

**Urban Crisis Response Center
(UCREC)
“Responding to the Unexpected”**

**Sharad Mehrotra
School of Information and Computer Science
University of California, Irvine**

Talk Overview

- **Brief Overview of our goals**
- **path to funding**
- **Research Plans for UCREC**

The Crisis

- **Man made (usually localized to a single region)**
 - Terrorist attacks
 - Accidents
 - Nuclear, biological, chemical, oil spills
- **Mother nature (region wide disasters)**
 - Earthquakes, hurricanes, floods, landslides, ...
- **Unexpected**
 - Specially man made disasters.
 - Each crisis is different.

Two Aspects of Crisis Management

- **Prevention, early warning, detection**
 - detect and mitigate crises before they happen
 - e.g., predicting terrorist attacks, surveillance, epidemic outbreak
- **Crisis Response**
 - **Short-term goal**
 - Save lives, Reduce suffering, Save property
 - limit/contain impact
 - prevent cascades of crises
 - **long term**
 - Bring society and infrastructure back to its pre-crisis state.

Abstraction of an Iterative Crisis Response Process



- **Phases of Response**
 - **Damage Assessment**
 - Quantify damage at site/regional scale
 - Identify severely impacted regions, disrupted lifelines, etc.
 - **Response Need Identification**
 - Who needs what resources.
 - **Response Prioritization**
 - Hard choices given limited resources
 - **Implementation and logistics**
 - Plan optimization, plan monitoring,
- **Information Driven Iterative process**
 - Better more informed decisions as new information arrives into system
 - technologies to gather, analyze, share, and disseminate information facilitate can accelerate:
 - transition between phases
 - convergence to optimal decisions

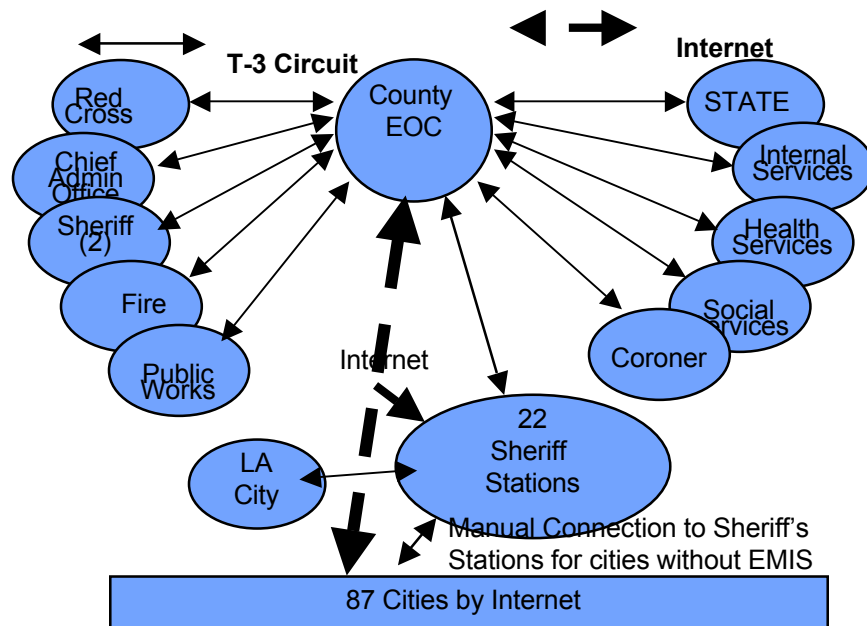
UCREC Goals

- To reduce response latency and prevent cascades of crisis by radically transforming the ability of responding organizations to **gather, analyze, manage, share** and **disseminate information** both within emergency response networks and to the general public
- Focus Area:
 - Technologies to seamlessly integrate human input with other sensory data, video for real-time and accurate situational assessment
 - conversations among first-responders
 - Eye witness accounts

The Response Environment

- A massive, multi-organization operation requiring collaboration in space and time under duress, extreme urgency, and confusion
- Many layers of government
 - **Federal:** FEMA, over 50 federal agencies, FBI, CDC, national guard, army, ..
 - **State:** Governor's Office of Emergency Services (OES), highway patrol, ...
 - **County:** county EOC, police, fire personnel, ...
 - **City:** city emergency offices, police, firefighters, ...
- Voluntary Organizations
 - Red cross
- Industry
 - Gas, electric utilities, telecommunication companies, hospitals, transportation companies, media companies

LA County EOC (Constance Perret, LA County)



Coroer

The Path to Funding

Building the Team

- **As a reaction to the 9/11 tragedy, many of us wondered:**
 - **Could IT research have helped in either prevention and/or mitigation?**
- **Grass root efforts started at both UCI and UCSD (Nov 2001)**
 - **participated in the national debate:**
 - **NSF workshops, DARPA workshops, homeland security forums**
 - **engaged with the local first-responder community to:**
 - **identify IT solutions that are currently being used?**
 - **How crisis response differs from armed forces command and control?**
 - **What are the technology wish lists of the responding organizations?**
 - **Lessons learnt from 9/11 -- what went right/what went wrong?**
 - **Visited with representatives from**
 - **the City of Irvine, city of LA, San Diego regional network of homeland security, city of San Diego, County of LA, state of California**
 - **Enlisted these organizations as partners in research**
 - **Ron Eguchi's (CEO, ImageCat) contacts within these organization was the key to establishing the collaboration**

LA County Emergency Command Center



CAL-IT2 Crisis Response Workshop (March 19th, 2002) @ UCI

- Brought researchers from government, academia, and industry together to discuss technology gaps in homeland defense
- About 75 attendees
 - various levels of government: FEMA, State, County of LA, city of LA, city of Irvine, Army, Navy
 - local industry: Raytheon, Cox, Conexant, ImageCat, Rockwell, Praja
 - Academia: UCI, UCSD, UCLA, USC, Riverside, Cal State Fullerton
- A day long meeting with break out sessions, panel discussions, plenary talks
- Helped in...
 - building a team for the ITR proposal submission
 - fostering collaboration with industry and government



Cal-(IT)² Homeland Security Experiments During Super Bowl 2003



Vehicle detection software running on Seaport Village video feed



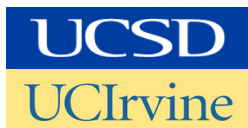
Crane deploys cameras across from QUALCOMM Stadium



Super Bowl XXXVII sign from Seaport Village Command Center



UCSD Triton sign on top of crane across from QUALCOMM Stadium



**UCSD Worked Closely
with SD Police (Bill Maheu)**



Lessons Learnt from Govt. Agencies

- The complexity, scale, and dynamic nature of the problem
- Two fundamental challenges
 - response latency: a response delayed is response denied
 - Prevention of cascades
 - Earthquake may cause hazardous material release resulting in catastrophes of unknown proportions
 - Terrorists may exploit system vulnerability to create panic and escalate the situation.
- IT solutions can help
 - access to the right information at the right time by the right people/organization can result in more informed decisions leading to more effective response
- BUT
 - to be useful IT solutions must be designed to:
 - be non-intrusive
 - not impede first-responders from their primary tasks
 - work effectively in partially failed/failure prone environments

Cal-(IT)²'s Role

- **Very supportive of the effort:**
 - sponsored the workshop at UCI
 - sponsored the meetings and travel costs for researchers
 - provided seed funds to nurture collaboration between research team and first-responders
 - provided help in proposal writing right from the beginning
 - ...
 - ...
- helped organize visits by the government agencies to the campus
- Provided a natural vehicle to establish a cross-campus collaboration
 - a vital link between the two campuses
- Cal-(IT)²'s support continues beyond help in proposal preparation
 - Administration of the project

Success/Failure of Initial Efforts...

- Many small, medium, large proposals submitted.
- Some Initial Success
 - Mining spatio-temporal and text data streams, KDD, funded 2002 (approx. 1.5M)
 - Padhraic Smyth, PI. Representation and mining of event streams (with Sharad Mehrotra)
- But
 - large ITR proposal that established the collaboration between UCI and UCSD was found competitive but finally did not get funded

Efforts in Year 2...

- **Refocused the project to incorporate social science research that**
 - explores the strength and weakness of humans in the role of information gatherers (cognitive overload, unreliability, ..)
 - social and cultural barriers in information sharing across autonomous organizations
- **Selectively expanded the research team to incorporate experts in areas deemed critical:**
 - University of Colorado (Kathleen Tierney): leading authority in disaster management.
 - University of Illinois and BYU (Winslett and Seamons): trust negotiation and management in open distributed environments
 - University of Maryland (Chang): Damage assessment
- **Maintained close connection with the first responder community**
- **Visited NSF to:**
 - inform NSF personnel of our research plans
 - seek advise on how to write a winning proposal
- **Submitted a Large ITR on “Responding to the Unexpected”**

Establishing the Urban Crisis Response Center

- **NSF Large Information Technology Research Grant**
 - **\$12.5 Million Over Five Years**
- **Research collaboration led by UCI and UCSD**
 - **UCI: Sharad Mehrotra (PI) Co-PIs: C. Butts, N. Venkatasubramanian, R. Eguchi (ImageCat), M. Winslett (Univ. of Illinois)**
 - **UCSD: Ramesh Rao (PI), Co-PIs: B. Rao, M. Trivedi**
- **Research Team**

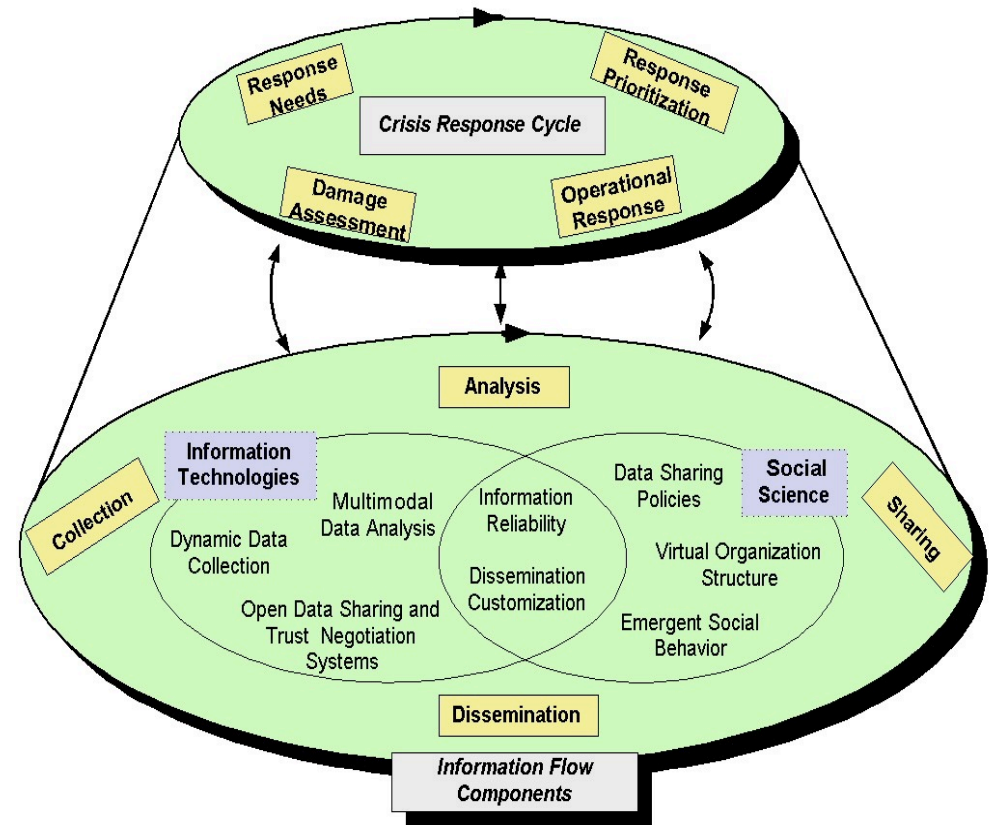
Organization	Researchers	Research Strengths
UCI, Info. & Comp. Sci.	Li, Mark, Mehrotra, Smyth, Tsudik, Venkatasubramanian	Data management, mining, machine learning, distributed systems, networking, security
UCI, Civil & Env. Eng.	Shinozuka, Feng	Damage assessment, optimization, sensors
UCI, Inst. For Trans. Studies	Recker	Simulation, transportation, traffic management
UCI, Sociology	Butts	Social networking and organizational behavior
UCSD, Cal-(IT) ²	Chokalingam, Jaffarian	Notification services, Wireless System development and deployment
UCSD, Elec. & Comp. Eng.	M. Trivedi, R. Rao, B. Rao	Speech Recognition, Video Processing, Networking
UCSD, Center for Wireless Comm.	B. Rao, R. Rao	Mobile computing, wireless technologies
Univ. of Illinois	Winslett	Trust management
Univ. of Colorado	Tierney	Social and organizational behavior in disasters
Brigham Young Univ.	Kent	Trust management
Univ. of Maryland	Chang	Use of sensors to detect damage to critical infrastructure
ImageCat, Inc.	Eguchi, Kehrlein, Huyck, Cho, Adams	Decision support, remote sensing, transportation, damage simulation

- **Government Partners:**
 - **City of LA, County of LA, City of Irvine, City of San Diego, State of California**

UCREC Research Agenda

Multidisciplinary Research Agenda of UCREC

- **Information Technology**
 - right information
 - right person
 - right time
- **Social and Organizational Science**
 - **The right context**
 - the distinctive nature of dynamic virtual organizations
 - their information needs
 - the social and cultural aspects of information sharing across organizations and individuals



Information Collection

- **Objective**
 - to bring relevant crisis-related information from a variety of information sources to decision makers in a timely and efficient manner
- **Challenges**
 - **Diversity of data sources**
 - **Sensors (in situ, satellite, remote sensing) to large knowledge and data banks belonging to autonomous organizations**
 - **Diversity of data**
 - **Voice streams from field-workers, video, sensor, relational, textual**
- **UCREC Research Threads**
 - **IT solutions for human as sensors**
 - **Speech recognition in noisy environments, video analysis, ...**
 - **Reliable knowledge from unreliable sources**
 - **Dynamic information collection**

Information Analysis

- **Objective**
 - Bridge the gap between **raw data** and **semantically richer representations** useful to humans in the context of their tasks
 - Data generated at instrumented sensors, field observations, conversations among field workers
 - Tasks include damage assessment, planning, situational awareness
- **Challenges**
 - Diversity of data
 - Urgency
- **UCREC Research Threads**
 - Event extraction from multimodal data streams
 - entity-event data management
 - Adaptive filtering of event streams
 - Damage and Impact Assessment

Information Sharing

- **Objective**
 - To facilitate seamless information sharing and collaboration among **dynamically evolving virtual organizations**
- **Challenges**
 - Frequent structural and functional changes within organizations
 - Lack of centralized control
 - Element of surprise
- **UCREC Research Threads**
 - Understanding and optimizing organizational structure
 - Dynamic mediation architecture to support information integration
 - Reflective middleware for group management
 - Trust management and negotiation for access control and authorization in open distributed systems

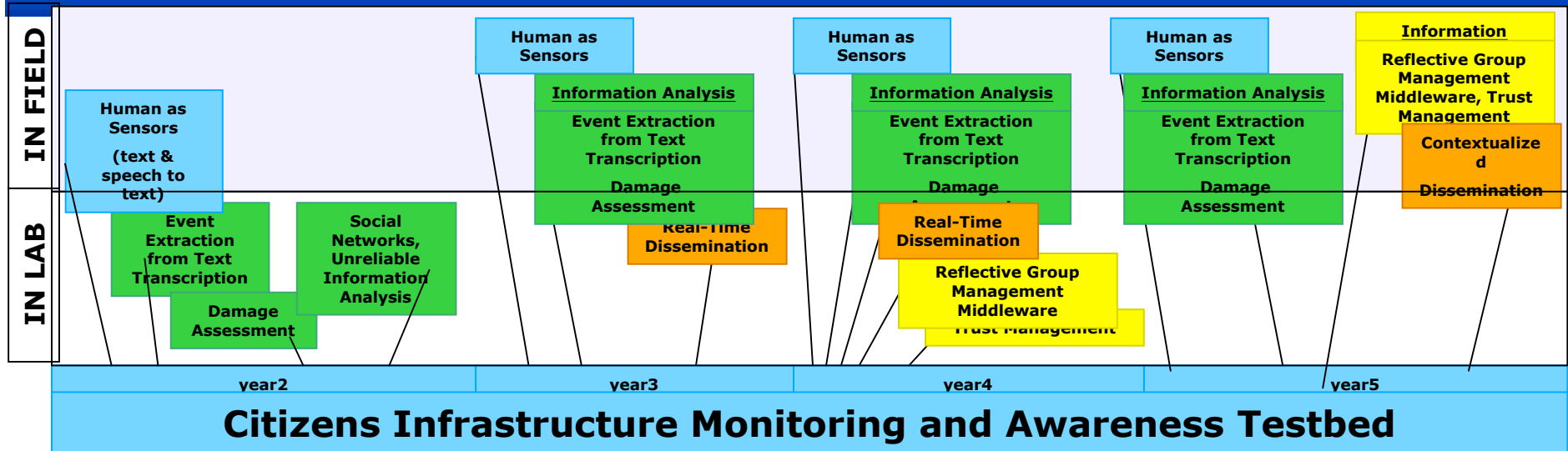
Information Dissemination

- **Objective**
 - timely dissemination of information to entities, organizations (e.g., mass media organizations), and to **the general public**
- **Challenges**
 - Confusion, panic, chaos
 - Urgency
 - Scale
- **UCREC Research Threads**
 - Emergent social behavior (e.g., panic, rumors) and its impact on dissemination
 - Structured approach to dissemination: understanding a taxonomy of messages/alerts; customizations to enhance interpretation; communication channels
 - System for customized information delivery

Testbeds

- **Citizens Infrastructure Monitoring and Awareness Testbed**
 - Web portal and toll-free number to empower the community to continuously monitor physical infrastructures coupled with sensor and video data
 - airports, government buildings, etc.
 - Initial plans to monitor activities in a university campus in which students, faculty and staff become active participants
 - provides a rich continuous data stream for testing of various information processing algorithms
- **The San Diego Gas Lamp Testbed (in collaboration with San Diego Police)**
 - 10 blocks of historic region adjoining San Diego Convention Center
 - Tests incident level crisis response
- **California Advanced Transportation Testbed**
 - Traffic modeling and simulation framework under diverse conditions (e.g., closure of key bridges/streets)
 - two contiguous sub-areas in Orange County around instrumented “smart streets and freeways”.
 - Tests wide area geographically dispersed disasters

Citizens Infrastructure Monitoring and Awareness Testbed



- **Testbed**
 - Web portal and toll-free number to empower the community to continuously monitor physical infrastructures coupled with sensor and video data
 - airports, government buildings, etc.
 - Provides a rich continuous data stream for testing of various information processing algorithms
- **Technologies Tested**
 - Approaches to maintain privacy during data collection
 - Models for determining reliability of human input under diverse conditions for different types of information
 - Algorithms for event extraction
 - Response need prioritization
 - Adaptive event filtering

CAMAS (1)

- **Information Collection**
 - text
 - speech to text (noisy voice data)
 - with and without feedback
 - roles (Firefighter, police officer, ...)
- **Feedback**
 - for proper event extraction
 - **event refinement**
 - provided by the user or/and analyst
- **Privacy preservation**
 - collect information such that privacy is preserved
 - top-down and bottom-up approaches
- **Event Extraction**
 - extract location, time of event, time of reporting
 - **to help identify same events**
 - **to understand the nature of the event**
 - **for ranking/prioritization**
 - **XML storage of locations, events, etc**
 - **easy for an analyst to update**
 - (e.g. add new problem on the fly as unexpected crisis occurs)

CAMAS(2)

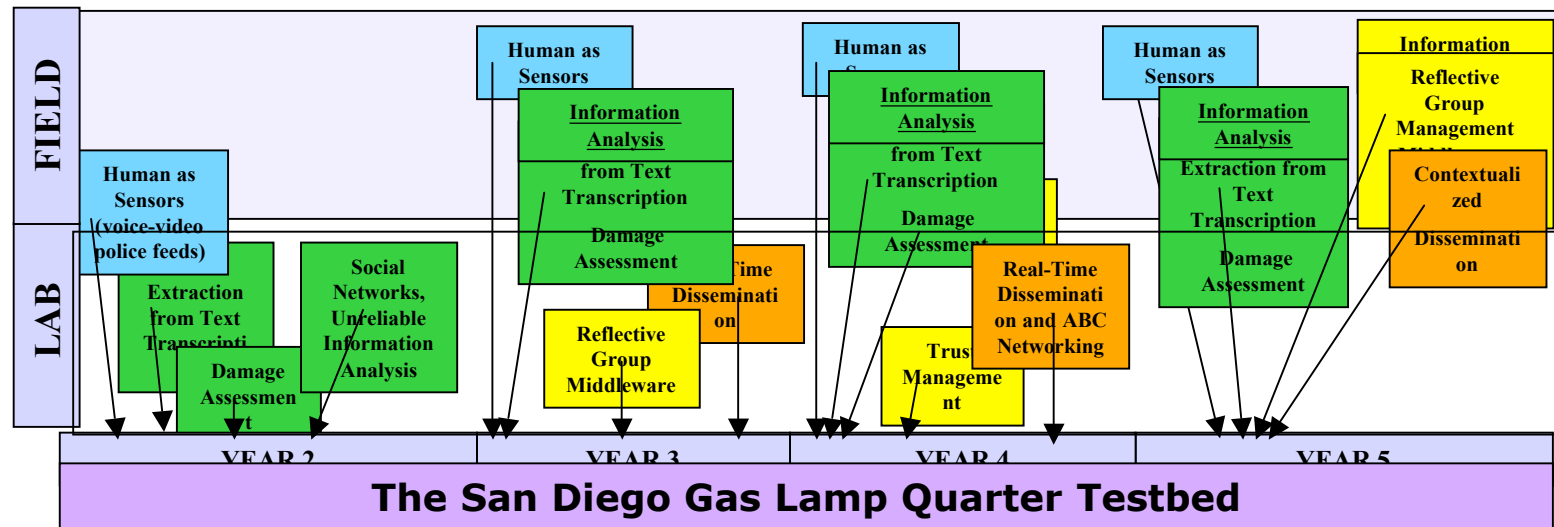
- **Event Prioritization**

- role of person(s) reporting the problem
- degree of confidence that reporting people are who they claim to be
- nature of problem
 - and attributes of the problem (loss of power to which facility)
- the user-specified urgency if available
- the number of people it affects
- the number of times it was reported
- the history of the problem
- the amount of damage it will cause if not addressed immediately
- probability of cause cascading effect
- can problem report be caused by a rumor/confusion/obscurity
- probability of exaggeration
- resistant to intentional abuse

CAMAS(3)

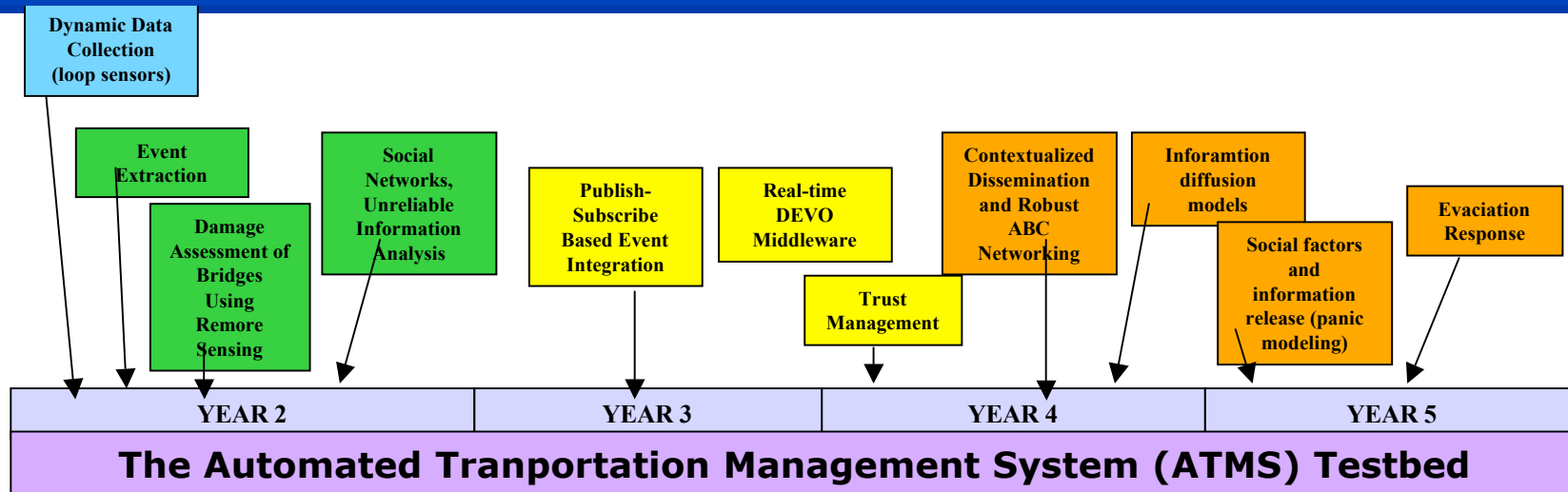
- **Event analysis**
 - Dependence/linkages between events
 - Forestalling cascading events
 - Discovering patterns (lax security on Fridays)
 - Discovering root cause of problems
 - Discovering intentional abuse
 - based on many factors, including history of events
- **Reliability**
 - system should function if partially down
- **Information dissemination**
 - most effective plan for information dissemination
 - part of infrastructure can be damaged
 - person might not be accessible via a particular medium
 - different plan of actions (instructions) for different responders
 - peer-to-peer aspects
 - some information is of interest within a certain location, spread from a responder to the neighborhood but not further (no flooding)
 - need-to-know basis (privacy)
 - dynamic, can change in case of a disaster
- **Information sharing**

The Gas Lamp Testbed



- **Testbed:**
 - 10 blocks of historic region adjoining San Diego Convention Center
- **Demonstration Study:** (tests improvement in response latency by incorporating human as sensors)
 - simulate spatially localized disasters and incidence level response
 - input from instrumented video, monitored conversations between law enforcement officials, eye witnesses accounts for real-time situational assessment
- **Primary Technology Tested:**
 - real time speech recognition in noisy environments, multi-modal event extraction, information reliability models, contextualized information dissemination to public.

California Advanced Transportation Testbed



- **ATMS Testbed**

- Traffic modeling and simulation framework under diverse conditions (e.g., closure of key bridges/streets)
- two contiguous sub-areas in Orange County around instrumented “smart streets and freeways”.

- **Demonstration Study (to test role of IT in forestalling crisis cascades)**

- Simulate large scale disasters using FEMA HAZUS and state EPEDAT tools resulting in potential hazardous material release
- ATMS testbed used to simulate and test traffic response and evacuation strategies

- **Technologies Tested**

- Real-time damage assessment, traffic rerouting strategies, information collection, analysis, information sharing across organizations, dissemination, social factors and effect of information release (e.g., panic, rumors)

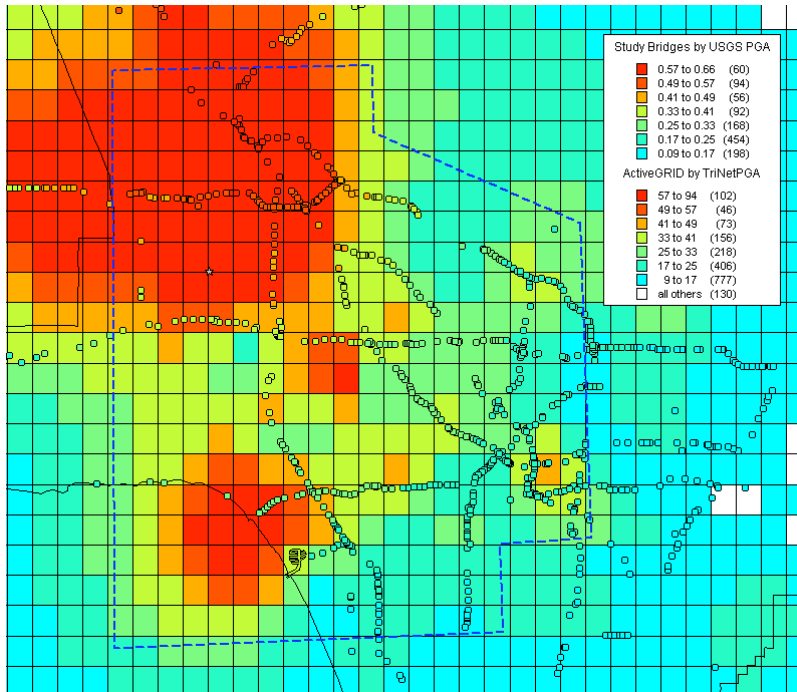
California Advanced Transportation Testbed



Interstate 5/Route 91 Freeway
Interchange in Orange County

- **Demonstration study will build on existing testbed – *California Advanced Transportation Management System or ATMS***
- **This system has been operating at UCI for over 10 ten years under research agreements with Caltrans**
- **Currently encompasses two contiguous sub-areas in Orange County**
- **Includes several instrumented “smart streets and freeways”**

California Advanced Transportation Testbed



Sample output from *EPEDAT*, an earthquake loss estimation model used by the Governor's Office of Emergency Services

- A major focus of our research will be on efficient technologies and methodologies for “detecting and sensing” damage and significant impacts from large, regional disasters, e.g., earthquakes
- Current technologies include: satellite imagery and ground-based sensors, humans-as-sensors, GIS-based loss estimation tools, emergency transportation re-routing methodologies, and visualization tools and techniques
- Demonstration study will focus on incidents that have the potential for cascading effects, e.g., release of hazardous materials

California Advanced Transportation Testbed



- A major element of this research will focus on the sociological aspects of crisis response
- The importance of rapid and accurate information will be studied at various levels, including government emergency response levels, and the public-at-large
- The impact of effective information in reducing potentially damaging post-disaster social phenomena (e.g., panic) will be studied by research team members