Thrust Area: Lifelines

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MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
MCEER LIFELINES VISION AND MISSION

- Improve substantially the seismic resilience of lifeline systems
- Develop, implement, and demonstrate the next generation lifeline system
- Set future standards with a state-of-the-art decision support process for integrated lifeline management
YEAR 8 RESEARCH INTEGRATION:
WATER SUPPLY LIFELINES (1)

- Development/Validation of Hydraulic Network Model for Damaged Systems
  (O’Rourke, LADWP, ABS)

- Development of Seismic Hazard Assessment for LADWP Lifelines
  (O’Rourke, Shinozuka, URS, LADWP)

- Guidelines on EQ Hydraulic Network Modeling (O’Rourke, LADWP)
  - Characterization Process
  - Degree of Detail Vs Simplification
  - Example Applications
YEAR 8 RESEARCH INTEGRATION: WATER SUPPLY LIFELINES (2)

- Advanced Web-Based GIS (O’Rourke & Lembo)
- Fragility Curves & Loss Estimation Algorithms (M. Grigoriu) & System Restoration Models (R. Davidson)
- Performance Objectives & Community Resilience (S. Chang) & Regional Economic Impact Models (A. Rose)
- Operation of Decision Support System with LADWP Engineers & Managers (All)
YEAR 8 ACCOMPLISHMENTS
(THRUST 1 WATER)

- MCEER/ LADWP Workshop: Utility Performance Objectives, May 2004 (LADWP & MCEER)
- Meetings/ Presentation LA Fire Department, July 2004 (O’Rourke)
- 13 WCEE Keynote Address/ Paper: Advances in Lifeline Earthquake Engineering (O’Rourke)
Expands Previous Work on welded slip joint steel
Cover jointed concrete and riveted steel pipelines
Collaboration with 4 water agencies
Improved regressions
Simplified model and numerical simulations for jointed concrete pipelines
SEISMIC HAZARD ASSESSMENT FOR LADWP

- Jointly Developed by MCEER, URS, & LADWP
- LADWP Provides Full Financial Support
- General Methodology for Lifeline Systems
- Combined Water & Electric
YEAR 8 ACCOMPLISHMENTS
(O’ROURKE ET AL.)

- Development/Validation of Hydraulic Network Model for Damaged Systems
- Upgrade of Hydraulic Network Model and Linkage to LADWP
- Validation of Model with Respect to Northridge EQ
EARTHQUAKE HYDRAULIC NETWORK MODEL

- Any Hydraulic Damage State
- EPANet Hydraulic Engine
- Customized for LADWP Model
- Rational Models for Leakage
- Improved Break Simulation
- Open Source Code
- Monte Carlo Simulations
LADWP SYSTEM

LADWP MODEL

GIRAFFE
Graphical Iterative Response Analysis of Flow Following Earthquakes

GIS

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH
Increasing Complexity

FUNDAMENTAL STUDY OF THE MODELING PROCESS
VALIDATION OF EQ HYDRAULIC NETWORK MODEL & WATER/ELECTRIC INTERACTION
YEAR 8 ACCOMPLISHMENTS: FRAGILITY CURVES & LOSS ESTIMATION (GRIGORIU)

- Methodology to obtain seismic activity matrices for various sites across United States.
- Monte Carlo algorithm to produce samples of seismic hazard scenarios.
- Methodology to produce samples of spatially correlated ground motions.
- Monte Carlo algorithm to estimate components fragility.
- Preliminary method to obtain fragility of water supply systems.
YEARS 8 ACCOMPLISHMENTS:
SERVICE RESTORATION MODELING
(DAVI DSON)

- Validated Post-EQ Restoration Model for Electric Power
- Applied Model to LADWP Electric
  - Power Rapidity Risk
  - Repair Resource Adequacy
  - Effectiveness of Mitigation Measures
- Initial Application to LADWP Water
- Initial Resource Optimization for Electric Power
YEAR 8 ACCOMPLISHMENTS:
PERFORMANCE OBJECTIVES & COMMUNITY RESILIENCE (CHANG)

- Interviews with 24 Lifeline Experts to Expand on Workshop & Develop Metrics
- Social Resilience Assessed by Modeling Emergency Shelter Populations and Hospital Services
- Incorporating Electric Power Restoration Models into Resilience Assessment
YEAR 8 ACCOMPLISHMENTS:
REGIONAL ECONOMIC IMPACT MODELS (ROSE)

- Models for Household Response to Utility Outage
- Updated CGE Model for LA Region
- GIS/Visualization Tools for LA CGE
- Meetings/Discussions with LADWP Staff
- Application to LA Water Supply
YEAR 9 VISION

- MCEER Decision Support System Implemented/Tested by LADWP with Full Integration of Seismic Hazard Assessment, Advanced Hydraulic Network Modeling, System Reliability, Advanced Web-based GIS, and Modeling of Social Resilience & Regional Economic Impact

- Advanced Sensor and Self-Organizing Network Technology for Chemical & Contaminant Detection
<table>
<thead>
<tr>
<th>Task Title</th>
<th>Main Objectives</th>
</tr>
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<tbody>
<tr>
<td>Comprehensive Model for Integrated Water &amp; Electric Power <em>(O’Rourke, et al.)</em></td>
<td>LADWP Implementation of Model and Decision Support System</td>
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<td>Fragility Curves/Loss Estimation For Water Systems <em>(Grigoriu)</em></td>
<td>Refined Models Proofed and Accepted by LADWP and MCEER Researchers</td>
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<td>Water System Restoration &amp; Optimal Response to Fire <em>(Davidson)</em></td>
<td>System Restoration Models Validated for Water Supply &amp; Agent Based Modeling Applied to Fire Following Earthquakes</td>
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<td>Regional Economic Impacts of Earthquakes and Extreme Events <em>(Rose)</em></td>
<td>Application of CGE Models to LADWP Water/Power and Extension of Modeling to Extreme Events</td>
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<td>Modeling Community Resilience &amp; Application of Performance Objectives <em>(Chang)</em></td>
<td>Implement Lifelines Resilience Models and Performance Objectives</td>
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<td>Advanced Web-Based GIS <em>(Lembo &amp; O’Rourke)</em></td>
<td>Demonstration for Rapid Response to EQs in LA and Human Threats in NYC</td>
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BIOSENSOR NETWORKS

- Cornell/ Wadsworth Center ITR
- Adaptive, Self-Configuring Sensor Networks
- Wadsworth Center: NYS Public Labs, Biotech & Biodefense Centers, 1050 employees, $120M/ yr
- Biosensors for Contaminant/ Pathogen Detection in Water Supplies
SENSORS: Numerous, Cheap, and Small

- Large numbers of small, low power sensors distributed (randomly) across coverage area
- Exploit redundancy
- Adaptive link and networking technologies
- Distributed processing, reporting tools
AMPOMERI C BIOSENSOR

Ion Gate

Biosensor

Lipid Blayer (6-10 nm thick)

Hydrogel

Electrode

100 µm
Area = 100 µm x 100 µm
RESEARCH TEAMS: CORNELL NSF ITR

- “Self-Configuring Sensor Networks for Disaster Mitigation and Recovery”
- Goal: Self-configuring, rapidly-deployed networks of bio-sensors
- Team includes electrical engineers, game theorists, molecular biologists, and civil engineers
- Multi-layer approach
  - sensor development tied to network design
  - network design tied to specific applications involving urban critical infrastructure
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MCEER LIFELINES TIME LINE

YEAR 5          6           7            8             9        YEAR 5          6           7            8             9        10

STRATEGIC GOALS

CENTER-WISE MEASURES OF RESILIENCE

• SYSTEM SIMULATION
• LARGE SCALE EXPERIMENTS
• SOCIAL/ECON. IMPACTS

INTEGRATED ELECTRIC & WATER SYSTEM RELIABILITY

• ROBUSTNESS
• SYSTEM PERFORMANCE
• IMPROVED TRANSFORMERS
• FRAGILITY CURVES
• COMMON GIS
• LADWP AGREEMENT & TRAINING
• HYDRAULIC NETWORK MODEL
• TECHNOLOGY SPECS & IMPLEMENTATION

INTEGRATED TECHNICAL & SOCIAL SYSTEMS

• POWER SYSTEM ADV. TECHNOLOGY & FRAGILITY CURVES
• SYSTEM SIMULATION
• ECONOMIC & SOCIAL IMPACT
• RESTORATION MODELS
• RESILIENCE MODEL FOR WATER & POWER
• DECISION SUPPORT SYSTEM & TECHNOLOGY SPECS & IMPLEMENTATION

INTEGRATED LIFELINE, HOSPITAL, & EMERGENCY RESPONSE

• RESILIENCE MODEL & CRITERIA FOR WATER, POWER, HOSPITALS, AND TRANSPORTATION
• EMERGENCY RESPONSE

DECISION SUPPORT SYSTEM & PROCESS

• SEISMIC RESILIENCE OF COMMUNITIES
• DEMONSTRATION & VALIDATION OF DECISION SUPPORT PROCESS

ELECTRIC POWER

• SYSTEM SIMULATION
• LARGE SCALE EXPERIMENTS
• SOCIAL/ECON. IMPACTS

WATER SUPPLY

• GIS VISUALIZATION
• LARGE SCALE EXPERIMENTS
• SYSTEM SIMULATION

LADWP TESTBED

PROOF OF ADVANCED TECHNOLOGIES

TECHNOLOGY SPECS & IMPLEMENTATION

MNGT. USE OF SYSTEM RELIABILITY MODEL & FEEDBACK TO MCEER

JOINT DECISION AMONG MNGT., TECHNICAL & SOCIAL RESEARCHERS

VALIDATION OF DECISION SUPPORT PROCESS