANALYSES

ABSTRACT:

The objective of this research is to investigate the effects of a series of earthquakes in the South Island of New Zealand (Christchurch) on the electricity infrastructure. Furthermore, this research study will make projections on what the impacts would look like if smart-grid technologies were integrated into the existing power network. Would the result be better, worse, or a combination of both? In what areas is further research needed? The approach is to carry out a real-time simulation of the New Zealand's power system with intelligent sensing, monitoring and control technologies in collaboration with New Zealand's university and utility experts in power systems and smart grids.

Intellectual merit:

During natural disasters and malicious attacks, intelligent monitoring and controlling power systems with new algorithms will increase real-time responsiveness to changing power loads and component failures, improve the dynamic and transient behavior of the power network, improve grid reliability, ensure local and wide area stability, and assist human experts in control rooms.

Broader Impacts:

Energy security is very important to United States, and thus it is critical to protect our electric grid from different forms of disturbances including natural disasters and malicious attacks by using advanced sensing, monitoring and control technologies.

Ganesh Kumar Venayagamoorthy

Professor of Electrical and Computer Engineering
Missouri University of Science and Technology

Founder and Director of the Real-Time Power and Intelligent Systems Laboratory

ganeshv@mst.edu / gkumar@ieee.org
Phone: 573-3416641
Fax: 573-3414532
http://web.mst.edu/~ganeshv/Index.htm

Education:
- PhD degree in Electrical Engineering at the University of Natal, Durban, South Africa, 2001.
- MSc(Eng) degree in Electrical Engineering at the University of Natal, Durban, South Africa, 1998.
- BEng(Honours) degree with a First Class from the Abubakar Tafawa Balewa University(ATBU), Bauchi, Nigeria, 1994.

Research Interests:
- Adaptive Devices, Circuits, & Systems
- Computational Intelligence
- Power and Energy Systems
- Sensor Networks and Robotics
- Signal Processing

Recent Research Projects:
- UMSAEP: Research and Education in Computational Intelligence, January 2011 to December 2011, $9,700, (PI, Venayagamoorthy).
- NSF CAREER: REU Supplement - Scalable Learning and Adaptation with Intelligent Techniques and Neural Networks for Reconfiguration and Survivability of Complex Systems - June - August 2009, $6,000, ECCS # 0348221, (PI, Venayagamoorthy).
- A GPU- based High Performance Computing Cluster for Multiple Military Modeling Capabilities, Air Force Office of Scientific Research, May 2009 to May 2010, $150,000 (Co-PI).
- EFRI-COPN: Neuroscience and Neural Networks for Engineering the Future Intelligent Electric Power Grid, National Science Foundation, November 2008 to October 2012, $2,000,183 (PI, Venayagamoorthy).
- GOALI: Neural Networks and Adaptive Critic Designs for Energy Security and Sustainability, National Science Foundation, May 2008 to April 2011, $192,311 (PI, Venayagamoorthy).
- Advanced Digital Power Laboratory, Office of Naval Research, April 2008 to March 2009, $488,997 (PI, Venayagamoorthy).
- Computer Go - A Proxy for Key Open Challenges and Opportunities in Computational Intelligence, National Science Foundation, August 2007 to July 2010, $299,121 (Co-PI, Venayagamoorthy).

RAPID: IMPACTS OF EARTHQUAKES ON THE ELECTRICITY INFRASTRUCTURE

Ganesh Kumar Venayagamoorthy, PhD
Clemson University
Clemson, SC, USA
gkumar@ieee.org

Neville Watson, PhD
University of Canterbury, Christchurch, New Zealand
neville.watson@canterbury.ac.nz

Research on the effects of the February 21, 2011 magnitude 6.3 South Island of New Zealand (Christchurch) earthquake on the electricity infrastructure, and project the impacts to scenario of if smart grid technologies were integrated to existing power network, what would the impacts look like. Will it be worse or better? Or a combination?
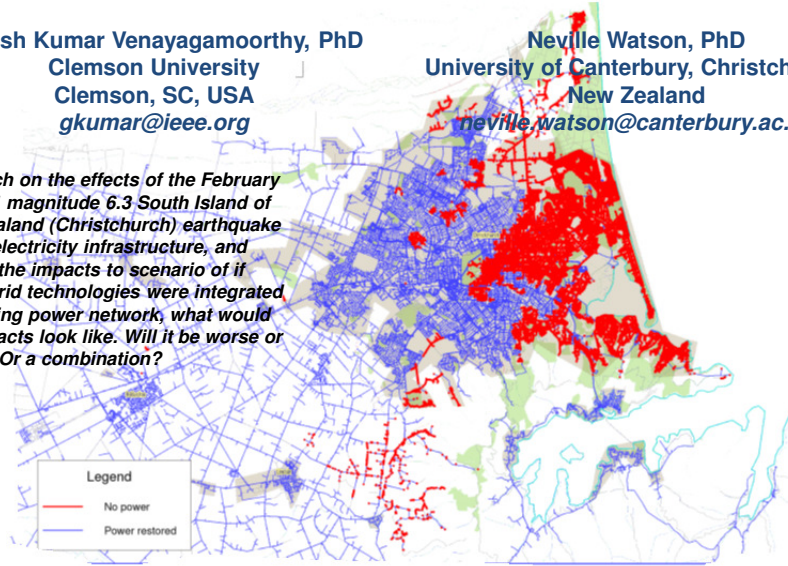
Legend
No power
Power restored

Key Findings

- Underground electric power distribution system and substations were seriously damaged. A significant portion of Christchurch lost power.

- 630 millions of customer minutes not met – earthquake of M6.3 – February 22, 2011 (hours of weeks of power loss). The longest in the history of major natural events in Christchurch.

- Off-grid electricity customers did not face power cuts e.g. solar panels powered homes.

- Communication infrastructure did not shut down.

Opportunities for Future Research

- Automatic reconfigurable and fault tolerant distribution systems.

- New data on failures of electric power distribution system assets and system.

- System planning needs to cater for such large disturbances. Smart electric power distribution systems are required.

- Smart grid development will need intelligent and secure smart grid systems.

Award Abstract # 1138674

RAPID: CRAWLER Robot with Dual-Use Limbed Locomotion and Manipulation for Void Inspection

Program Manager: Sajal Das
CNS Division of Computer and Network Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Anneliese Andrews (Principal Investigator)
Mohammad Mahoor (Co-Principal Investigator)

Sponsor: University of Denver
2199 S. University Blvd.
Denver, CO 80208 303/871-2000

NSF Program(s):   INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

This RAPID project, developing and fabricating a custom robotic tool based on the ongoing work in the CRAWLER robot with reconfigurable attachments, aims to deploy the tool in the areas affected by the 2011 tsunami and nuclear disaster in Fukushima, Japan. The robot, to be donated to International Rescue System Institute at Tohoku University in Sendai, will be based on the recent improvements that would make CRAWLER more resistant to water and more cleanable and maintainable. The system expands on the present robotic systems developed by the team to enable the use of multi-camera, orthogonal vision system for emergency responders that would be attached to the robot for enhanced situational awareness. This new vision subsystem constitutes part of its novelty. The Japanese-USA academic researcher team will be engaged in some of the following activities:

- Develop methods to analyze the efficacy of the improved robots' vision system.
- Engineer and deploy the robot to collect data about the degree of contamination. Deploy the robots in
- Japan through Japanese colleagues at the International Rescue System Institute at Tohoku University in Sendai.

The investigators collaborate with Dr. Satoshi Tadokoro (Tohoku University), a search and rescue researcher. A support letter has been submitted by Dr. Tadokoro for the proposed joint research. The project is expected to fabricate an improved version of the robots (developed under a separate NSF grant) in extreme environment tests, and donate this robot to the Japanese lab for joint experimentation and in-situ testing. Additional funding is also requested to travel to Japan for collaborative research and experimentation. Proposed are also interactions and coordinating efforts with Robin Murphy (TAMU) who is organizing a workshop following up on the disaster in Japan (the related travel funds are not part of this proposal).

Broader Impacts:

This proposal promises an immediate benefit to society by supporting economic recovery efforts in Japan through a participatory research paradigm. Moreover, long term benefits for future disasters are

in evidence since emergency response and unmanned systems are both formative domains and the data collected will advance the discovery and understanding of intelligent, human-centered systems in unpredictable situations. In addition, the use of the proposed tool should establish an important milestone in robotics allowing the nuclear power industry to be better positioned to rapidly respond to disasters in the future. Finally, the project aims to train undergraduate and graduate students and expose them to high-impact application areas. The PIs have strong track record in advising underrepresented students.

Anneliese Andrews
Note: Her co-PI will be attending instead.

Professor
University of Denver

andrews@cs.du.edu
Phone: (303) -871-3374
http://web.cs.du.edu/~andrews/index.htm

Education:
- Ph. D. in Computer Sc., Duke University, North Carolina, 1979
- M.A. in Computer Science, Duke University, North Carolina, 1978
- Dipl. Inf. in Informatik (Computer Science), Technische Universitat Karlsruhe, Germany, 1976

Research Interests:
- Software Engineering: Tools, Metrics, Software Testing, Reliability, Productivity Assessment, Program Comprehension, Maintenance
- System Engineering: Multi-Criteria System Evaluation, Testing of Embedded and Intelligent Systems.

Recent Research Projects:
- Automated Test Generation for Robot Teams
- Quantitative Assessment of Modern Reusability Techniques for Embedded Critical Systems
- Safety Testing.
- Security Testing

RAPID: CRAWLER Robot with Dual-Use Limbed Locomotion and Manipulation for Void Inspection
J-RAPID: Search in Disaster Rubble Piles by Collaboration of CRAWLER and Active Scope Camera

Anneliese Andrews and Mohammad Mahoor, University of Denver and
Satoshi Tadokoro, International Rescue System Institute / Tohoku University

- CRAWLER aka TerminatorBot
  - Limbed Crawler for Rubble Penetration
  - Two limbs for locomotion and manipulation
  - Drags body like a cold-blooded animal
  - Actuated Control Tether for deep penetration

Proposed Work - CRAWLER & Active Scope Camera
- Physical Enhancements
  - Water proof skin
  - Cellphone chip camera
- Active Scope Camera (ASC)
  - Mobile video scope with Actuated Cable Skin
  - Robust intrusion into narrow gap of rubble piles
  - Need of Explosion Proof

Key Findings - CRAWLER: Results

- **More Robust Elbow Design**
  - Eliminates Precision Gears (subject to dirt and damage)
  - Tougher Cable Drive
- **Cellphone Chip Camera**
  - < 1 cm in Size, Digital
  - Easy to include multiple cameras
  - FPGA-based frame grabber
- **First Visit to Sendai Region in Nov.**
  - Tohoku University for lab tests
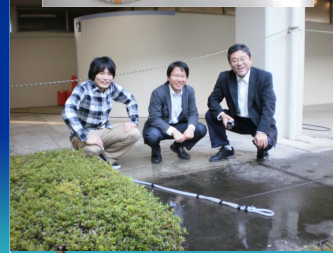
Award Abstract # 1138646

RAPID: Earthquake Damage Assessment from Social Media

Program Manager: Sylvia J. Spengler
IIS Division of Information & Intelligent Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s): James Caverlee (Principal Investigator)
John Mander (Co-Principal Investigator)

Sponsor: Texas Engineering Experiment Station
TEES State Headquarters Bldg.
College Station, TX 77845 979/458-7617

NSF Program(s): INFO INTEGRATION & INFORMATICS

ABSTRACT:

In the minutes and hours following the recent earthquakes in New Zealand and in Japan, and storm in Haiti, thousands of locals posted pictures to social media sites like Facebook and Twitter. These pictures when coupled with extremely granular spatio-temporal information (e.g., timestamps and GPS-style geocodes) provide a minute-by-minute and region-by-region pictorial account of the emergency as it unfolded. The goal of this project is to assess, characterize, and model the quality of these images posted to social media in the minutes and hours post-emergency for guiding policy-based stakeholders and assets. Carefully framed images can convey a wealth of structural information to recovery experts: revealing damage levels, guiding resource allocation, and directing other policy-based assets. First, a sample of several thousand social media images from New Zealand will be assessed by domain experts and specifically structural earthquake engineers. Second, with RAPID funding, this project will link images posted during the emergency to actual damage assessments made in Christchurch for validating the quality of images. First, a sample of several thousand social media images from New Zealand will be assessed by domain experts and specifically structural earthquake engineers. The results of this project will have broad impacts, particularly in the development and deployment of a new rapid assessment tool for earthquake damage assessment based on social media. An additional broader impact is the ancillary development of training modules for increasing the effectiveness and image quality of future socially-generated image capture, which would greatly improve social computing for disasters. The methods and data generated by this project will be archived and made available for future studies.

James Caverlee

Assistant Professor
Department of Computer Science and Engineering
Texas A&M University

caverlee@cse.tamu.edu
Phone: (979) 845-0537
Fax: (979) 847-8578
http://www.cs.tamu.edu/people/faculty/caverlee

Education:
- Ph.D., Computer Science, Georgia Institute of Technology, 2007
- M.S., Computer Science, Stanford University, 2001
- M.S., Engineering-Economic Systems & Operations Research, Stanford University, 2000
- B.A., Economics magna cum laude, Duke University, 1996

Research Interests:
- Web-scale information management
- Distributed data-intensive systems
- Information retrieval
- Databases
- Social computing

Recent Research Projects:
Dr. Caverlee directs the Texas A&M infolab, a research lab founded in 2007 to study problems at the intersection of web-scale information management, distributed data-intensive systems, and social computing. The overall research goal is to develop algorithms and systems to enable efficient and trustworthy information sharing and knowledge discovery over dynamic, heterogeneous, and massive-scale networked information systems (like the Web, online social networking and social media systems, mobile information systems, and other emerging distributed systems).

Earthquake Damage Assessment from Social Media

James Caverlee (Computer Science)
John Mander (Civil Engineering)
Texas A&M University

- <u>Objective</u>: Assess, characterize, and model earthquake damage using GPS-labeled social media posted in the minutes and hours post-emergency
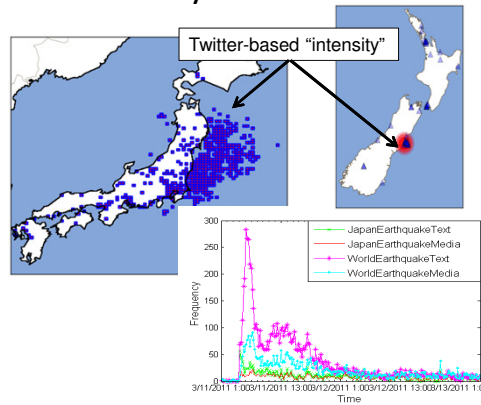
Twitter-based "intensity"

Key Findings

- Spatial density of all social media posts is consistent with shaking intensity trend (compared to isoseismal map)

- Surprisingly, density of social media posts <u>including photos</u> is highest in seriously-damaged areas, indicating capacity of images for rapid damage assessment

Opportunities for Future Research
- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- What are roadblocks/opportunities to integrating non-traditional data into the response decision-making process?
  - Preliminary results suggest social media may be harnessed to refine and enhance damage assessments made through traditional channels
- What are the "error bars" for social media-driven models of death, damage, and economic downtime?
  - And in what ways can this uncertainty be mitigated?

RAPID: The Role of Urban Development Patterns in Mitigating the Effects of Tsunami Run-up

Program Manager: Dennis Wenger
                                      CMMI Division of Civil, Mechanical, and Manufacturing Innovation
                                      ENG Directorate for Engineering

Investigator(s):   Ronald Eguchi (Principal Investigator)
                                      Albert Lin (Co-Principal Investigator)
                                      John Bevington (Co-Principal Investigator)

Sponsor: ImageCat, Inc.
                                      400 Oceangate
                                      Long Beach, CA 90802 562/628-1675

NSF Program(s):   COLLABORATIVE RESEARCH,
                                      INFRAST MGMT & EXTREME EVENTS,
                                      SPECIAL STUDIES AND ANALYSES

ABSTRACT:

This Grant for Rapid Response Research (RAPID) project seeks to understand the relationship between urban development patterns and the extent of physical damage caused by widespread tsunami run up. The 11 March 2011 Tohoku, Japan earthquake caused significant damage all along the northeastern coast of Japan. In order to understand how the built environment can affect the performance of communities in a tsunami, the project will study at least nine communities in the Miyagi/Chiba/Ibaraki Prefectures ¨C areas ranging from minor to moderate damage to complete devastation. The central research question is: Can the urban topology of a community mitigate the effects of a tsunami by isolating the more damaging surge effects to a few well designed and well placed buildings, thus limiting damage to protected buildings to just rising water effects. The main objectives of this study are: 1) to perform field studies to collect perishable data on coastal community performance following the Tohoku earthquake, 2) to develop an understanding of the data landscape in post-earthquake Japan, and 3) to develop a preliminary understanding of the role that urban development patterns played in either mitigating or exacerbating tsunami induced impacts.

This project will gather new information to systematically and comprehensively assess the effect that urban development patterns have in mitigating or exacerbating the effects of tsunamis. Such information would complement current studies that focus only on the performance of individual structures, i.e., not on the performance of communities. This information can also provide an important reference point for any future studies on long term recovery in Japan by documenting the initial damage states of representative communities along the coast of Japan. In addition to data collection, this project will explore new methods of performing rapid damage assessment using distributed visual analytics and crowd sourcing, and high resolution aerial and satellite imagery; these methods can be vital in situations where immediate field access is not possible or damage is widespread (as was the case in the Tohoku earthquake). Furthermore, the knowledge gained in this study will help to inform future tsunami loss modeling activities by introducing community based parameters that can either enhance or exacerbate the direct effects of an earthquake. The results of this study will also enforce the notion that resilience

should be viewed at a community level in order to minimize the socioeconomic impacts of large disasters. The knowledge gained from this study will help to improve regional preparedness plans for many coastal areas, including the west coast of the United States, which also experienced significant damage in the Tohoku earthquake.

Ronald T. Eguchi

President and CEO
ImageCat, Inc.

rte@imagecatinc.com
Phone: (562) 628-1675
Fax: (562) 628-1676
http://www.imagecatinc.com/

Education:
- University of California, Los Angeles: M.S. Systems Engineering, 1975
- University of California, Los Angeles: B.S. Engineering, 1974

Professional History:
Mr. Eguchi is President and CEO of ImageCat, Inc., a risk management company specializing in the development and use of advanced technologies for risk assessment and reduction. Mr. Eguchi has over 30 years of experience in risk analysis and risk management studies. He has directed major research and application studies in these areas for government agencies and private industry. He currently serves or has served on several Editorial Boards including the Natural Hazards Review published by the American Society of Civil Engineers and the Natural Hazards Research and Applications Information Center, University of Colorado; the Journal on Uncertainties in Engineering Mechanics published by Resonance Publications, Inc.; and the Earthquake Engineering Research Institute's Journal SPECTRA.

He is a member of the National Research Council's Disaster Roundtable whose mission it is to identify urgent and important issues related to the understanding and mitigation of natural, technological, and other disasters. He is a past member of the Scientific Advisory Committee of the U.S. Geological Survey, a committee that reports to Congress on recommended research directions for the USGS in the area of earthquake hazard reduction. In 1997, he was awarded the ASCE C. Martin Duke Award for his contributions to the area of lifeline earthquake engineering. He still remains active in the ASCE Technical Council on Lifeline Earthquake Engineering serving on several committees and having chaired the Council's Executive Committee in 1991. In 1992, Mr. Eguchi was asked to chair a panel, established jointly by the Federal Emergency Management Agency and the National Institute of Standards and Technology to develop a plan for assembling and adopting seismic design standards for public and private lifelines in the U.S. This effort has led to the formation of the American Lifeline Alliance, currently managed by the National Institute of Building Sciences. In 2006, he accepted an ATC Award of Excellence on behalf of the ATC-61 project team for work on An Independent Study to Assess Future Savings from Mitigation Activities that showed that a dollar spent on hazard mitigation saves the nation about $4 in future benefits. He was recently recognized by EERI as the 2008 Distinguished Lecture where he discussed the topic of "Earthquakes, Hurricanes, and other Disasters: A View from Space." He has authored over 250 publications, many of them dealing with the seismic risk of utility lifeline systems and the use of remote sensing technologies for disaster response.

The Role of Urban Development Patterns in Mitigating the Effects of Tsunami Run-up

- US
  - Ronald T. Eguchi
  - John Bevington
  - Albert Lin
  - James D. Goltz, Consultant

ImageCat
UCSanDiego

- Japan
  - Fumio Yamazaki
  - Shunichi Koshimura
  - Masashi Matsuoka

Chiba University
東北大学 TOHOKU UNIVERSITY
AIST

Purpose of RAPID Grant: *to understand the relationship between urban development patterns and the extent of physical damage caused by widespread tsunami run-up.*

Technologies & data used:

- <u>Remote-sensing</u> image analysis of pre & post-earthquake data
- <u>Crowdsourcing</u> techniques for scalable analysis of the large imagery datasets
- Tsunami <u>simulation</u> models to scale community results to larger areas or regions.
- Interaction of demographic and social characteristics with the built environment to produce <u>safety</u> or <u>mortality</u> in the earthquake and tsunami.
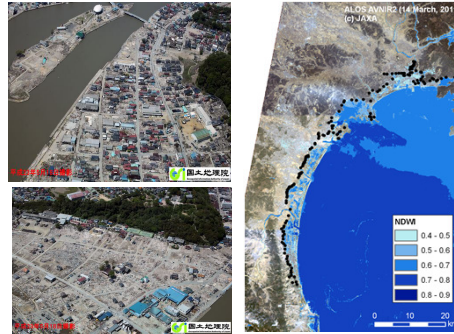
Key Findings

▪ The data collected so far indicates that certain neighborhood configurations can offer some protection to community residents (e.g., parts of Ishinomaki that were located behind large, coastal wharf structures) while other configurations can actually enhance damage and impacts (e.g., Onagawa).

▪ Ground survey data are needed in order to fully characterize the extent of building damage, i.e., much damage is missed by only using remote sensing imagery.

Ishinomaki — Not Protected — Protected — Red - Destroyed

Onagawa — Before — After

Community-based fragility curves have been developed
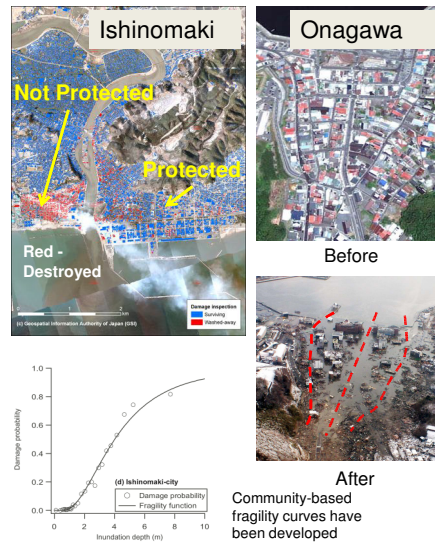
Opportunities for Future Research

▪ **Questions raised by the earthquake** – A significant amount of damage was quantified using remotely-sensed data, but much was missed. Can we create scaling functions that will accurately estimate the remaining damage from remote sensing results?

▪ **New Data** – New datasets are available to generate tsunami damage and fragility curves. These data are unique in that they include a mix of rural, industrial and commercial areas, unlike many previous tsunamis.

▪ **Opportunities for a focused research program** – Several areas: a) damage assessment using remotely-sensed imagery, b) tsunami fragility model development, c) rapid and efficient analysis of large datasets, e.g., using crowdsourcing, d) analysis of mortality rates from tsunami effects, and e) impact of community configurations on regional damage and impacts.

▪ **Lessons for the U.S.** – Several: a) we don't have adequate fragility or damage models in the U.S. to quantify the effects of tsunamis (this is especially true for lifelines), b) we don't know how to model the effects of community configurations on regional damage, and c) we don't have the right set of building exposure models to characterize the effects of tsunamis.

Award Abstract # 1138625

RAPID: Robots Designed to Assist During Nuclear Catastrophes - Autonomously Creating 3-D Maps, Collecting Radiation/Other Data at Japan's Fukushima Nuclear Plants

Program Manager: Richard Voyles
IIS Division of Information & Intelligent Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Mark Haley (Principal Investigator)
Tomonari Furukawa (Co-Principal Investigator)

Sponsor: Analytical Software Inc.
8505 Broad Meadow Lane
McKinney, TX 75071 972/303-4433

NSF Program(s):   ROBUST INTELLIGENCE

ABSTRACT:

The project advances the state-of-the-art of autonomous Simultaneous Localization and Mapping (SLAM) algorithms, and maximizes the ability to explore under extreme conditions with minimal time using real-time 3D methods in nuclear power plants. The integrated system consists of a hardware system with three LIDAR's, a CPU, a GPU, a battery and a wireless unit.

The state-of-the-art in nuclear power plant disaster mitigation is a direct consequence, as well as the development of more advanced and robust SLAM techniques that are applicable in all domains.

Mark Haley

President
Analytical Software, Inc.

Professor
Multi-Career Center and Robotics Research,
Chiba University

haley@uavnavigator.com / http://uavnavigator.com
Phone: 972-303-4433

Education:
- B.S., Mechanical Engineering, Massachusettes Institute of Technology (MIT), 1974
- MBA, Columbia University, 1978

Appointments:
- Chiba University, Chiba, Japan
- 2009 –Present; Professor, Multi-Career Center and Robotics Research

Experience:

Analytical Software Inc. – Currently President – Formed Company, which focuses on robotics. Analytical Software Inc. has been in business for over 20 years and it has been a project manager for large companies and government customers.

Analytical Software is a systems integrator which specializes in robotics, software and communications networks. In addition, it provides engineering services related to state-of-the-art robotics. Analytical Software Inc. teamed with one of America's largest telecommunication companies to offer commercial high bandwidth worldwide voice and data networks for corporate customers.   Due to its unique technology, the company was invited to show its products at high technology conferences including meetings throughout Japan at the invitation of a Japanese government organization. The company teamed with Chiba University and Virginia Tech to be ranked 6th in the world in small UGVs in a competition sponsored by the U.S. government (MAGIC 2010). In addition, the company was also in a competition with Chiba University where its technology was ranked in the top 5 in the world (MAV 08).

Bell Helicopter/Textron - Manager Commercial Helicopters - Supervised five professionals, Recommended manufacturing efficiencies to reduce costs. Assisted in $69 million Co-production contracts in Canada and other countries. Analyzed competitors and set Bell's commercial helicopter prices.

Westinghouse Electric - Project Engineer - Managed design, procurement, and production of a million-dollar component for nuclear division. Managed two professionals.

Military - United States Army Reserve - Second Lieutenant – Engineering
Publications Related to This Project:
Daisuke Iwakura, Wei Wang, Kenzo Nonami and Mark Haley, "Movable Range-Finding Sensor System and Precise Automated Landing of Quad-Rotor", Journal of System Design and Dynamics, Vol.5. (2011), No.1 pp. 17-29

Synergetic Activities:

Professional Society Activities

International Advisory Committee: *Int. Conf. on Intelligent Unmanned Systems 2011* (ICIUS2011), Chiba, Japan, October 31 – November 2, 2011

Enhanced capabilities for Fukushima-type Rescue Robots

– RAPID Title: **Robots designed to assist during Nuclear Catastrophes - Autonomously creating 3-D Maps, Collecting Radiation/other data at Nuclear Power Plants such as at Fukushima**

– Mark Haley, President, Analytical Software Inc., TX

– **Professor Kenzo Nonami** and **Professor Mark Haley**, Chiba University, Japan

– Added autonomous capabilities for iRobot's Packbot, main robot currently operating inside Fukushima

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Key Findings

• **Autonomous Capabilities are key for Fukushima-type rescue robots -** Real-time 3D SLAM and other technologies which reduce manual operations are crucial for rescue robots.

• Research focused on adding capabilities to iRobot's Packbot, main robot currently operating inside Fukushima. Japan. **In high profile disasters it is risky to use untested technology in the field.**

Opportunities for Future Research

- **Issues raised by research** – Real-time 3D SLAM was proven as key technology needed for autonomous rescue robots. However, further enhancements refining 3D capabilities are required.

- **New Data** – Operation of the Packbots inside Fukushima indicated additional technologies needed for autonomous robots versus the existing technology which was basically manually operated units.

- **Key Focused Research program** – To create fully autonomous rescue robots it is crucial to add enhanced real-time 3-D mapping and other data collection and operating capabilities**.**

- **Lessons Learned** – In disasters such as Fukushima **there are risks to using untested technology in the field**

Award Abstract # 1139707

IT Virtualization for Disaster Mitigation and Recovery

Program Manager: Sajal Das
CNS Division of Computer and Network Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Mauricio Tsugawa (Principal Investigator)
Jose Fortes (Co-Principal Investigator)
Renato Figueiredo (Co-Principal Investigator)

Sponsor: University of Florida
1 UNIVERSITY OF FLORIDA
GAINESVILLE, FL 32611 352/392-3516

NSF Program(s):   INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

This RAPID project, aiding the process of recovering Information Technology (IT) infrastructure damaged by catastrophic events, conducts research on the use of virtualization technologies to provide such aid. The work includes IT infrastructure needed to recover damages to non-IT infrastructures and human beings. Machine virtualization offers key mechanisms to move applications from one location (e.g., a data center) potentially affected by a disaster to another safe location. The project responds to many challenges such as: The

- Inability to migrate Virtual Machines (VMs) from a disaster site to an unaffected site maintaining live services;

- Severe limitation of power of network failures that limit the ability of performing live-migrations;

- Need for coordination with recovery efforts to effectively prioritize critical services.

Machine virtualization offers the ability to checkpoint VMs, thus enabling the creation of back-ups not only of data but also of partial application executions. VM checkpoints can be used to recover an IT infrastructure in a different location with minimal loss of data. The challenge lies in how to efficiently manage the massive amount of data and network traffic generated by the VM check-point process.

With the main goals of keeping alive IT services as long as possible, and restoring recovery-critical IT services as quickly as possible during and after a disaster, the project focuses on

- Analyzing data and events associated with damaged IT services due to the Great-East Japan Earthquake,

- Studying scalability of wide-area VM live-migration and Back/checkpoint, and

- Developing a resilient architecture to partial physical infrastructure failure in order to deploy IT infrastructures in virtualized and distributed datacenters.

The investigators collaborate with Dr. Satoshi Sekiguchi, Director of the Information Technology Research Institute (ITIR) within the National Institute of Advanced Industrial Science and Technology (AOST), an Institution under the Ministry of Economy, Trade, and Industry (MET), Japan. This group are experts in the area of virtualization and has had some interactions with the Florida group.

Broader Impacts:

The work develops an understanding of how well virtualized IT systems can cope with partial physical damages, of what changes in hardware, software, and general practice are needed, and how to determine the best way to adopt them. In the long term the project should enable informing the adoption of a virtualized datacenter to host essential IT services. Hence, the project is likely to enable informed decisions and should also contribute in graduate student education.

Mauricio Tsugawa

Research Scientist
Department of Electrical and Computer Engineering
University of Florida

tsugawa@acis.ufl.edu / tsugawa@ufl.edu
Phone: (352)392-5989
http://www.ece.ufl.edu/people/faculty/tsugawa.html

Education:
- PhD, ECE, University of Florida, 2009
- MS,EE, Universidade de São Paulo, 2001
- BSEE, EE, Universidade de São Paulo, 1998

Research Interests:
- Computer networks
- Advanced computing architecture
- Distributed systems

Refereed Journals in the Last 3 Years:

Tsugawa, Mauricio; and Fortes, Jose; A.B. 'Characterizing user-level network virtualization: performance, overheads and limits'. International Journal of Network Management, Volume 20, Issue 3, John Wiley & Sons, 2010.

1139707: IT Virtualization for Disaster Mitigation and Recovery

- US
  - Maurício Tsugawa
  - Renato Figueiredo
  - José Fortes

- Japan
  - Takahiro Hirofuchi
  - Hidemoto Nakada
  - Ryousei Takano

This project studies the effectiveness of movable virtualized datacenters in keeping IT services alive during and after a disaster by 1) analyzing real data and events associated with damaged IT services due to the Great East-Japan Earthquake and 2) investigating the joint usage of VM migration (live or using checkpoints), virtual networking, and shared/replicated storage for VM images.

Key Findings

- The data collected from several institutions indicate that despite the extreme intensity of the earthquake, reported damages suffered by IT equipments were minimal.
- In many datacenters affected by the earthquake, there was a 30 to 60 minutes window, in which power and network services were available to move virtualized systems from a disaster site to a safe location.

Opportunities for Future Research

- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- What new questions raised by these events require basic research?
  How to keep IT services alive during and after a disaster.
  How to encapsulate IT services into virtualized environments to make them movable.

- What new data are available as a result of these events?
  Information about failures of IT equipment, network and power.

- What unique aspects of these events require the development of a focused research program?
  Keeping IT services alive is key to recover non-IT infrastructures. Research on all aspects of virtualized systems, including machine, network, and storage, is needed to improve the efficiency of the movement of virtualized IT infrastructures.

- What are the important lessons from these larger than expected events for the U.S.?
  IT services running in virtualized environments can be made resilient to catastrophic events.

Award Abstract # 1138110

RAPID: Aerial Robots for Remote Autonomous Exploration and Mapping

Program Manager: Sajal Das
CNS Division of Computer and Network Systems
CSE Directorate for Computer & Information Science & Engineering

Investigator(s): R. Vijay Kumar (Principal Investigator)
Nathan Michael (Co-Principal Investigator)

Sponsor: University of Pennsylvania
Research Services
Philadelphia, PA 19104 215/898-7293

NSF Program(s): COLLABORATIVE RESEARCH,
INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

This RAPID project, developing and deploying a team of autonomous aerial robots that can enter an unstructured, hazardous environment to explore and map a facility, provides information to human operators in safe, remote locations. The work brings together research groups with complementary expertise in robotics to address the challenging problem of acquiring imagery and three-dimensional maps for post-disaster assessment. Autonomous robots will be deployed without a direct communication link enabling access to areas in the Fukushima that are currently inaccessible.

Addressing an urgent need, the work consists of redesigning aerial robotic systems to perform mapping, localization, and exploration functions in indoor and outdoor environments without prior knowledge of the environment or GPS (Global Positioning System). The system, to be deployed in highly contaminated environments such as the area of Fukushima disasters in Japan, expands the present robotic systems developed by the team. It should be able to build maps and localize, plan, and control autonomously in that map, but requires interactions with a base-station to communicate the relevant information. The paradigm shifting capabilities of aerial robots to act independently and be deployed in critical contaminated areas exhibit novelty. The Japanese-American academic research team will be engaged in some of the following activities:

- Develop methods to acquire information from highly contaminated environments, such as in case of radiation contamination.

- Engineer and deploy one or more autonomous robots (i.e., without the link to the base station) equipped with cameras and laser range finders as well as potentially carrying sensors that might reveal new insights about the degree of contamination.

- Develop algorithms and methods for information gathering and map building.

- Deploy the robots in Japan through Japanese colleagues.

Most UAVs (Unmanned Aerial Vehicles) are teleoperated with several human operators engaged in the deployment of each UAV. The cross fertilization of technologies for robotics and UAVs has potential to create new small to medium scale autonomous UAVs with a wide range of civilian and defense applications. This project will explore the use of autonomous UAVs for acquiring information from environments that are impossible to access because of radiation contamination. One or more autonomous quad rotor robots equipped with cameras and laser range finders will be deployed to explore the partially-known environment and build 3-D maps of the structure and potentially carrying sensors that might reveal new insights about the degree of contamination. These robots will have to operate without any communication link to the base station. Thus this will represent the first deployment of a truly autonomous robot of its kind.

This work involves a collaboration with Dr. Satoshi Tadokoro, a researcher in search and rescue robotics, from Tohuku University in Sendai, Japan. A support letter has been submitted by Dr. Tadokoro for the proposed joint research. Another collaborator from the same University, Dr. Kazuya Yoshida, leads the project entitled "Robotics in Extreme Environment" and brings the "Extreme Robotics" background to this collaborative research endeavor. The project, expected to lose robots in extreme environment tests, consequently requires building additional autonomous aerial robots for the purpose of the experiments. Funding is also requested to travel to Japan for collaborative research and experimentation.

Broader Impacts:

The tragic sequence of events in Sendai and the Fukushima I and II nuclear power plants has resulted in significant contamination due to radioactive iodine, cesium and strontium, making it nearly impossible for humans to enter many areas in the power plants to assess damage. First, the use of robots to acquire information from currently inaccessible areas will have a significant impact on post-disaster recovery operations. Second, the use of autonomous aerial robots will establish an important milestone in robotics and will allow the nuclear power industry to be better positioned to rapidly respond to disasters in the future. This proposal promises an immediate benefit to society by supporting economic recovery efforts in Japan through a participatory research paradigm. Moreover, long term benefits for future disasters are in evidence since emergency response and unmanned systems are both formative domains and the data collected will advance the discovery and understanding of intelligent, human-centered systems in unpredictable situations. Furthermore, the use of autonomous aerial robots will establish an important milestone in robotics allowing the nuclear power industry to be better positioned to rapidly respond to disasters in the future. Finally, the project will train undergraduate and graduate students and expose them to high-impact application areas.

Vijay Kumar

UPS Foundation Professor, Departments of Mechanical Engineering and Applied Mechanics and Computer and Information Science,
School of Engineering & Applied Sciences, University of Pennsylvania

kumar@cis.upenn.edu
Phone: 215-898-0374
Fax: 215-573-2048
https://alliance.seas.upenn.edu/~kumar/wiki/

Education:

- B. Tech., Mechanical Engineering, Indian Institute of Technology, Kanpur, India, May 1983
- M.Sc., Mechanical Engineering, The Ohio State University, Columbus, Ohio, March 1985
- Ph.D., Mechanical Engineering, The Ohio State University, Columbus, Ohio, September 198

Research Interests:

Dynamics and control of multirobot and multiagent coordination, manipulation, biomechanics, assistive technology for disabled people, modeling and control of networks.

Biography:

VIJAY KUMAR is the UPS Foundation Professor and the Deputy Dean for Education in the School of Engineering and Applied Science at the University of Pennsylvania. He received his Ph.D. in Mechanical Engineering from The Ohio State University in 1987. He has been on the Faculty in the Department of Mechanical Engineering and Applied Mechanics with a secondary appointment in the Department of Computer and Information Science at the University of Pennsylvania since 1987.
Dr. Kumar served as the Deputy Dean for Research in the School of Engineering and Applied Science from 2000-2004. He directed the GRASP Laboratory, a multidisciplinary robotics and perception laboratory, from 1998-2004. He was the Chairman of the Department of Mechanical Engineering and Applied Mechanics from 2005-2008.

Dr. Kumar's research interests lie in the areas of robotics and manufacturing. He is a Fellow of the American Society of Mechanical Engineers (ASME) and the Institution of Electrical and Electronic Engineers (IEEE). He has served on the editorial boards of the IEEE Transactions on Robotics and Automation, Journal of Franklin Institute, IEEE Transactions on Automation Science and Engineering, ASME Journal of Mechanical Design, the ASME Journal of Mechanisms and Robotics and the Springer Stracts in Advanced Robotics (STAR). He is the recipient of the 1991 National Science Foundation Presidential Young Investigator award, the Lindback Award for Distinguished Teaching, and the 1997 Freudenstein Award for significant accomplishments in mechanisms and robotics. He has won best paper awards at DARS 2002, ICRA 2004, ICRA 2011, and RSS 2011 and has advised doctoral students who have won Best Student Paper Awards at ICRA 2008, RSS 2009, and DARS 2010. He is also a Distinguished Lecturer in the IEEE Robotics and Automation Society and an elected member of the Robotics and Automation Society Administrative Committee.

Current projects:

- The SWARMS project
- Multiple Autonomous Robot Systems (recent demonstration at Ft. Benning)
- Differential Algebraic and Variational Inequalites in Control and Simulation
- Smart Chair
- Modeling, Analysis and Simulation of Biomolecular and Cellular Networks
- MoBies

RAPID: **Aerial Robots for Remote Autonomous Exploration and Mapping**

Vijay Kumar and Nathan Michael, University of Pennsylvania

Kazuya Yoshida, Keiji Nagatani, Satoshi Tadokoro and Kazunori Ohno
Tohoku University, Sendai Japan

Objective: Consider 3D mapping and exploration of a multi-story earthquake-damaged building in Sendai, Japan via ground and aerial robots.
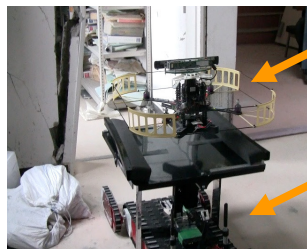
Aerial robot "Pelican"

Ground robot "Quince"
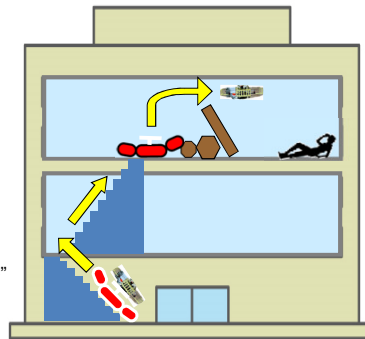
Key Findings

- Successfully mapped the 7th, 8th, and 9th floors of an earthquake-damaged building via remotely operated ground robots from Tohoku and an aerial robot from UPenn.
- Mapping results clearly show locations of structural damage and environment layout.
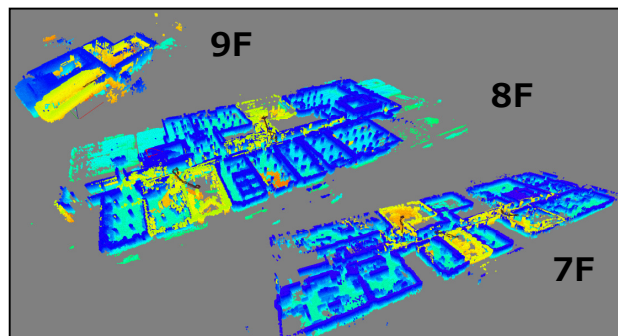
Opportunities for Future Research

➤What new questions raised by these events require basic research?
- ➤ Autonomous flight (localization, mapping, and autonomous low-level control) is essential for aerial robots, even when humans are in complete control of the robot. How does this affect human-robot interaction?
- ➤ What is the role of autonomy when considering robots in disaster scenarios as the autonomy may not be trusted by the operators?

➤What new data are available as a result of these events?
- ➤ Sensor data from the 3D mapping of a building using multiple robots.

➤What unique aspects of these events require the development of a focused research program?
- ➤ Synergy of multiple robots in different designs in disaster situations which are totally unstructured and unexpected
- ➤ Managing integration of research-grade components and emphasis on the intellectual agenda underlying this integration

➤What are the important lessons from these larger than expected events for the U.S.?
- ➤Emphasis on robustness of technology in addition to development of technology

Award Abstract # 1135848

RAPID: Sendai Earthquake and Tsunami- Remote Assessment Using Land, Sea and Aerial Unmanned Systems

Program Manager: Rita V. Rodriguez
                            CNS Division of Computer and Network Systems
                            CSE Directorate for Computer & Information Science & Engineering

Investigator(s):   Robin Murphy (Principal Investigator)

Sponsor: Texas Engineering Experiment Station
                            TEES State Headquarters Bldg.
                            College Station, TX 77845 979/458-7617

NSF Program(s):   COLLABORATIVE RESEARCH,
                            SPECIAL PROJECTS - CISE,
                            INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

This RAPID project proposal, consisting of participatory research with land, sea, and aerial unmanned systems for remote assessment and situation awareness for critical life saving and recovery operations in the aftermath of the Sendai earthquake and tsunami, will capture and analyze valuable data on the effectiveness of various robots for recovery and inspection as well as user interface paradigms. The researchers will be engaged in some of the following activities:

- Participate in the ongoing recovery efforts in the Sendai region and northward
- Gather data on the effectiveness of various robots in various real-world scenarios
- Gather data on the effectiveness of various user interfaces for remote devices during the recovery process
- Deploy the RESPOND-R mobile instrument (NSF MRI grant CNS-0923203) to inspect critical infrastructure

The PI has secured invitations from Japanese researchers and responders, including the International Rescue Systems Institute, to bring robots to the north of Japan to assist in the inspection of critical infrastructure and other recovery operations as well as perform research on the efficacy of emergency response methods and practices. (The search and rescue phase has been terminated.) US and Japanese response teams will be deployed for victim and economic recovery decision-making while simultaneously collecting never-before-possible, ephemeral data. The Sendai disaster is unique in its large geographical and economic scale and types of damage. The geographical, damage, and economic scales drive the need for distributed decision-making, where experts will have to consult and work at a distance using remotely acquired data. Sendai also provides the first opportunity to create a corpus from multiple modalities of unmanned systems being used by the same agency. Of the 15 deployments since the first use of rescue robots at the 9-11 World Trade Center collapse, only two, Hurricanes Katrina and Haiti, used both sea and aerial vehicles; notwithstanding, these were controlled by different organizations for tasks by different agencies preventing a longitudinal survey of what works (or does not) for decision-makers and why and how assets should be coordinated.

Broader Impacts:
This proposal promises an immediate benefit to society by supporting life saving and economic recovery efforts in Japan through a participatory research paradigm. There are also long term benefits for future disasters since emergency response and unmanned systems are both formative domains and the data collected will advance the discovery and understanding of intelligent, human-centered systems in unpredictable situations. The PI is a woman who is well known as a role model for recruiting women and minorities; the data from this project will be integrated into her numerous museum, documentary, K-12, and general public education events. Data gathered by the NSF-sponsored RESPOND-R mobile distributed instrument for response research will be organized into an ontology and made available as appropriate given the sensitive nature of video footage.

Robin R. Murphy
Professor, Texas Engineering Experiment Station

murphy@cs.tamu.edu
Phone: 979.845.8737
Fax: 979.845-8737
http://faculty.cs.tamu.edu/murphy/bio.html

Biography:

Robin Roberson Murphy (IEEE Fellow) received a B.M.E. in mechanical engineering, a M.S. and Ph.D. in computer science in 1980, 1989, and 1992, respectively, from Georgia Tech, where she was a Rockwell International Doctoral Fellow. She is the Raytheon Professor of Computer Science and Engineering at Texas A&M and directs the Center for Robot-Assisted Search and Rescue and an IEEE Fellow. Her research interests are artificial intelligence, human-robot interaction, and heterogeneous teams of robots and she has over 100 publications including the bestselling textbook, Introduction to AI Robotics (MIT Press 2000). She is a founder of the fields of rescue robots and human-robot interaction. In 2008, she was awarded the Al Aube Outstanding Contributor award by the AUVSI Foundation, for her insertion of ground, air, and sea robots for urban search and rescue (US&R) at 11 disasters, including the 9/11 World Trade Center disaster, Hurricanes Katrina and Charley, and the Crandall Canyon Utah mine collapse. Since arriving at Texas A&M in 2008, she has been leading an initiative in emergency informatics, which stems in part from witnessing valuable data from robots not reaching the right decision maker. Dr. Murphy is active in the community, having served on the IEEE Robotics and Automation executive committees, numerous National Academies and defense boards, including the Defense Science Board.

Current research:

Research interests are artificial intelligence as applied to emergency informatics, especially tactical land, sea, and air vehicles. Specific topics are: human-robot interaction, heterogeneous teams, victim management, and perceptual directed behavior-based control.

Active projects:

- Survivor Buddy (with Prof. Cliff Nass and Dr. Victoria Groom, Stanford Communication between Humans and Interactive Media (CHIMe) Lab and Dr. Cindy Bethel, Yale). Survivor Buddy 1.0 was WINNER Popular Science best of 2009. This project combines efforts in victim management with fundamental research in human-robot interaction. With funding from Microsoft External Research have created a multi-media robot "head" for a rescue robot that can serve as the interface between a trapped victim and the rest of the world while waiting to be extracted. The robot allows two way videoconferencing, web surfing, and general entertainment options to stay relaxed. Under funding from NSF, we are exploring how to make sure that the robot is not creepy or socially inconsistent (no robot versions of a frustrating automated call center!)
- *A Midsummer's Night Dream* (with Dylan Shell, Distributed AI Robotics Laboratory TAMU). This project was a collaboration with the Theater Department at Texas A&M. We applied our work in affect and human-robot interaction to small UAV's to create robot faries.
- *Air Joey*. In this project, a AirRobot quad robot will autonomously launch, coordinate with, and dock with a ground robot. This project addresses fundamental research in heterogeneous teams and behavior-based control. Funded by Lockheed-Martin.

RAPID #1135848: Sendai Earthquake & Tsunami- Remote Assessment Using Land, Sea, & Aerial Unmanned Systems

Objective: participatory research in order to understand human-robot interaction, sensing for structural missions, multi-robot coordination, and GIS integration and reasoning

Courtesy of IRS & CRASAR

Center for Robot-Assisted Search & Rescue (USA)

- Prof. Robin Murphy, Director and Team Leader, Texas A&M University
- Dr. Eric Steimle, Deputy Team Leader, AEOS Inc.
- Mr. Jesse Rodocker & Mr. Sean Newsome, SeaBotix, Inc
- Ms. Karen Dreger, University of South Florida Center for Ocean Technology
- Mr. Richard Smith, Texas A&M Corpus Christi
- Mr. Brian Slaughter, General Dynamics

International Rescue System Institute (Japan)

- Prof. Fumihito Matsuno, VP IRS and government liaison, and Dr. Kazuyuki Kon, Kyoto University
- Prof. Tetsuya Kimura, Field Team Leader, Nagaoka University of Technology
- Mr. Kenichi Makabe, Professional Firefighter
- Prof. Satoshi Takokoro, Director IRS, Tohoku University
- Nobutoshi Hiro, Yudai Hasumi, graduate students

Key Findings

- Unmanned marine vehicle performance is superior to manual divers in mission time, coverage, accuracy
  - 4 remotely operated underwater vehicles, 1 autonomous underwater vehicle
  - In 6 hours found 104 major submerged objects polluting fishing waters (leaking cars, boats) or interfering with nets (building debris) in areas searched manually over 6 months and declared clear
  - Averaged 212m^2/min of underwater area inspection
  - Re-opened Minamisanriku Port for fishing boats
  - Assisted Japanese Coast Guard with victim recovery operations in shallow water and under islands of flotsam

- Research in human-robot interaction, autonomy, and multi-robot coordination is needed
  - "Human error" due to poor interface/interaction
  - Significant number of distributed "consumers" of robot information
  - Image enhancement improved recognition but did not take advantage of advances in computer vision
  - Under-actuated systems prevent accurate position control and station-keeping
  - Active sonars add a new dimension for coordination of coverage for multiple robots

Opportunities for Future Research

- Basic research is needed in:
    - Cyber-physical systems
    - Computer vision and cognitive engineering
    - Geographical information systems
    - Heterogeneous multi-robot coordination
    - Human-robot interaction

- New data sets in field robotics, human-robot interaction, and sensor fusion (video, sonar)

- A focused research program is needed to engage researchers with responders, agencies, field work, and commercial systems

- Transfer of existing AI and HRI research could dramatically improve existing robots and led to accelerated economic recovery after a disaster or extreme event

RAPID: Geotechnical Engineering Reconnaissance of the March 11, 2011, Tohoku Earthquake, Japan

Program Manager: Richard J. Fragaszy
                         CMMI Division of Civil, Mechanical, and Manufacturing Innovation
                         ENG Directorate for Engineering

Investigator(s):   Ross Boulanger (Principal Investigator)
                         Nicholas Sitar (Co-Principal Investigator)

Sponsor: University of California-Davis
                         OR/Sponsored Programs
                         Davis, CA 95618 530/754-7000

NSF Program(s):   COLLABORATIVE RESEARCH,
                         GEOTECHNICAL ENGINEERING

ABSTRACT:
This Grant for Rapid Response Research (RAPID) award funds field reconnaissance with Japanese colleagues that will focus on capturing perishable data, documenting high-value case histories, and assisting in geotechnical characterization at key sites in regards to the March 11, 2011, Mw = 9 Tohoku Earthquake which ranks as one of the largest in recorded history. It occurred as a result of thrust faulting on or near the subduction zone interface plate boundary between the Pacific and North America plates. The earthquake was followed by a tsunami that caused tremendous damage and loss of life. The reconnaissance team will be coordinated through the Geotechnical Extreme Events Reconnaissance (GEER) Association and will be working closely with teams from other organizations in the US and Japan. The damage caused by this Mw = 9.0 event and the subsequent tsunami provides a number of important lessons for the Pacific Northwest and the West Coast of the United States. The wealth of strong motion data from the Japanese networks dwarfs those from any of the previous subduction zone events, providing numerous opportunities for studying the ground motion characteristics and the effects of very long-duration shaking on ground failure and local site response patterns. The affected urban areas provide an opportunity to examine the performance of various parts of civil infrastructure including the performance of underground structures, utilities and lifelines in areas of extensive ground deformations; the performance of levee systems along the different major rivers; the performance of natural slopes, embankment fills, and dams; the performance of improved ground; and tectonic uplift and subduction along the coastline. The historically unprecedented tsunami also provides opportunity to collect data on its erosive power with respect to variety of structures and bridge piers in particular.

Documenting and learning from observations after design level earthquakes are invaluable to advancing the state-of-art and practice in earthquake engineering. Building and infrastructure performance and damage patterns, the distribution of ground failure, cases of lateral spreading and seismically induced slope displacements, ground movements associated with tectonics, among others, provide invaluable information that will serve as benchmarks to the profession's understanding of the effects of earthquakes. This megathrust Mw = 9.0 event represents an important earthquake scenario in the Pacific Northwest, and thus, there is a real need to document its geotechnical effects. Moreover, the GEER team includes researchers who are in the early part of their careers to help develop their capabilities in earthquake engineering and allow them to establish research contacts in Japan.

Ross W. Boulanger

Associate Professor
Position, University

rwboulanger@ucdavis.edu
Phone: (530) 752-2947
Fax: (530) 752-7872
http://cee.engr.ucdavis.edu/faculty/boulanger/

Education:
- Ph.D. University of California, Berkeley, CA, 1990.
- M.S. University of California, Berkeley, CA, May 1987.
- B.A.Sc. University of British Columbia, Canada, May 1986.

Research Interests:
- Geotechnical earthquake engineering with emphases on liquefaction and its remediation, seismic soil-pile-structure interaction, and seismic performance of earth dams and levees.

Recent Research Projects:
- Characterization of intermediate soils. In collaboration with Jason DeJong.
- Inertial and kinematic load combinations on pile foundations in liquefying and laterally spreading abutments. In collaboration with Bruce Kutter.
- Dynamic properties of organic soils and site response in the Sacramento-San Joaquin Delta.
- Liquefaction and its effects on earth dams.
- Soil liquefaction. In collaboration with I. M. Idriss.
- Effects of void redistribution on liquefaction flow of layered soils.
- Effect of ground deformations and liquefaction on bridges.
- NEES Operations and Maintenance Subaward. In collaboration with Bruce Kutter and Dan Wilson.

RAPID: Geotechnical Engineering Reconnaissance of the M 9.0 Japan Earthquake of March 11, 2011

PIs: Ross W. Boulanger, UC Davis, and Nick Sitar, UC Berkeley

GEER Team: Pedro Arduino, University of Washington; Scott Ashford, Oregon State University; Jonathan Bray, UC Berkeley; Shideh Dashti, University of Colorado, Boulder; Craig Davis, Los Angeles Dept. of Water and Power; Jennifer Donahue, Geosyntec; David Frost, Georgia Tech; Les Harder, Jr., HDR Engineering, Inc.; Youssef Hashash, University of Illinois at Urbana-Champaign; Robert Kayen, USGS; Keith Kelson, Fugro; Stephen Kramer, University of Washington; Jorge Meneses, Kleinfelder; Thomas O'Rourke, Cornell University; Ellen Rathje, University of Texas, Austin; Kyle Rollins, Brigham Young University; Isabelle Ryder, University of Liverpool; Jonathan Stewart, UCLA; Ashley Streig, Oregon State University; Joe Wartman, University of Washington; and Josh Zupan, UC Berkeley.

With: Akio Abe, Tokyo Soil Research; Masanori Hamada, Waseda University; Kenji Ishihara, Chuo University; Tadahiro Kishida, Chiba University; Eiji Kohama, Port and Airport Research Institute (PARI); Takaji Kokusho, Chuo University; Kazuhiko Kawashima, Tokyo Institute of Technology; Kazuo Konagai, University of Tokyo; Tetsurou Kuwabara, Public Works Research Institute; Takashi Nagao, National Institute for Land and Infrastructure Management; Shingo Satou, Ministry of Land, Infrastructure, Transport, and Tourism (MLIT); Toshiro Suzuki, MLIT; Kohji Tokimatsu, Tokyo Institute of Technology; Yasuo Tanaka, Kobe University; Hajime Tanaka, University of Tokyo; Takahiro Sugano, PARI; Ikuo Towhata, University of Tokyo; Akihiro Takahashi, Tokyo Institute of Technology; Jiro Takemura, Tokyo Institute of Technology; Keiichi Tamura, Public Works Research Institute; Hideo Tokuyama, MLIT, Tohoku Bureau; Toru Tomoika, Japan Water Works Association; Kiyoshi Yamada, Ritsumeikan University; Yoshimichi Tsukamoto, Tokyo University of Science; Mitsutoshi Yoshimine, Tokyo Metropolitan University; and M. Yoshizawa, Fukushima Pref.

Primary Findings

- Team members investigated and documented aspects of site response, liquefaction, levees, dams, ports, bridges, lifelines, and surface fault rupture (from the April 11 earthquake).

- The broad range of compiled data provides opportunities to gain insights into the correlation between ground motion characteristics and the type and extent of damage in ways that have not previously been possible.

- Initial findings on each aspect of the reconnaissance effort have been published on-line at the GEER website. Analyses of field testing data obtained in collaboration with Japanese colleagues are ongoing.

RAPID: Liquefaction and Its Effects on Buildings and Lifelines in the February 22, 2011 Christchurch, New Zealand Earthquake

Program Manager:	Richard J. Fragaszy
	CMMI Division of Civil, Mechanical, and Manufacturing Innovation
	ENG Directorate for Engineering
Investigator(s):	Jonathan Bray (Principal Investigator)
	Thomas O'Rourke (Co-Principal Investigator)
	Russell Green (Co-Principal Investigator)
Sponsor:	University of California-Berkeley
	Sponsored Projects Office
	BERKELEY, CA 94704 510/642-8109
NSF Program(s):	COLLABORATIVE RESEARCH,
	GEOTECHNICAL ENGINEERING

ABSTRACT:

This Grant for Rapid Response Research (RAPID) award provides funding to investigate the effects of liquefaction on the built environment during the 22 February 2011, Mw=6.1 Christchurch, New Zealand, earthquake and the 4 September 2010, Mw=7.0 Darfield, New Zealand, earthquake with the goal of capturing perishable data that would lead to the development of enhanced analytical procedures for evaluating the hazard holistically. The intense ground shaking and resulting soil liquefaction from the Christchurch earthquake damaged many buildings, lifelines, and engineered systems. The Central Business District (CBD) of Christchurch is still in ruins. The 22 February event is particularly meaningful, because it occurred just 5 months after the Darfield earthquake, the epicenter of which was approximately 40 km from the CBD. Whereas the 22 February event killed almost two hundred people, the September event resulted in no deaths. Additionally, although the 4 September event caused widespread liquefaction-induced damage in the Christchurch area, it did not produce significant liquefaction-induced damage within the CBD. There is much to learn from comparing the different levels of soil liquefaction from these two earthquakes and from evaluating the differing seismic performance of buildings, lifelines, and engineered systems during these two earthquakes. It is extremely rare to have the opportunity to learn how the same ground and infrastructure responded to two significant earthquakes. The magnitude and distances of these two earthquakes are two of the scenarios often considered in US cities. Capturing details of lateral spreads and the impacts of liquefaction on well-built structures, such as office buildings and their interconnecting buried utilities, are critically important. Understanding how local geologic conditions influenced the observed damage patterns is also important. Field reconnaissance is focusing on capturing perishable data and characterizing the subsurface conditions through: (1) trenching of liquefaction features, (2) performing dynamic cone penetration tests, and (3) measuring shear wave velocities (Vs).

The effects of soil liquefaction on the built environment in the Christhurch area were pervasive. The New Zealand building code is similar to that used in the U.S., and with much recent construction, there is much that can be learned that is directly applicable to seismic regions across the U.S. This study is

being coordinated through the Geoengineering Extreme Events Reconnaissance (GEER) Association and in collaboration with the Univ. of Canterbury and the New Zealand government. Documenting and learning from observations after design level earthquakes are invaluable to advancing the state-of-practice in earthquake engineering. Surveying the re-occurrence of liquefaction, documenting cases of liquefaction-induced ground movements, and evaluating the effects of liquefaction on buildings and lifelines provide invaluable information that will serve as benchmarks to the profession's understanding of the effects of earthquakes. These earthquakes involve also multi-hazard effects. The combined settlement caused by liquefaction during both earthquakes has exposed many Christchurch neighborhoods to increased threats from river and ocean flooding, including tsunami. Collection of data on liquefaction-induced ground movement will form the basis for flood risk assessment as well as earthquake vulnerability. The study combines the efforts of several leading researchers to examine the effects of liquefaction holistically. The team also includes a junior faculty member and graduate students who are in the early stages of their careers, so it will help develop their capabilities in earthquake engineering and allow them to establish research contacts in New Zealand.

Jonathan D. Bray

Professor of Geotechnical Engineering
University of California, Berkeley

bray@ce.berkeley.edu
Phone: (510) 642-9843
Fax: (510) 642-7476
http://www.ce.berkeley.edu/~bray/

Education:
- University of California, Berkeley, California, Ph.D. in Geotechnical Engineering, 1990
- Stanford University, Palo Alto, California, MS in Structural Engineering, 1981
- United States Military Academy, West Point, New York, BS, 1980

Research Interests:
- Earthquake engineering
- Geotechnical engineering
- Physical and numerical modeling
- Environmental geotechnics

Professional Qualifications:
- Registered Professional Civil Engineer in California, No. C 45519, since 1990
- Registered Professional Engineer in Virginia, No. 015644, since 1985

RAPID: Liquefaction and Its Effects on Buildings & Lifelines in the Feb. 22, 2011 Christchurch, New Zealand Earthquake

PIs: Jonathan Bray, UC Berkeley, Thomas O'Rourke, Cornell U, & Russell Green, Virginia Tech

GSRs: Josh Zupan, UC Berkeley; Clint Wood, U. of Arkansas; Brad Wham & Serozhah Milashuk, Cornell U.

With: Misko Cubrinovski & Brendon Bradley, U. of Canterbury, Brady Cox, U. of Arkansas, Liam Wotherspoon, U. of Auckland, & Iain Haycock, McMillan Drillers

International Students: Merrick Taylor, Simona Giorgini, Kelly Robinson, & Duncan Henderson, U. of Canterbury

Stakeholders & Partners: Christchurch City Council, CERA, EQC, NHRP

OBJ: Surveying the re-occurrence of liquefaction, documenting cases of liquefaction-induced ground movements, and evaluating the effects of liquefaction on lifelines and buildings provide invaluable information that will advance our understanding the effects of earthquakes.
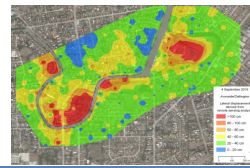
Primary Findings

- Soil liquefaction in a substantial part of Christchurch damaged many multi-story buildings resulting in global and differential settlements, lateral movement of foundations, tilt of buildings, and bearing failures.

- Integrated GIS for water supply, wastewater, storm water, electric power, and gas distribution systems show spatial distribution of damage in all systems relative to transient motion (from seismometer data) and liquefaction-induced ground deformation (from LiDAR, air photo measurements, scan lines, and geodetic surveys) for three major earthquake events.

- Multiple episodes of liquefaction were clearly discernible in trenches cut through undisturbed sand boils. Trends in grain sizes both vertically and horizontally in the blow material are currently being quantified.
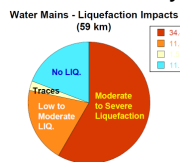
Opportunities for Future Research

A: - What are the system-wide relationships among damage to underground lifelines and buildings and subsurface stratigraphy, soil properties, and topography?
- How can the performance of existing lifeline systems and buildings be most effectively improved against liquefaction and recurrent earthquake effects?
- Can episodic occurrence of liquefaction be discerned from the structure of liquefaction dikes, and does the liquefaction susceptibility of a deposit change after being liquefied once?

B: - The Canterbury EQ sequence has yielded the most comprehensive data set ever assembled of the integrated effects of multiple EQs and liquefaction episodes (e.g., soil and damage)
- Data on the structure of liquefaction dikes and blow material at sites of known recurrent liquefaction has not been documented comprehensively.

C: - The combined effects of multiple EQs and liquefaction episodes on the integrated performance of lifelines and buildings should be investigated further.
- The social repercussions of multiple recurrent EQs and extensive infrastructure damage, including changes in land use, effects on communities, development of resilient communities, policies for sustainability, best practices for recovery, and impact on insurance can be studied.
- Little is known about the susceptibility of liquefiable deposits to aftershocks or triggered earthquakes closely spaced in time.

D: - HDPE water mains installed after the Darfield EQ sustained no damage, even when subjected to more than 2 m of ground movement in subsequent EQs. No damage was sustained in MDPE gas distribution systems during all earthquakes
- Damage to wastewater systems was most difficult and expensive to repair.
- These data will allow better interpretation of paleoliquefaction features in the U.S.
- Liquefaction caused extensive damage to modern buildings wherein a city's business district was essentially put out of operation for a sustained period.

RAPID: Cone Penetration Testing (CPT) and Spectral Analysis of Surface Waves (SASW) Testing at Seismograph Stations with Liquefiable Soils Affected by the Tohoku Earthquake, Japan

ABSTRACT:

This Grant for Rapid Response Research (RAPID) award is for a detailed study that focuses specifically on characterizing the soil conditions at a select set of strong ground motion recording stations that are underlain by liquefiable soils in regards to the March 11, 2011 magnitude 9.0 Tohoku, Japan Earthquake, which ranks as one of the largest in recorded history. In the aftermath of the earthquake, an advance team from the Geotechnical Extreme Events Reconnaissance (GEER) Association traveled to Japan to coordinate perishable data collection and research efforts with our Japanese colleagues from the Japanese Geotechnical Society, the Center for Urban Earthquake Engineering, and the Port and Airport Research Institute. On this visit, Cone Penetration Testing (CPT) and Spectral Analysis of Surface Waves (SASW) testing at key strong ground motion recording stations where liquefaction occurred were identified as priority research tasks that the US could contribute to joint US-Japan reconnaissance efforts. The GEER Advance Team visited 14 strong ground motion recording stations underlain by liquefiable soils in the Kanto Plain region, including several with both downhole and surface recordings. Peak ground accelerations at these stations ranged from 0.14 to 0.22 g, and surface evidence of liquefaction was observed at 7 of them. In addition, the Port and Airport Research Institute has indicated they have several strong ground motion recording stations further to the north, where shaking was stronger, that are underlain by liquefiable soils, including some with ground improvements. These key ground motion recordings represent a unique set of data that captures the dynamic response and liquefaction of soft soils during long-duration shaking produced by this M9.0 earthquake. As such, these data can be used to anchor liquefaction triggering curves and refine magnitude scaling factors, assess procedures for estimating ground surface deformations, and evaluate dynamic site response analysis models for liquefiable soils. However, proper characterization of these sites is an imperative step before subsequent analyses can be performed accurately. Subsurface information at these sites is currently limited to a single Standard Penetration Test (SPT) and downhole shear wave velocity (Vs) profile at each site. CPT soundings and many additional Vs profiles from SASW testing at six or more of the most significant strong ground motion recording stations will be obtained. CPT is often preferred over SPT in the US and much of the world for evaluating liquefaction triggering, but CPT is relatively uncommon in Japan for various reasons, and it is unlikely that this work will be performed by our Japanese colleagues. This work is an important and valuable contribution that will enhance the value of these case histories

and tie them to US practice. The urgency of this project is due to: (1) the possibility of post-earthquake repair work that could modify ground conditions at key sites, and (2) the need for rapid distribution of CPT and SASW results, which will have maximum impact if obtained before the ground motion records are used for other research studies.

The results of this study are expected to contribute to a significant advancement in the procedures used to predict and model liquefaction effects across the US and elsewhere in the world. Significant research collaborations have existed between the US and Japan since the 1964 Niigata Earthquake. Both counties have benefitted from this partnership, and have used these experiences as a spring board to lead the rest of the world in seismic design and building standards. The CPT and SASW testing will be performed in close coordination with our Japanese colleagues in an effort to continue this tradition by facilitating cross-training of researchers and students on testing practices in our respective countries, providing an avenue for new and important international collaborations.

Brady R. Cox

Note: His student Clinton M. Woods will be attending instead.

Assistant Professor
Department of Civil Engineering

brcox@uark.edu
Phone: (479) 575-6027
http://www.cveg.uark.edu/BradyCox.php

Education:
- Ph.D., The University of Texas, Austin Texas (2006)
- M.S., Utah State University, Logan Utah (2001)
- B.S., Utah State University, Logan Utah (2000)

Research Interests:

Dr. Cox specializes in Geotechnical Engineering issues related to earthquake loading, soil dynamics and nondestructive material characterization using stress waves. Recently, he has been a part of the Geo-engineering Extreme Events Reconnaissance (GEER) teams deployed immediately following the M7.0 2010 Haiti Earthquake, the M6.9 2008 Iwate-Miyagi, Japan Earthquake and the M8.0 2007 Pisco, Peru Earthquake. He has also been a part of teams deployed to collect shear wave velocity data at strong motion stations and soil liquefaction sites following the 2006 Kiholo Bay, Hawaii Earthquake, the 2001 Nisqually (Seattle), Washington Earthquake, and the 1999 Kocaeli, Turkey Earthquake.

Biography:

Dr. Cox has been involved with numerous dynamic site characterization projects where crosshole, downhole and surface wave techniques were employed at critical government facilities such as the Yucca Mountain Project, the Device Assembly Facility (Nevada Test Site), the DOE Hanford Site, the Y-12 National Security Complex, Oak Ridge National Laboratory, and Los Alamos National Laboratory. His Ph.D. graduate research centered around the development of a new in-situ test method for directly measuring the dynamic pore pressure response and nonlinear shear modulus behavior of liquefiable soil deposits.

For this research, he was selected as the 2004-2005 FEMA Graduate Fellow in Earthquake Hazard Reduction by the Earthquake Engineering Research Institute (EERI). Dr. Cox currently operates a Vibroseis shaker truck (affectionately named 'The Hawg') as part of his earthquake and dynamic material characterization research. He is a member of the American Society of Engineers (ASCE), GEER, EERI, and the Arkansas Governor's Earthquake Advisory Council (AGEAC).

RAPID: CPT AND SASW TESTING AT SEISMOGRAPH STATIONS WITH LIQUEFIABLE SOILS AFFECTED BY THE TOHOKU EARTHQUAKE, JAPAN

US Team

- Dr. Brady Cox (PI), Dr. Ross Boulanger, Dr. Nick Sitar, Dr. Robert Kayen, Mr. Clinton Wood, Dr. Robb Moss, Dr. Dimitrios Zekkos, and Dr. Ben Mason

Japan Team

- Dr. Kenji Ishihara, Dr. Kohji Tokimatsu, Dr. Akio Abe, Mr. Kazushi Tohyama, Mr. Kota

Rapid Objective

- Characterize strong motion stations (SMS) that liquefied during the Tohoku Earthquake using Cone Penetration Testing (CPT) and shear wave velocity (Vs) profiles from Spectral Analysis of Surface Waves (SASW) Testing.

- Measure Vs for various ages of fill within the City of Urayasu to investigate the effects of aging within man-made fills and its impact on liquefaction resistance.

Station TKY017

Geophones

Shaker
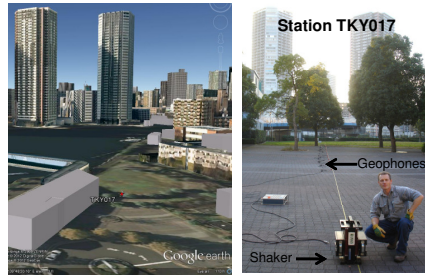
Key Findings

- Surface wave Vs profiling was conducted at 56 liquefaction/no liquefaction sites (including 10 key SMS) in November 2011.
- CPT testing at select SMS are currently being planned with our Japanese colleagues using the results from the Vs profiling to screen potential sites.
- Vs profiling in the city of Urayasu was conducted in various age fills. The older 1968 fill is observed to have a slightly lower median near-surface stiffness than the younger 1978-1980 fills, indicating slightly lower liquefaction resistance. However, at depths greater than 10 m the older fill is stiffer.
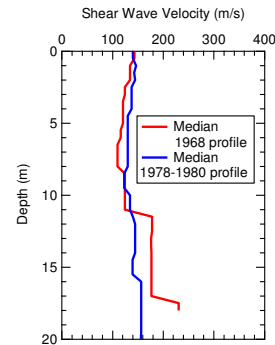
Opportunities for Future Research

- The CPT and Vs data at key SMS near Tokyo will help researchers analyze the dynamic soil response of potentially liquefiable soils subject to GM's with relatively low accelerations yet significant numbers of loading cycles. These GM's are currently lacking in the case history databases for liquefaction triggering.

- Some of these SMS sites would have been predicted to liquefy using current simplified liquefaction triggering procedures, yet did not. These cases need to be studied further.

- Much collaboration is still needed between the U.S. and Japan research teams to fully utilize the wealth of data collected in Urayasu.

- In particular, studies involving the liquefaction susceptibility of various ages of man-made fill and improved ground will be particularly beneficial.

Award Abstract #

Evaluation of the potential of large aftershocks of The 2011 off the Pacific coast of Tohoku Earthquake

Investigator(s):   Yo Fukushima (Principal Investigator), Kyoto University

Counter-part: Paul Segall (Principal Investigator), Stanford University

ABSTRACT:

This study aims to evaluate the potential of the occurrence of large aftershocks near the source region of The 2011 off the Pacific coast of Tohoku Earthquake by analyzing all the available geodetic data. Specifically, the triangulation, trilateration, leveling, tide gauge data collected in recent several decades as well as the GPS displacement data collected in recent 16 years are re-evaluated to compare the amount of slip and afterslip of the Tohoku-oki earthquake and the slip deficit rates of the pre-earthquake period in order to ultimately estimate the slip deficit that was not fully released by the earthquake. The Japanese team is responsible for the evaluation of the potentials of the aftershock generation and the US team is responsible for development of the analysis methodology. The complementary works done by the both teams enable evaluation of the potential of maximum-possible aftershocks, which is expected to contribute to disaster mitigation through seismic and tsunami simulations.

Evaluation of the potential of large aftershocks of the 2011 Tohoku earthquake

- Japan team (J-RAPID): Yo Fukushima, Shinichi Miyazaki, and Manabu Hashimoto (Kyoto Univ.)

- US team (NSF): Paul Segall (Stanford Univ.) and Kaj Johnson (Indiana Univ.)

- Objective: Re-evaluate of the recent and historic geodetic data to estimate the potential of future large aftershocks of the Tohoku earthquake.

Key Findings

No conclusion yet, findings at the moment:

- Purely elastic models considered in most previous studies can not explain the cycle of the magathrust earthquakes. Viscoelastic/elastic layered model is required. The rheological properties should be ideally constrained simultaneously with the evaluation of the future aftershocks.

Opportunities for Future Research
- feel free to include ideas beyond the scope of awarded RAPID
- Will be merged with feedback from other RAPIDs

- What new questions raised by these events require basic research?
  - Estimation of the potential of the future quakes

- What new data are available as a result of these events?
  - A wealth of geodetic data (pre-, co-, and post-seismic), that enables tracking how the strain accumulated and released.

- What unique aspects of these events require the development of a focused research program?
  - The nature of subduction earthquakes cannot be known without seafloor measurements.

- What are the important lessons from these larger than expected events for the U.S.?
  - At the current stage, the theory of earthquake physics and observation data are generally insufficient for forecasting the nature of future earthquakes. Expectation is OK, but the uncertainty in the expectation should be taken into account.

RAPID: Real-Time Investigations of the Tohoku and Darfield Earthquake Sequences

Program Manager: Gregory J. Anderson
                         EAR Division of Earth Sciences
                         GEO Directorate for Geosciences

Investigator(s):   Thomas Jordan (Principal Investigator)
                         Gregory Beroza (Co-Principal Investigator)

Sponsor: University of Southern California
                         University Park
                         Los Angeles, CA 90089 213/740-7762

NSF Program(s):   DEEP EARTH PROCESSES SECTION,
                         SCEC

ABSTRACT:

The earthquake sequences excited by 2010 Darfield (New Zealand) and 2011 Tohoku (Japan) are natural experiments being conducted in two distinctive and well-instrumented tectonic laboratories. This NSF project supports U.S. scientists to participate in these experiments by collaborating with their Japanese and New Zealand colleagues. The international project team is gaining new knowledge about short-term earthquake predictability, which is a major unsolved problem of physical science.

Intellectual Merit:

The project goal is to improve the physical and statistical foundations for time-dependent earthquake forecasting. New forecasting models incorporating seismic, geodetic, and other data are being developed and evaluated using the existing infrastructure of the Collaboratory for the Study of Earthquake Predictability. The research is focused in two areas: (a) the retrospective calibration and prospective testing of physics-based forecasting models, including those based on rate/state-dependent friction, the Coulomb stress function, and observations of slow slip events, and (b) the evaluation of hypotheses critical to forecasting large earthquakes, including the characteristic earthquake hypothesis, the seismic gap hypothesis, and the maximum-magnitude hypothesis.

Broader Impacts:

The basic research sponsored by this project is elucidating critical scientific issues related to temporal changes in primary and secondary seismic hazards. The results will help the Working Group on California Earthquake Probabilities formulate an improved time-dependent Uniform California Earthquake Rupture Forecast, and they will also aid the U.S. Geological Survey and the National Oceanic and Atmospheric Administration improve their procedures for time-dependent forecasting of earthquake and tsunami hazards off the Cascadia coast.

Thomas Hillman Jordan

University Professor and W. M. Keck Foundation Chair in Geological Sciences
Director
University of Southern California

tjordan@usc.edu
Phone: (213) 821-1237
http://dornsife.usc.edu/cf/faculty-and-staff/faculty.cfm?pid=1003391

Education:
- B.A. , California Institute of Technology, 6/1969
- M.S. , California Institute of Technology, 6/1970
- Ph.D. , California Institute of Technology, 8/1972

Biographical Sketch:
Tom Jordan is the Director of the Southern California Earthquake Center and the W. M. Keck Professor of Earth Sciences at the University of Southern California, where SCEC is headquartered.

He is responsible for all aspects of SCEC's program, which currently involves over 600 scientists at more than 60 universities and research institutions. He is a member of the California Earthquake Prediction Evaluation Council and the Governing Council of the National Academy of Sciences. He is the author or co-author of approximately 170 scientific publications, including the NAS decadal report, Living on an Active Earth: Perspectives on Earthquake Science, and a popular textbook, Understanding Earth (5th edition).

He received his Ph.D. from Caltech in 1972 and taught at Princeton University and the Scripps Institution of Oceanography before joining the Massachusetts Institute of Technology as the Robert R. Shrock Professor in 1984. He served as the head of MIT's Department of Earth, Atmospheric and Planetary Sciences for the decade 1988-1998. In 2000, he moved from MIT to USC. He has been awarded the Macelwane and Lehmann Medals of the American Geophysical Union and the Woollard Award of the Geological Society of America. He has been elected to the American Academy of Arts and Sciences, the National Academy of Sciences, and the American Philosophical Society.

Description of Research:
Summary Statement of Research Interests
Thomas Jordan came to USC College to run the Southern California Earthquake Center (SCEC), a leading consortium of earthquake research made up of move than 50 universities and other institutions. He also came to USC to teach. Jordan is a geophysicist, applied mathematician and member of the National Academy of Sciences (NAS). Jordan studies earthquakes, seismological study of earth structure and geodetic observations of plate motions and interplate deformation. Other areas of interests include continental formation and tectonic evolution, mantle dynamics, and statistical descriptions of seafloor morphology. Through his research, Professor Jordan has made a series of major discoveries about the three-dimensional structure of the Earth's interior. He used the waves from earthquakes to look deep inside the earth in an effort to understand the machinery that drives plate tectonics. The surface motions of the plates are a manifestation of the convection in the Earth's solid mantle, and he and his group have been able to show that this convection goes very deep.
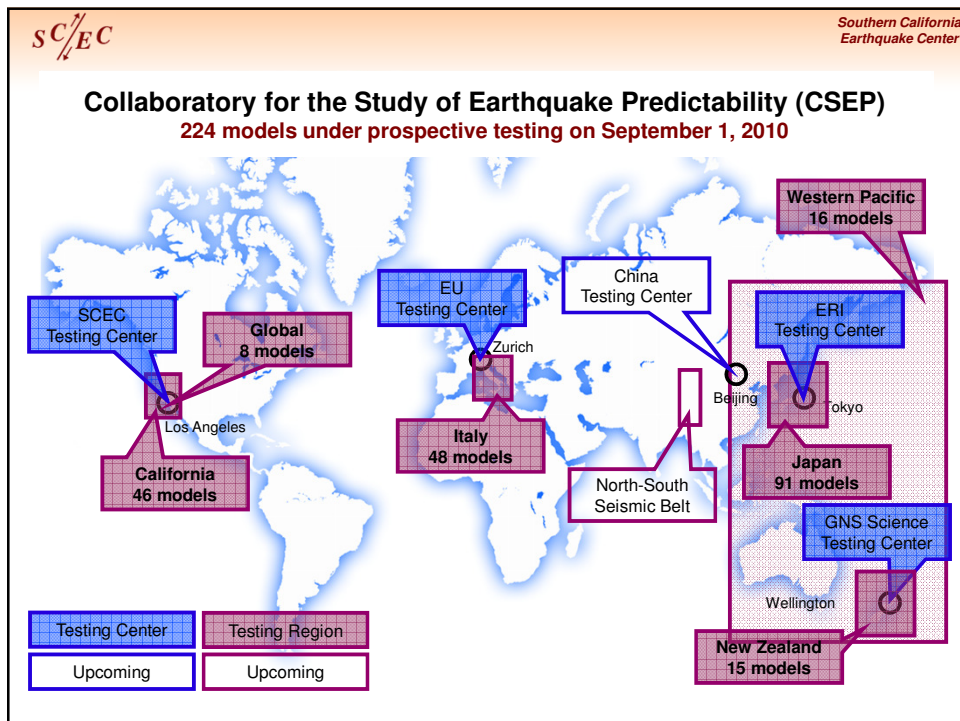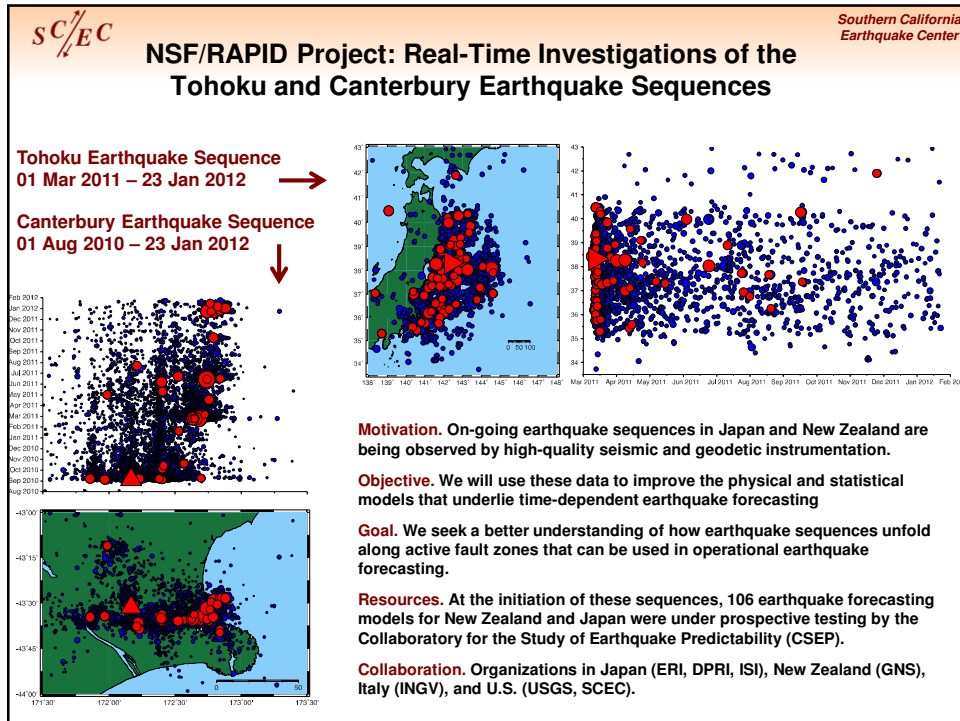
S C / E C   *Southern California*
                                                         Earthquake Center

NSF/RAPID Project: Real-Time Investigations of the Tohoku and Canterbury Earthquake Sequences

- **Project objectives:**
  - **Prospectively test earthquake forecasting models using the CSEP cyberinfrastructure**
  - **Develop and test forecasting models based on rate/state-dependent friction and Coulomb stress function**
  - **Evaluate the relative performance of dynamic and quasi-static earthquake triggering models**

- **Project activities in 2011:**
  - **Collaboration with GNS Science (Wellington) to process Canterbury sequence data**
  - **Visits by GNS personnel to SCEC CSEP testing center**
  - **Collaboration with ERI (Tokyo) to process Tohoku sequence data**
  - **Joint ERI-SCEC workshop at Stanford on Dec 10-11, 2011**

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                                                         Earthquake Center

Canterbury Sequence Forecasting Results

M. Gerstenberger & D. Rhoades, GNS Science; processing by M. Liukis, SCEC

Testing region: **New Zealand**
Target events: **M ≥ 4 (PPE-1d), M ≥ 5 (PPE-3m, PPE-5y)**
Testing period: **4 Sept 2010 - 8 Mar 2011**
Testing method: **Paired T-test**
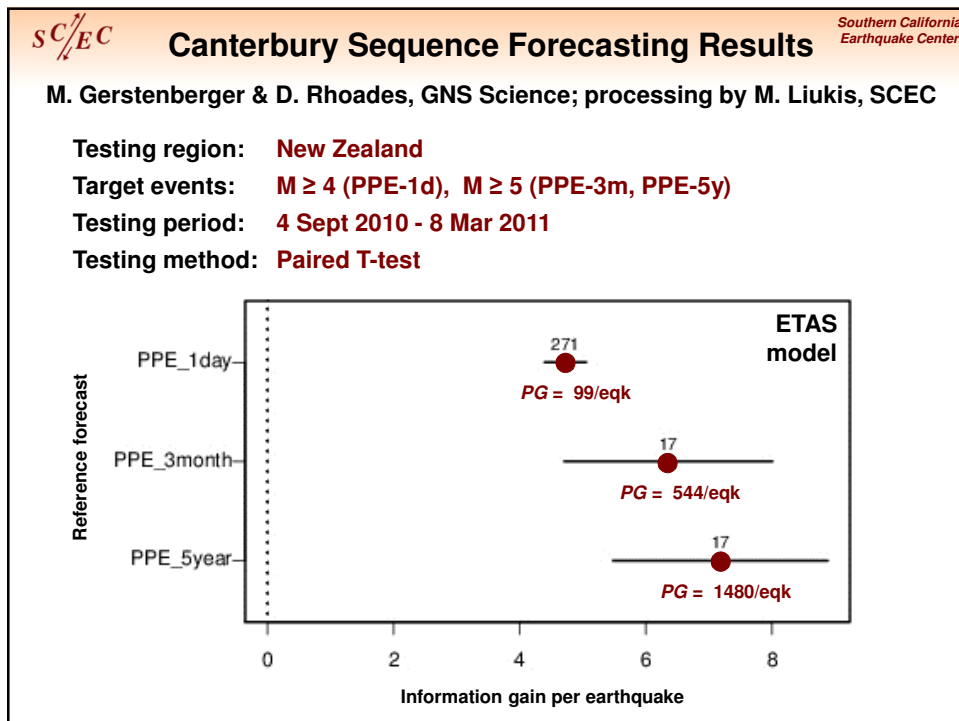
RAPID: Recording Fault-Zone Trapped Waves from Aftershocks of the M6.3 Christchurch Earthquake Sequence in New Zealand to Document the Subsurface Damage Zones

Program Manager:	Eva E. Zanzerkia
	EAR Division of Earth Sciences
	GEO Directorate for Geosciences
Investigator(s):	Yong-Gang Li (Principal Investigator)
Sponsor:	University of Southern California
	University Park
	Los Angeles, CA 90089 213/740-7762
NSF Program(s):	GEOPHYSICS

ABSTRACT:

The M6.3 Christchurch earthquake struck the Canterbury region in New Zealand's South Island on 22 February 2011, causing widespread damage and multiple fatalities. The earthquake occurred at 5 km depth, 10 km south-east of Christchurch, New Zealand's 2nd-most populous city. It followed ~6 months after the Sept. 4, 2010 M7.1 Darfield earthquake in the same region. The Christchurch earthquake was part of a series of earthquakes and aftershocks in the region following the 2010 M7.1 Darfield. New Zealand's GNS Science describe it as "technically an aftershock" of the earlier event while other seismologists from USA and Australia consider it a separate event, given its location on a separate fault system. Seismologically, this M6.3 quake is classed as an aftershock because of its relationship to the ongoing activity since September last year. However, it has generated a significant series of its own aftershocks, many of which are considered big for a M6.3 earthquake. Over 200 aftershocks including a M5.7 were experienced in the first week. It did not occur on the Greendale Fault, on which the 2010 M7.1 Darfield quake occurred, but on a previously unknown blind fault line running 17 km east-west south of Christchurch, at depths of 3?12 km. On the contrary, precise aftershock relocations suggest that at least two north-east/south-west trending faults lie between the two and that there is no evidence from the earthquake data of an extension of the Greendale Fault. However, there are still many aftershocks of the 2010 M7.1 Darfield earthquake spread along the fault line of the 2011 M6.3 Christchurch earthquake.

In order to document the complicated subsurface structure of the damage zones caused by the sequence of the 2010 M7.1 Darfield and the 2011 M6.3 Christchurch earthquakes in the Canterbury region of NZ's South Island, the investigator proposes to record fault-zone trapped waves (FZTWs) generated by aftershocks, and use the FZTWs to image the rupture zones composed by damaged fault rocks at seismogenic depths. Because the amplitude and dispersive feature of FZTWs are sensitive to the geometry and physical properties, and the location of aftershocks (within or outside) of the low-velocity fault-zone waveguide formed by severely damaged rocks in these two earthquakes, observations and numerical modeling of recorded FZTWs allow us to learn more about (1) the width, velocity reduction, Q value and depth extension of damage zones of the 2010 M7.2 and 2011 M6.3 earthquakes, (2) the shape of subsurface rupture zones with the principal slip plans of the mainshocks, and if the two rupture segments are connected at seismogenic depths, (3) the difference in rock damage magnitude caused by

these two earthquakes occurring at different depths with different sizes, (4) the fault healing with time after the mainshock.This RAMP experiment will be collaborated by USC/UoA /UoC/GNS in NZ to pursue the value of the work proposed, likewise with the ongoing efforts by the NZ national GEONET seismic network and researchers. GNS will offer to follow the USC/UoA/UoC work and help them keep up with other initiatives and projects concerning the Darfield event.

Yong Gang Li

Adjunct Associate Professor (Research) of Earth Sciences
University of Southern California

ygli@usc.edu
Phone: (213) 740-3556
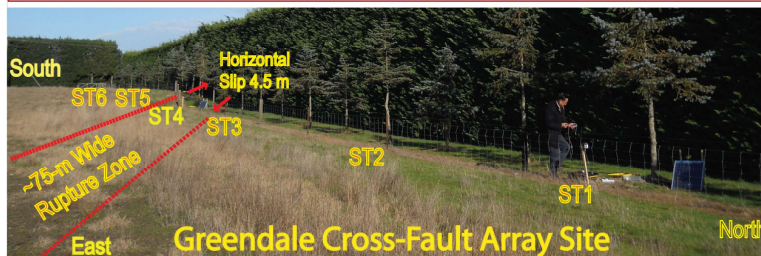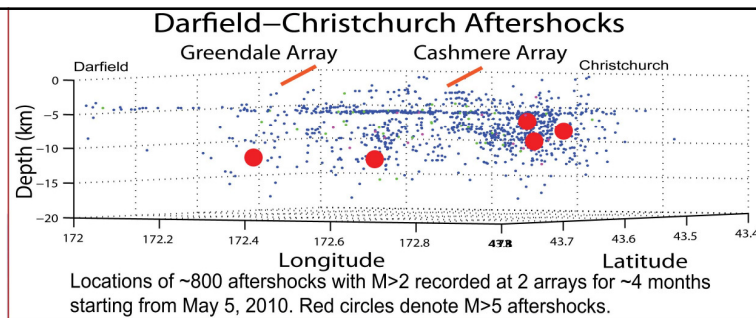http://dornsife.usc.edu/cf/faculty-and-staff/faculty.cfm?pid=1008200

Education:
- Ph.D. (Honorary) Geophysics (Seismology), University of Southern California, 1987

Research Interests:
(1) Characterization of earthquake faults includes the pioneering work in discovery and simulation of the fault-zone trapped waves, high-resolution delineation of internal structure and physical properties in 3-D, fault rock co-seismic damage and post-mainshock heal at major active faults in California, Japan, China and New Zealand. (2) Investigation of crustal fracturing and anisotropy in active tectonic margins from shear-wave splitting observations and computation. Developed 2-D and 3-D dynamic ray tracing for seismic waves propagating in the crustal cracked media for evaluation of the in-situ stress states associated with occurrence of earthquakes. (3) Investigation of the crustal structure and evolution by seismic reflection/refraction profiling at Western U.S (COCOOP). Developed a combination computer modeling procedure of multi-channel reflection/refraction profiles, ray tracing, gravity and plate flexure to interpret the seismotectonic structures. (4) Analysis of earthquake source parameters using the method of joint inverse of source and path effects, and the Empirical Green's Function (EGF) method to study the dependence of corner frequency with depth and the stress drop with seismic moment. (5) High-resolution image using fault-zone guided waves for the subsurface water-born fracture zone in geothermal areas and 3-D tomography migration to image the shape of geothermal reservoir, aiming at the development of sustainable renewal energy from deep geothermal resources in the world.

- **RAPID project title:** Recording Fault-Zone Trapped Waves from Aftershocks of the *M*6.3 Christchurch Earthquake Sequence in New Zealand to Document the Subsurface Damage Zones
- **US Researchers:** Yong-Gang Li, University of Southern California
- **International counterparts:** University of Canterbury, University of Auckland, Victoria University of Wellington
- **Objective of RAPID:** In order to document the complicated subsurface rupture zones in the 2010 *M*7.1 Darfield and the 2011 *M*6.3 Christchurch earthquakes, we deployed 12 seismic stations in two cross-fault arrays to record fault-zone trapped waves generated by aftershocks in 2011. We use these FZTWs to address the magnitude of co-seismic rock damage along the Greendale fault and Port Hills fault at seismogenic depths as well as the post-mainshock fault healing.
- **Selected graphic:**

Darfield–Christchurch Aftershocks

Locations of ~800 aftershocks with M>2 recorded at 2 arrays for ~4 months starting from May 5, 2010. Red circles denote M>5 aftershocks.

Greendale Cross-Fault Array Site

We deployed a linear seismic array across the Glendale fault to record fault-zone trapped waves generated by aftershocks, where 4.5-m horizontal right-lateral slip (shown by frence offset) and 1.6-m vertical slip caused by the 2010 M7.1 Darfield earthquake. Many enechelon cracks were seen in a ~75m wide zone along the Glendale fault trace at surface.

Key Findings

• Observations and 3-D finite-difference synthetics of fault-zone trapped waves (FZTWs) shows a distinct low-velocity waveguide formed by severely damaged rocks along the Greendale fault, which likely extends across seismogenic depths. The damage zone is 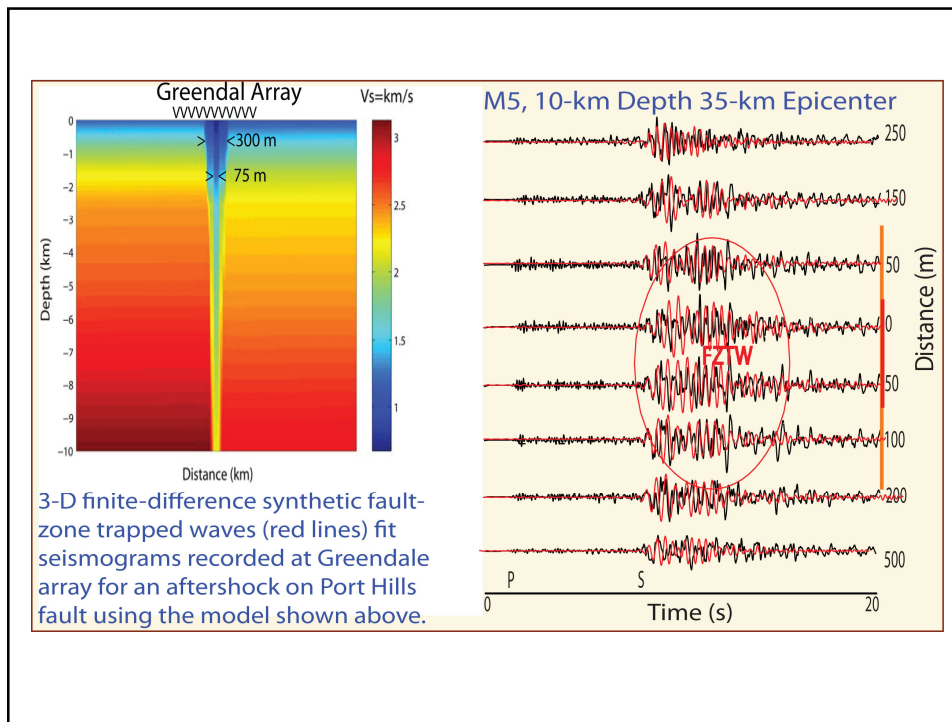200-300-m wide, within which seismic velocities are reduced by ~35-50% from wall-rock velocities, mainly caused by dynamic rupture of the 2010 M7.2 Darfield mainshock.

• We observed the FZTWs at the array across the Greendale fault for aftershocks either on the Greendale fault or on the Port Hills fault, suggesting that the Darfield rupture zone likely connects the blind rupture zone of the 2011 M6.3 Christchurch earthquake at depth beneath a slip gap between them where the moment release was minimal in this earthquake sequence.

• **Selected graphic:**

Cross-Fault Profiles at Greendale Site

Top: Seismograms recorded at Greendale array for two aftershocks occurring at depths of 8-10-km on the Greendale fault and Port Hills fault, respectively, show fault-zone trapped waves (FZTWs) with relative large amplitudes and long wave-trains (marked by red circles) at stations located within a 300-m zone (marked by vertical brown bar) along the Greendale fault at surface. **Bottom:** The schematic diagram shows the subsurface rupture zones of the Darfield-Christchurch earth-quake sequence and raypaths between the array and these two aftershocks.

3-D finite-difference synthetic fault-zone trapped waves (red lines) fit seismograms recorded at Greendale array for an aftershock on Port Hills fault using the model shown above.

<u>Opportunities for Future Research</u>

- What new questions raised by these events require basic research?

  The *M*6.3 Christchurch earthquake struck the Canterbury region in New Zealand's South Island on 22 February 2011, ~6 months after the September 4, 2010 *M*7.1 Darfield earthquake in the same region. It is primarily unclear whether the later *M*6.3 event is technically an aftershock, or a separate event. To address this problem, we require a high-resolution image of subsurface fault segmentation and connection in this complicated region with multiple slips and simulation of dynamic ruptures.

- What new data are available as a result of these events?

  Fault-zone trapped waves have been recorded after the Christchurch earthquake. These data will improve the resolution to delineate the spatio-temporal variations in rock damage along the rupture zones at seismogenic depth.

- What unique aspects of these events require the development of a focused research program? It is in a few cases to illuminate the in-situ fault-zone rock damage and healing associated with two successive large earthquakes, the *M*7.1 Darfield and *M*6.3 Christchurch earthquakes occurring in the same region.

- What are the important lessons from these larger than expected events for the U.S.? Pay more attention to the likelihood of earthquake sequence in the complicated slip region with multiple faults at depth, such as in Southern California.

Award Abstract # 1138675

RAPID: Post-Earthquake Fires in the March 2011 Japan Earthquake and Tsunami

Program Manager: Dennis Wenger
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s):   Rachel Davidson (Principal Investigator)

Sponsor: University of Delaware
210 Hullihen Hall
Newark, DE 19716 302/831-2136

NSF Program(s):   COLLABORATIVE RESEARCH,
INFRAST MGMT & EXTREME EVENTS,
SPECIAL STUDIES AND ANALYSES

ABSTRACT:

This Grant for Rapid Response Research (RAPID) award provides funds to study the fire-related aspects of the March 2011 Japan earthquake with the aims to improve understanding of where, when, and how fires ignite; how fires spread through a neighborhood; and how they ignite and are suppressed in industrial facilities. The Tôhoku earthquake and tsunami caused 345 fires more recorded fires than any other earthquake in history. By comparison, there were about 110 recorded in Kobe (1995), 110 in Northridge (1994), 128 in San Fernando (1971), and 36 in Loma Prieta (1989). This project will involve three main steps: (1) collecting data on the fire-related aspects of the event through site visits, interviews with key informants, and secondary data sources; (2) compiling the data into easily usable, comprehensive databases that includes all data on each fire and relevant auxiliary data in a consistent format; and (3) analyzing the data through descriptive statistics, fitting generalized linear statistical models to the ignition data, and comparing observations of spread to that estimated by a new physics-based urban fire spread model. The PI and consultant on the project have extensive background in the study of post-earthquake fires, including field investigation of past events and development of models of ignitions, spread, and suppression. This research will contribute knowledge on three main aspects of post-earthquake fires ignitions, spread through a neighborhood, and fires in industrial facilities. It will improve understanding of the number, locations, causes, and timing of post-earthquake ignitions. The substantial inherent randomness in the phenomenon requires use of statistical approaches that are highly dependent on the amount and quality of available data. This project will greatly improve the available ignition data by almost doubling the number of observations documented in previous earthquakes; documenting areas in which ground shaking was strong enough to induce ignitions but did not, substantially improving our ability to forecast ignitions; by providing more consistent and comprehensive data than currently available; and by providing data on both ground shaking and tsunami-induced ignitions. Statistical modeling will be conducted to determine what the data suggests about where, when, why ignitions occur and to improve forecasting of ignitions in the future. Understanding of fire spread through a neighborhood will be enhanced by collection of data that allows more meaningful comparison with the emerging new generation of physics-based urban fire models. These models are potentially powerful but they need more comparisons to real events to improve them and build their credibility. Finally, the project promises to provide new insights into how post-

earthquake fires start, spread, and are suppressed in industrial facilities specifically. We will examine how the fire safety systems in place perform in the face of extreme common cause failure mode of a major earthquake.

The improved knowledge of post-earthquake ignitions and urban fire spread will be directly integrated into the development of better post-earthquake fire models. Those models can then in turn be integrated into regional earthquake loss models like HAZUS-MH, which have great demonstrated value to society by supporting long-term emergency response planning, urban planning, and loss estimation. The research results will be integrated into the PIs graduate Risk Analysis course and will be presented at professional conferences. A graduate student research assistant will participate in all aspects of the project and the research will form an integral part of his dissertation on post-earthquake fire modeling.

Rachel A. Davidson

Associate Professor
Position, University

rdavidso@udel.edu
Phone: (302) 831-4952
Fax: (302) 831-3640
http://www.ce.udel.edu/directories/profiles.html?rdavidso

Education:
- Ph.D, Stanford University, 1997
- Master, Stanford University, 1994
- Bachelor, Princeton University, 1993

Biography:
Rachel Davidson is an Associate Professor in the Department of Civil and Environmental Engineering and a core faculty member in the Disaster Research Center at the University of Delaware. After completing her B.S.E. from Princeton University and M.S. and Ph.D. from Stanford University, she spent two years at the University of North Carolina at Charlotte, then six years at Cornell University, both as an Assistant Professor of Civil Engineering. Following a year as a Visiting Assistant Professor at Columbia University, she joined the faculty at the University of Delaware and the Disaster Research Center in 2007.

Davidson conducts research on natural disaster risk modeling and civil infrastructure systems. Her work involves developing new engineering models to better characterize the impact of future natural disasters, and use that understanding to support decisions to help reduce future losses. It focuses particularly on lifelines (e.g., electric power, water supply) and risk from a regional perspective; on earthquakes and hurricanes. Problems in this field typically involve a great deal of uncertainty, a long time horizon, multiple and competing objectives, and sometimes numerous and conflicting constituencies. They are often spatial and dynamic, and the technical aspects must be understood in the social, economic, political, and cultural context in which they exist.

She currently serves as President of the Society for Risk Analysis, as a member of the Executive Committee of the ASCE Technical Council on Lifeline Earthquake Engineering (TCLEE), and as a mentor for the NSF-funded "Enabling the Next Generation of Hazards and Disaster Researchers" program.

Project Description/Objective

Post-earthquake fires
in the March 2011 Japan earthquake and tsunami
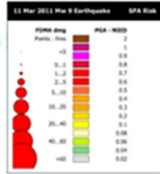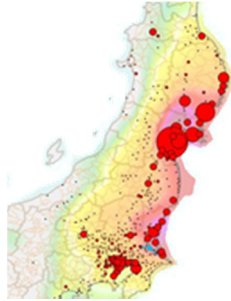
PI: Rachel Davidson, U. Delaware
Consultant: Charles Scawthorn, U. Calif. Berkeley and Waseda U. (Tokyo)
Intl. Counterparts: A. Sekizawa (Tokyo Univ. of Science), M. Hamada, Waseda U.

Objectives

• Collect perishable data on ignitions and fire spread / compile into a database
• Analysis for new statistical ignition model including tsunamigenic ignitions

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Key Findings

1. Nearly 300 post-earthquake ignitions, more than in all previous earthquakes.

2. About half of all fires are tsunami-related, rather than due to shaking. Fires have been seen in previous tsunamis, but the number of fires in this event, and their mechanism of spread via flaming liquids (primarily oil) floating on the incoming tsunami, may have grave implications for a possible event in Tokyo Bay, Los Angeles or the Pacific Northwest.

Opportunities for Future Research

New questions: Two questions emerge, one new and one old:

- Tsunamigenic fires – there were many here – how important are they for the US?

- Fire following earthquake in general – whether it is relevant to modern construction is a controversial issue – has this event contributed to resolving this question?

New data: there are more fires in this event than in all previous events combined. The dataset that will result will be vitally important data for assessing and mitigating this problem.

Focused research program: fire following earthquake is a significant problem for the US that has long been largely ignored. A research program focused on this problem is needed, with projects related to ignition, spread, water supply, post-earthquake firefighting and decision-making, and mitigation via a wide variety of currently unrealized opportunities.

Important lessons for US: this event confirms that fires following earthquake, and following tsunami, are potentially disastrous for the San Francisco Bay Area, Los Angeles region and the Pacific Northwest.

RAPID: Field Investigation on Post-Disaster Humanitarian Logistic Practices under Cascading Disasters and a Persistent Threat: The Tohoku Earthquake Disasters

Program Manager: Dennis Wenger
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s): Jose Holguin-Veras (Principal Investigator)

Sponsor: Rensselaer Polytechnic Institute
110 8TH ST
Troy, NY 12180 518/276-6000

NSF Program(s): COLLABORATIVE RESEARCH,
INFRAST MGMT & EXTREME EVENTS,
SPECIAL STUDIES AND ANALYSES

ABSTRACT:

Objectives: The Tohoku disaster(s) is an event almost without parallels in disaster history. Four specific features make it a very unique disaster: severity and pervasiveness of the trigger and cascading disasters, geographic coverage, and persistence over time of the nuclear threat. As a result of these factors the disaster and its response offer important lessons of benefit to future relief operations. In this context, the main objectives of the project are: (1) to study the impacts on the humanitarian logistic response produced by the cascading disasters that impacted Tohoku; (2) to study how the post-disaster humanitarian logistic (PD-HL) system responded to the disasters; (3) to study how the persistent nuclear threat impacted the overall PD-HL effort; (4) to identify a preliminary topology and features of the various PD-HL structures that emerged in the response; (5) to gather insight into their level of effectiveness, positive and negative characteristics, manpower provided, coverage and extent of their operations; (5) to gather data about the flows of critical / non-critical supplies, and their dynamic patterns over time; (6) to gather data about the impact of preexisting conditions on post-disaster relief capacity; and, (7) to document lessons learned, both positive and negative.

Intellectual merit and broader impacts: The research to be conducted is important to the nascent field of PD-HL and disaster research because it will provide much needed evidence-based insight into actual/emerging PD-HL practices, and lessons both positive and negative that could benefit future relief operations. In this context, it is important to highlight that the realities of PD-HL response are not well understood by the disaster research community at large. This is because of: (1) the relatively low occurrence of disasters; (2) the extremely small size of the professional and research PD-HL communities; and (3) the ephemeral nature of the data. The project will provide the first systemic characterization of the PD-HL process that emerged after cascading disasters with a persistent nuclear threat. The findings produced by such characterization would: (1) enhance theoretical understandings of organizations and organizing in disaster environments; and (2) set the stage for advanced modeling of these approaches. The research will: (1) promote multidisciplinary collaboration on humanitarian logistics research; (2) integrate students to a multidisciplinary and international research process, with a

particular emphasis on underrepresented students; (3) generate findings that will be integrated into disaster and logistics courses; (4) generate findings with applied benefits that will be broadly disseminated to organizations engaged in humanitarian logistics, including stakeholders in Japan.

Jose Holguin-Veras

Professor
Department of Civil and Environmental Engineering
Rensselaer Polytechnic Institute

jhv@rpi.edu
Phone: 518-276-6221
Fax: 518-276-4833
http://homepages.rpi.edu/~holguj2/

Education:
- Ph.D. in Transportation, University of Texas at Austin
- M.S. in Transportation, Universidad Central de Venezuala
- B.S. in Civil Engineering, Universidad Autonoma de Santo Domingo

Research Interests:
- Decision Support Systems
- Operations Research
- Transportation

Biography:
Professor Holguin-Veras's research emphasizes: the integration of state of the art economic principles into transportation modeling, so that a complete picture could be developed on the broader impacts of transportation activity on the economy and the environment; and the study of the behavior of the participating agents to support sustainable policies. His work includes a broad spectrum of research tracks ranging from: basic research on transportation modeling, research on the behavioral responses of agents to pricing and other sustainable policies, research on simplified modeling techniques, i.e., to estimate demand using secondary data. The latter techniques are bound to benefit developing countries because they minimize the need for expensive data collection efforts.

His leadership positions at key international research organizations include: Vice-President for Logistics of the Pan-American Conferences of Traffic and Transportation Engineering, Elected Member of the Council for the Association for European Transport, member of the International Organizing Committee of the City Logistics Conferences, member of three Technical Committees and invitational Task Forces on freight modeling at the Transportation Research Board. He is member of a number of editorial boards, Review Chair for freight transportation at the Transportation Research Board, and Transportation Editor at Networks and Spatial Economics.

Holguin-Veras is the author of dozens of articles on transportation modeling and economics.

Project Description/Objective

- RAPID: "Field Investigation on Post-Disaster Humanitarian Logistic Practices under Cascading Disasters and a Persistent Threat: The Tohoku Earthquake Disasters"

- Team Leaders: José Holguín-Veras (Rensselaer Polytechnic Institute) and Eiichi Taniguchi (Kyoto University)

- Objectives:
  - To identify lessons learned both positive and negative
  - To assess the impacts of the cascading disasters
  - To assess the impacts of the persistent nuclear threat
  - To identify policy changes to improve disaster response efforts

Key Findings

- Consider and prepare for worst case scenarios
  - Response for <u>Catastrophes</u> are significantly more complex than the ones for <u>Disasters</u>
  - Prepare for <u>local distribution</u> of relief supplies
  - Conduct training and realistic exercises on logistics
- Need to engage private sector, contrasting examples:
  - Construction: Played a key role; Had specific agreements in place; Knew what they were supposed to do; Brought to bear expertise/assets
  - Transportation: Helped as volunteers; Participation was improvised, unanticipated, not sought after…and even refused because of lack of fuel for return trips; Had general agreements but not for specific local distribution, Did not know what they were expected to do; Brought resources/assets, not clear who was in charge; Had major difficulties transitioning out…

Opportunities for Future Research

- What new questions raised by these events require basic research?
  - The differential scalability of constructions and logistical operations, construction operations scaled up well, logistics did not
  - How best to integrate social and technological aspects
- What new data are available as a result of these events?
  - Enhanced insight of the differences between Disasters / Catastrophes
  - Enhanced understanding of post-disaster logistic operations
- What unique aspects of these events require the development of a focused research program?
  - Diagnosis and characterization of actual disaster response (logistical) operations, needed to identify lessons learned on a systematic basis
  - Foster researcher/practitioner/disaster relief agency cooperation
- What are the important lessons from these larger than expected events for the U.S.?
  - Catastrophes and Disasters require qualitatively different responses
  - The importance of preparing for catastrophic events
  - The importance of planning for local distribution (the most difficult part)

Johnston - GNS Science - Social Sciences in New Zealand

Research is focused around a number of key questions, such as:

- What are the consequences of the earthquake on individuals, communities and organisations, over varying timeframes?

- What are the societal factors that influence community resilience to the impacts of an earthquake?

- What are the trends and emerging issues in Canterbury that influence vulnerability to and recovery from the earthquake?

- How effective are (were) emergency management procedures, and crisis management practices for managing societal response to earthquake?

Major Findings

1. Location and time of the day a key influence on the nature of impacts
2. Risk judgments are often affected by two factors: experience of a particular hazard and optimistic biases
3. Complex interrelated issues shape the recovery and recovery process
4. Cumulative impacts of on-going aftershocks

Opportunities for Future Research

- So very many!!!!!

- The Canterbury earthquakes, with its widespread social and economic impacts, provides a unique opportunity to explore the complex factors that shape the recovery process.

RAPID: Immediate Behavioral Response to Earthquakes in New Zealand and Japan

Program Manager: Dennis Wenger
CMMI Division of Civil, Mechanical, and Manufacturing Innovation
ENG Directorate for Engineering

Investigator(s): Michael Lindell (Principal Investigator)
Carla Prater (Co-Principal Investigator)

Sponsor: Texas A&M Research Foundation
400 Harvey Mitchell Parkway, S
College Station, TX 77845 979/845-8600

NSF Program(s): COLLABORATIVE RESEARCH,
INFRAST MGMT & EXTREME EVENTS,
SPECIAL STUDIES AND ANALYSES

ABSTRACT:
A substantial portion of the US population at risk from earthquakes lives and works in structures that are likely to experience partial or complete collapse in the event of a major earthquake. There is no technology available that provides forewarning of local earthquakes, so people's immediate response to earthquake shaking is very likely to determine whether they survive the event. Unfortunately, the research literature on people's immediate response to earthquake shaking is quite small in comparison to the literature on responses to tornadoes or hurricanes or even the literature on pre-impact seismic hazard adjustments. In part, this is because major earthquakes are rare events in the US so there are few opportunities to study them. This makes it especially important to collaborate with researchers in New Zealand and Japan to examine their residents' immediate responses to the recent earthquakes in Christchurch and Tohoku.

The proposed project will send questionnaires to 1200 residents in areas stricken by the Christchurch and Tohoku earthquakes. Using our standard mail survey procedures, we expect to get a response rate in the range of 30-50%. This project will extend the American investigators' recent research on the earthquake and tsunami in American Samoa by documenting people's behavioral response during the earthquake shaking and all of the actions they took during the next half hour after the shaking stopped. In addition, we will collect data and conduct analyses of the effects of physical context (e.g., location in open spaces, vehicles, and buildings of various types) and social context (e.g., alone, with children, with known adults, or with adult strangers), previous earthquake experience (e.g., damage or casualties), hazard education (e.g., meetings or brochures), and household emergency preparedness (e.g., emergency plan, emergency kit, battery radio) on people's behavioral responses. A major contribution of this study will be to assess the effects of people's immediate emotional reactions on their behavioral responses. Although people's emotional reactions are likely to have a significant effect on their behavior, this class of variables has been almost completely ignored in previous research on earthquake response and has been studied inadequately even in the few cases when it has been addressed.

Michael K. Lindell

Professor
Department of Landscape Architecture and Urban Planning
Texas A&M University

mlindell@arch.tamu.edu
Phone: (979) 862-3969
http://archone.tamu.edu/laup/people/Faculty/faculty_profile/Lindell.html

Education:
- Graduate degree in Social Psychology with a specialty in disaster research

Biography:
Dr. Lindell has over 35 years of experience in the field of emergency management, during which he has conducted a long term program of research on the processes by which individuals and organizations respond to natural and technological hazards. Research and related technical services have been provided to 40 different organizations in the public and private sectors. Professor Lindell has made over 170 presentations before scientific societies and short courses for emergency planners, as well as being an invited participant in workshops on risk communication and emergency management in this country and abroad. He organized and chaired an American Society of Civil Engineers Specialty Conference on Hazardous Facilities, served on the ASCE Task Committee on Natural Disaster Reduction, and served twice as Secretary of the Executive Committee of the ASCE Council on Natural Disaster Reduction.

He participated in the NSF's Second Assessment of Research and Applications on Natural Hazards, serving as a member of the committee on Preparedness and Response, and chairing the committee on Adoption, Implementation, and Evaluation of Hazard Adjustments. He has served seven times as a consultant to the International Atomic Energy Agency in developing planning guidance for response to nuclear and radiological incidents, has made four presentations to National Academy of Sciences panels, and was a member of two National Research Council panels— *Disasters Research in Social Sciences Assessing Vulnerabilities Related to the Nation's Chemical Infrastructure.* He recently served as an external reviewer for the National Oceanographic and Atmospheric Administration's *National Tsunami Hazard Mitigation Program* and the U.S. Department of Homeland Security's Center for *Studies of Terrorism and Responses to Terrorism,* currently is a member of the National Earthquake Hazard Reduction *Program's Advisory Committee on Earthquake Hazard Reduction.*

Professor Lindell has also reviewed research proposals for 20 different foreign, federal, and state agencies as well as performing manuscript reviews for over 40 different journals in the social and environmental sciences and engineering. He has written extensively on emergency management and is the author of 70 technical reports, 90 journal articles and book chapters, and ten books. He recently published a book on risk communication in multiethnic communities (Sage, 2004) and a textbook on community emergency planning (Wiley, 2006). He recently completed an introductory textbook on emergency management under contract to the Federal Emergency Management Agency, a condensed version of which has been published by Wiley. Professor Lindell is a former director of the Hazard Reduction & Recovery Center and the current editor of the *International Journal of Mass Emergencies and Disasters.*

Project Description/Objective

- Immediate Behavioral Response to Earthquakes in New Zealand and Japan
- Investigators
  - Michael K. Lindell & Carla S. Prater Texas A&M Hazard Reduction & Recovery Center
  - David Johnston & Julia Becker GNS Science (New Zealand)
  - Hideyuki Shiroshita Kansai University (Japan)
- Objective: To achieve a better understanding of people's immediate emotional and behavioral responses during earthquakes.

Key Findings

Key findings
- Only a minority of the respondents engaged in the recommended protective action—drop, cover and hold.
- Demographic, contextual, and emotional variables, as well as situational perceptions are related to people's immediate responses to earthquake shaking, but the magnitudes of the correlations are small, so further research is needed to better explain why so many people took inappropriate actions and to develop programs that guide them to taking appropriate protective actions.

Opportunities for Future Research

- What new questions raised by these events require basic research? *The nonsignificant correlations of prior earthquake training indicate that research is needed to better understand the transfer of training to actual practice.*

- What unique aspects of these events require the development of a focused research program? *There is a need to systematically assess earthquake hazard awareness programs in terms of reaction, learning, behavior, and outcome criteria.*

- What are the important lessons from these larger than expected events for the U.S.? *California residents might engage in similarly modest levels of recommended responses but other areas of the US are likely to exhibit even lower levels of adaptive behavior.*

RAPID: Disasters, Resilience, and Vulnerability of Fishing Communities in Post-Tsunami Japan

Program Manager:	Deborah Winslow
	BCS Division of Behavioral and Cognitive Sciences
	SBE Directorate for Social, Behavioral & Economic Sciences
Investigator(s):	Bonnie McCay (Principal Investigator)
	Satsuki Takahashi (Co-Principal Investigator)
Sponsor:	Rutgers University New Brunswick
	3 RUTGERS PLAZA
	NEW BRUNSWICK, NJ 08901 848/932-0150
NSF Program(s):	CULTURAL ANTHROPOLOGY

ABSTRACT:

Dr. Bonnie J McKay (Rutgers University) and Dr. Satsuki Takahashi (Institute of Social Science, University of Tokyo) will undertake joint research on the rebuilding efforts in Japanese coastal fishing towns damaged by the recent earthquake, tsunami, and nuclear power crisis. The focus of the research will be on how combined natural and human disasters affect community responses. Previous research on the relationships between disasters, vulnerability, and resilience have led in different directions, depending on whether the disasters are understood as caused by human or natural agency. In these accounts, natural disasters encourage communities to work together to develop better systems in the future, while human-made problems, such as air and water pollution, disproportionally affect vulnerable communities and limit their ability to rebuild. Building upon and contributing to social scientific theories on resilience, vulnerability, and nature-culture relationships, this project will investigate the cultural and political outcomes of dual (natural and human-caused) disasters. The research will comprise historical and ethnographic fieldwork, including archival research, open-ended and semi-structured interviews, and participant observation, in two Japanese fishing towns for which the researchers have baseline data.

This research is being supported through NSF's Rapid Response Research (RAPID) program, which is used for projects having severe urgency with regard to availability of or access to data, facilities or specialized equipment, including quick-response research on natural or anthropogenic disasters and similar unanticipated events. By addressing the responses in coastal Japan over five months shortly after the disaster, with follow-up research several months later, this project will be sensitive to any changes that may occur as time passes. It will investigate early and middle-term responses to the extraordinary disaster as a way to shed light on the complex relationships among "natural" and "human" hazards, resilience, and vulnerability, offering important lessons for researchers and policymakers.

Bonnie McCay
Note: She will not be attending.

Board of Governors Distinguished Service Professor, Rutgers, The State University of New Jersey

mccay@aesop.rutgers.edu
http://humeco.rutgers.edu/facultypages/mccaybio.html

Education:
- Valparaiso University, Indiana 1959-60
- University of California, Berkeley 1960-62
- Portland State University, B.A. (Anthropology) 1967-69
- Columbia University, 1969-76
- M.Phil (Anthropology) 1971
- Ph.D (Anthropology) 1976

Biography:
Bonnie McCay is Board of Governors Distinguished Service Professor at Rutgers University, New Brunswick, in the Department of Human Ecology of the School of Environmental and Biological Sciences. Her graduate training was in environmental anthropology at Columbia University (PhD 1976), and her research and teaching have focused on challenges and policies for managing common pool resources such as fish and shellfish, with particular attention to intersections of ecology, community, and social institutions of science, law and property. She has done field research in Newfoundland and Nova Scotia, Canada, in the Middle Atlantic region of the U.S., and in Baja California, Mexico, with funding from the U.S. National Science Foundation, the Sea Grant College Program, and the New Jersey Agricultural Experiment Station.

Her books include "The Question of the Commons," "Oyster Wars and the Public Trust," and "Enclosing the Commons." She currently serves on numerous editorial boards and on the Scientific and Statistical Committee of the Mid-Atlantic Fisheries Management Council. Her graduate teaching and mentoring is within the Anthropology, Geography, and Ecology & Evolution programs at Rutgers University.

Current Research
As a human ecologist, her project is on the many dimensions of human adaptations and mal-adaptations to changes in their environments. Although her theoretical approaches and interests are very broad, her own research, grounded in the methods of cultural anthropology, has focused on marine and coastal ecosystems and communities and the institutional aspects of adapting to and managing commercial fisheries.
- **Systems and Processes in Fishery-Dependent Communities**
- **Coupled Natural and Human Systems and Climate Change**
- **Property Rights, Community, and Ecology**

Tide Us Over: Disasters, Resilience, and Vulnerability of Fishing Communities in Post-Tsunami Japan

Bonnie J. McCay, Rutgers University (PI)

Satsuki Takahashi, University of Tokyo (Co-PI)

Outline

- **Research Questions**

    "Natural" and "Human" Disasters

    3.11 Disaster: quake, tsunami, and nuclear accident

    —How do people respond to challenges caused by both natural and human disasters?

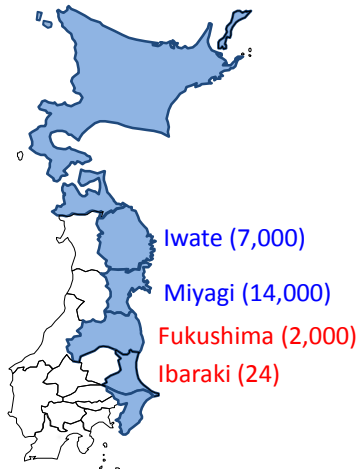   —How do concepts of "natural" and "human" matter for ways in which people respond to a disaster?

- **Research Methods**

    Interviews; Participant observation; archival research

- **Findings (so far)**

- **Remaining questions**

"Twofold" and "Fourfold" disaster

Iwate (7,000)

Miyagi (14,000)

Fukushima (2,000)

Ibaraki (24)

- Iwate and Miyagi Pref.
  Natural disaster
  Quake and Tsunami
  ("Twofold" Disaster)
- Fukushima & Ibaraki Pref.
  Natural/*Human* disaster
  Quake, Tsunami, Radiation
      Contamination, and
      Reputational Damage
  ("Fourfold" Disaster)

Remaining questions

- How will "radiation contamination" and "reputational damage" look after another month, 6 months, or a year?
- How will fishing families experience and deal with developing uncertainty and anxieties?

Award Abstract # 1138901

RAPID: When Online is Off: Communicating in Disaster Following the February 22, 2011 Christchurch, NZ Earthquake

Program Manager:	Susan Fussell IIS Division of Information & Intelligent Systems CSE Directorate for Computer & Information Science & Engineering
Investigator(s):	Jeannette Sutton (Principal Investigator)
Sponsor:	University of Colorado at Colorado Springs 1420, Austin Bluffs Parkway Colorado Springs, CO 80918 719/255-3153
NSF Program(s):	HUMAN-CENTERED COMPUTING, INFORMATION TECHNOLOGY RESEARCH

ABSTRACT:

The February 22, 2011 earthquake in Christchurch New Zealand, an aftershock of a larger earthquake in September 2010, caused significant infrastructure and economic damage, and life loss, to a modern city with similar population characteristics as US metropolitan communities. In the days and weeks following the earthquake, various risk communication strategies were utilized to reach individuals affected by the ongoing aftershocks, including online networked communications. By collecting data on access to and use of online information in this critical period following the earthquake, this project will advance knowledge about information and communication capacities as they affect coping and resiliency in the aftermath of disaster. Specifically, the project examines the effects of reliance on online communications on individual coping ability and community recovery, and on the role of networked online communication among those directly affected by disaster. These questions will be examined through a series of focus groups and a household survey in the disaster-affected area.

Intellectual Merit:

This research will address key questions about information access in disaster; the effectiveness of crisis communications using networked online technology; and links between information access and resiliency among disaster-affected populations. It will make substantial contributions to the literature on "crisis informatics" due to the fact that this study will include a representative sample of a disaster affected community rather than just technology users who are utilizing social media. It will also contribute knowledge to the effects of information access on perceptions of community resiliency, in a metropolitan area, linked to shifting communication capacities in disaster.

Broader Impacts:

The project will address the effect of networked communications, and its absence, on coping post disaster and has the potential to inform policy at the local, state, and national levels and to improve resiliency in U.S. communities. Outcomes from this project will include written reports, peer-reviewed articles, and presentations to a number of audiences including the U.S. Natural Hazards Workshop. This research will also provide support for one researcher from an underrepresented STEM group.

Jeannette N. Sutton, Ph.D.

Senior Research Scientist
University of Colorado at Colorado Springs

Special Term Appointee
Argonne National Lab, Decision and Information Sciences

jsutton2@uccs.edu / suttonj@colorado.edu
Phone: 719.255.4128
http://www.uccs.edu/~thhc/sutton.html

Education:
- Ph.D. in Sociology at University of Colorado, Boulder, CO
  Dissertation: Constructing Vulnerability: Legitimating Therapeutic Religion in the World Trade Center Disaster
  Committee: Dennis Mileti (Chair), Kathleen Tierney, Ann Janette Rosga, Joyce Nielsen, John Sorensen
- Master of Divinity from Princeton Theological Seminary, Princeton, NJ
- BA in Sociology/Education at Seattle Pacific University, Seattle, WA

Research Interests:
- Qualitative Research Methods
- Social Problems
- Environmental Sociology
- Hazards and Disasters, Risk Communication, Social Construction of Risk, Social Media

Recent Research Projects:

Dr. Sutton is a disaster sociologist, specializing in research on the users of social media in crises and disasters. Jeannette's research is helping to transform the way that emergency managers understand public communication during disasters, create strategies to improve warning systems, and engage the public in times of crisis.

Dr. Sutton is currently working on the following projects: RAPID, HA/DRTech, HEROIC, and DRRC.

Project Objectives

When Online is Off: Public Communications Following the February 2011 Christchurch, NZ Earthquake.
In collaboration with GNS Science and Massey University.
Co-Investigator, Dr. David Johnston

1. Investigates the strategies used by local government to communicate electronically with disaster affected individuals,
2. Individual access to information in the immediate aftermath of the earthquake
3. Effects of information access on individual perceptions of community resiliency.

Major Findings

1. Public officials had no strategies in place to communicate via social media; no plans to coordinate with digital volunteers
2. The public who were directly affected searched for information across multiple sources; established their own information flow; found local information most useful.
3. Digital volunteers sought out and curated open data onto locally relevant maps

Opportunities for Future Research

- Trust and trustworthiness through digital media post disaster
- Digital volunteerism: emergence, leadership, resiliency
- Disaster coordination networks and integration of digital volunteers into official communications efforts