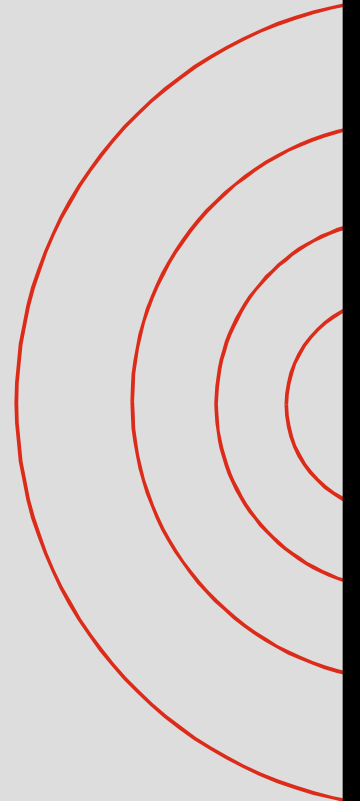




**r**<sup>4</sup>

*Using Remote Sensing  
Technologies to  
Improve Resilience*

*Ronald T. Eguchi  
CEO, ImageCat, Inc.*



## 6 years ago ...

- The world had just survived the Y2K bug with no major incidents
- Nations around the world commit to extend the use of space facilities for disaster response (UN Charter on Space and Major Disasters)
- Smooth, Santana featuring Rob Thomas was the #1 hit in the U.S.

## 5 years ago ...

- The U.S. was reacting to 9/11
- The first sub-meter high-resolution commercial satellite was launched by DigitalGlobe
- The Bhuj, India earthquake occurred killing over 20,000 people and leaving over 600,000 homeless

## 4 years ago ...

- European Space Agency successfully launches Envisat (Environmental Satellite) – 9 different sensors
- Department of Homeland Security formed in response to terrorists concerns in the U.S.

## 3 years ago ...

- Earthquake in Bourmerdes region of northern Algeria - 2,200 killed
- A big heat wave in Paris has had temperatures up to 112°F), killing more than 3,000 people.
- Widespread power outage affects northeast United States and Canada

## 2 years ago ...

- One of the worst natural disasters in recorded history hits southeastern Asia when the strongest earthquake in 40 years hits the entire Indian Ocean region. Over 200,000 killed and millions left without shelter.
- Hurricane Ivan strikes Gulf Shores, Alabama, as a Category 3 storm, killing 25 in Alabama and Florida becoming the 3rd costliest hurricane in American history

## 1 year ago ...

- Four explosions rock the transport network in London killing 56 people and injuring over 700
- At least 1,604 are killed, and severe damage is caused along the U.S. Gulf Coast, as Hurricane Katrina strikes the Louisiana, Mississippi and Alabama coastal areas

# Today ...

- Tremendous technological push especially in the areas of situational awareness
- The need for rapid damage assessment and resilient response systems has been strongly noted in many recent natural disasters
- In spite these factors, we continue to lag in our implementation of these technologies

# Why is this happening?

- The efficacy of these technologies are not being fully recognized throughout the emergency management response chain
- Users are not fully educated on the use of these technologies for either pre- or post-disaster use

# What needs to be done

- Stronger partnerships between the research community and end-users
- Better integration of beta products within industry
- A stronger commitment by government agencies to advance research to levels where research results and products can be more effectively transferred to technology integrators

# In what ways has MCEER contributed to the solution?

- A long-term commitment to research in remote sensing with the ultimate goal of developing and transferring usable products to the emergency management community
- Organized and sponsored several U.S. and international workshops that have promoted genuine collaboration in post multi-hazard investigations and research
- Established the Remote Sensing Institute (RSI)

# Remote Sensing Technologies Offer a Number of Solutions to Enhancing Resilience

- Rapidity – provide rapid visual assessments of impact
- Robustness – multiple sensors that collect a wide range of data and information on impacted areas
- Redundancy – offer an alternative situation awareness capability
- Resourcefulness – can aid in reconnaissance in areas that are not easily accessible

# Specific Achievements in Remote Sensing Research

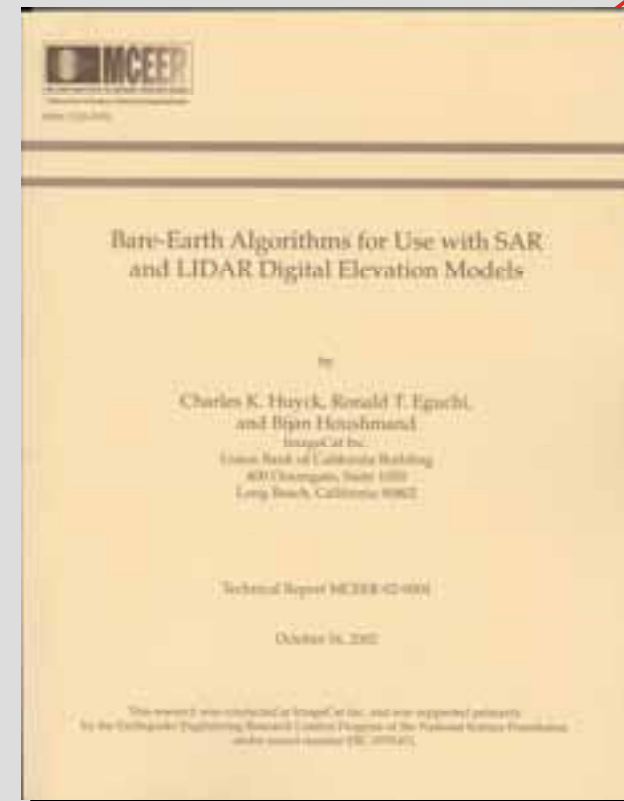
1. Created various techniques to quantify the built environment for large urban areas
2. Developed three-tiered approach to damage assessment
3. Developed and implemented post-disaster data collection and visualization systems
4. Expanded research to other hazards, including tsunamis, hurricanes and terrorist attacks

# 1. Building Inventory Development

- Created innovative techniques to extract buildings from high- and moderate-resolution optical satellite images
- Pioneered techniques to develop 3D models of cities; have augmented these models with information on building heights, number of stories, total square footage and structural classifications
- Implemented satellite-derived building inventory models in HAZUS

# Building Footprint Extraction

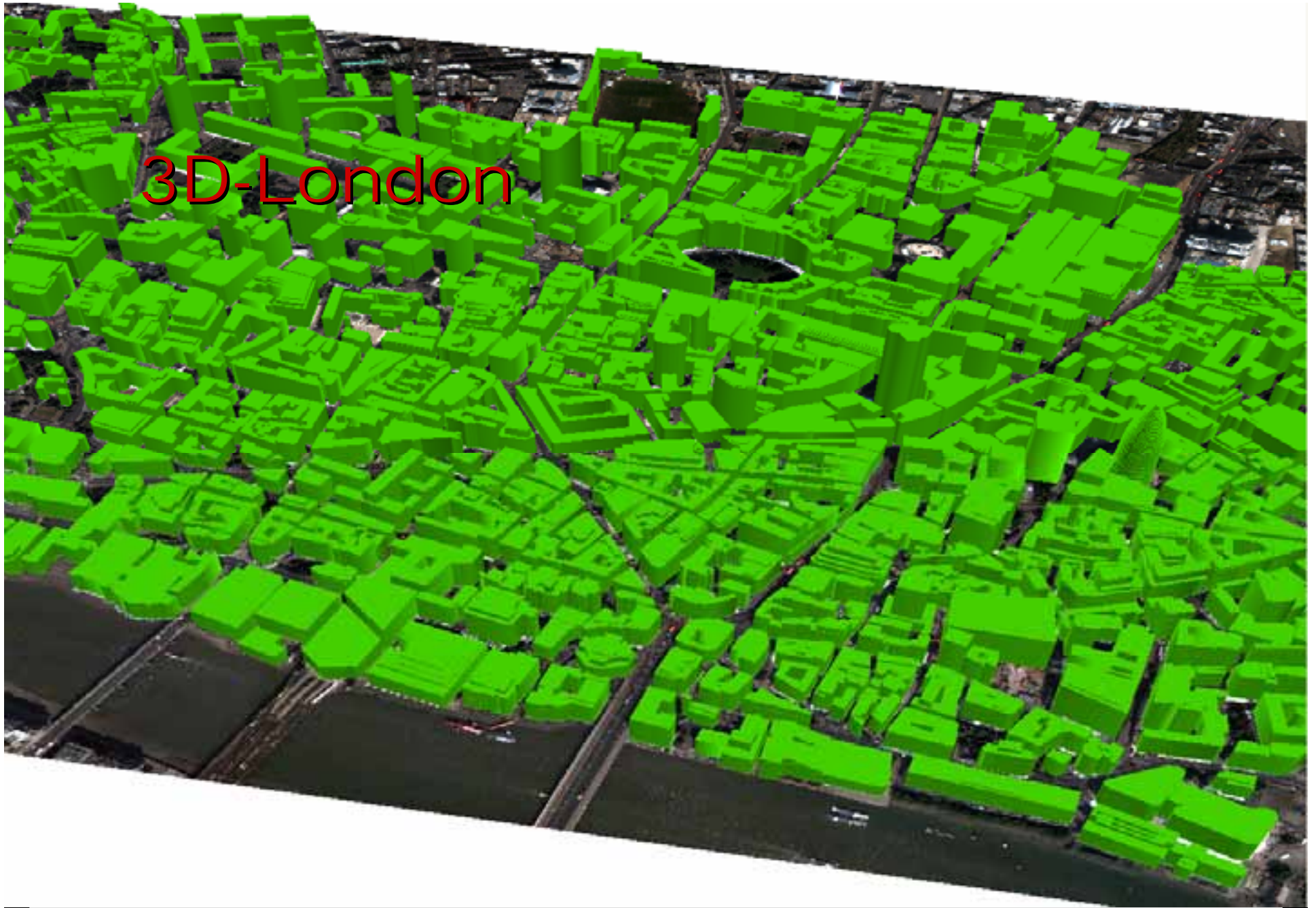
- Using a series of filters, it is possible to create a bare-earth DEM (digital elevation model) of a city
- Another useful application of the model is the ability to delineate urbanized areas anywhere in the world using automated extraction algorithms



# MIHEA – Mono-Image Height Extraction Algorithm

- Methodology uses: single high-resolution satellite images and *rational functions* to replicate the parameters of the camera
- A major benefit of MIHEA is that a user can create highly accurate 3D city models for anywhere in the world





3D-London

MULTIDISCIPLINARY CENTER FOR EARTHQUAKE ENGINEERING RESEARCH

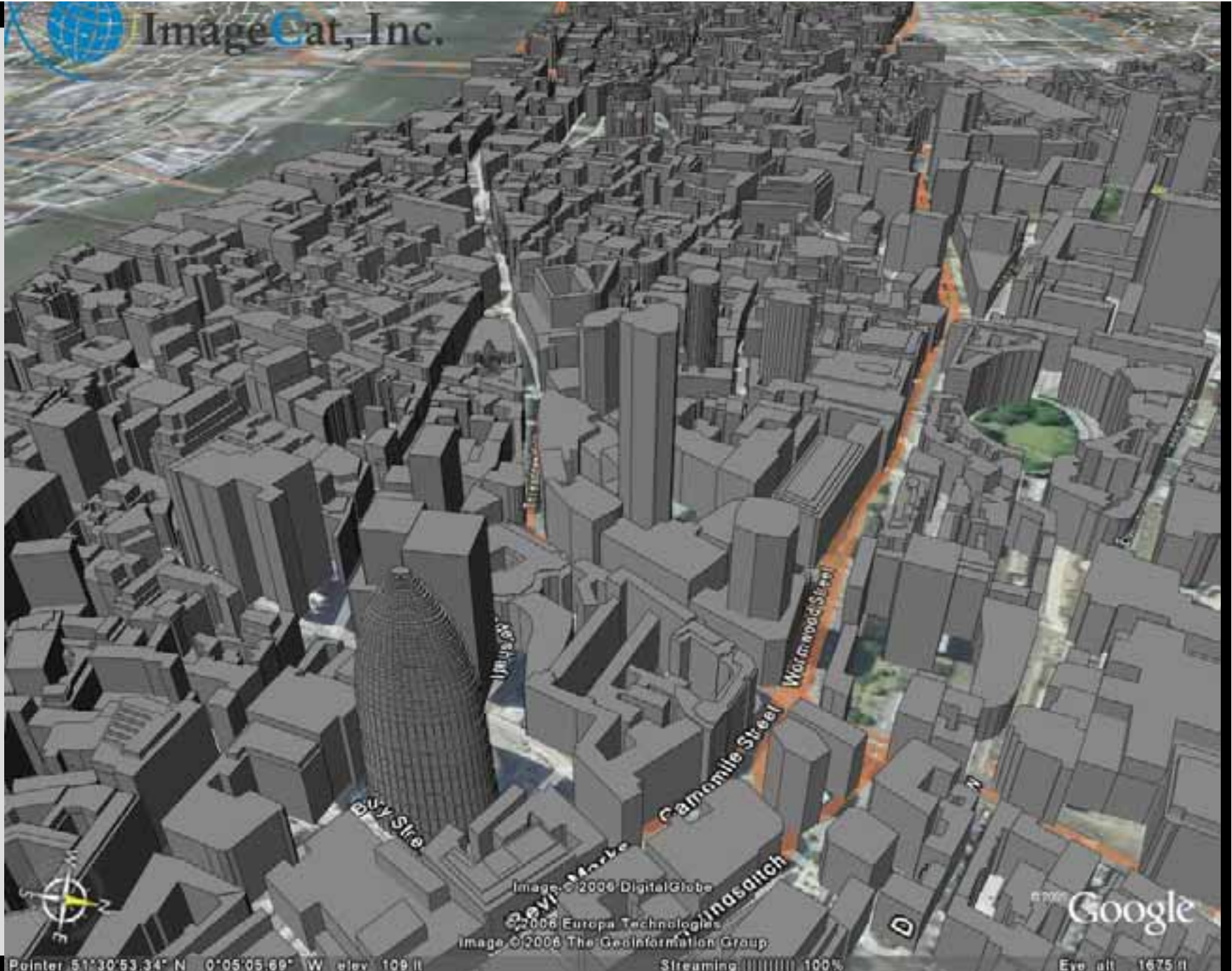


Image © 2006 DigitalGlobe

© 2006 Europa Technologies

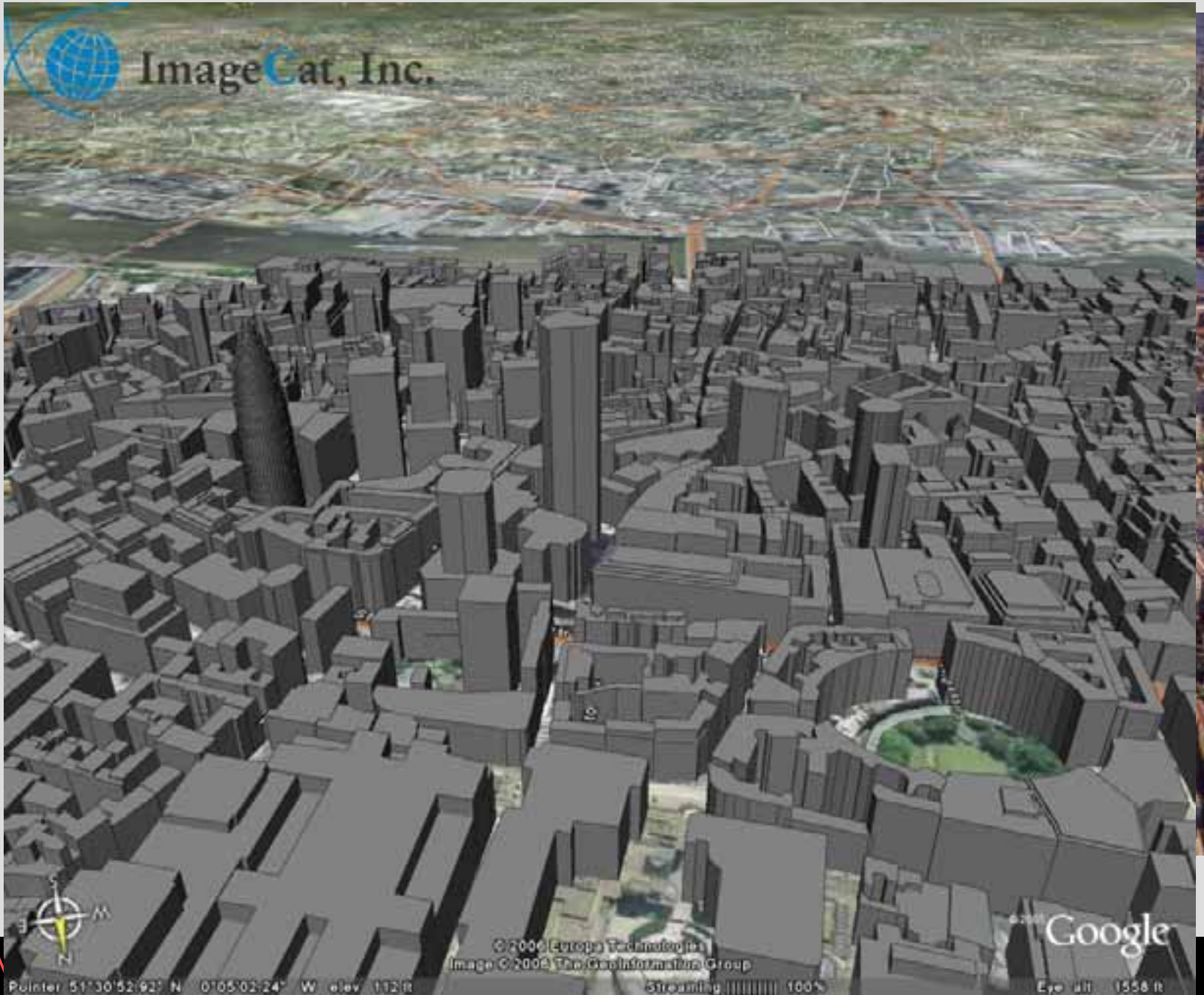
Image © 2006 The GeoInformation Group

Google

Pointer 51°30'53.34" N 0°05'05.69" W elev 109 ft

Streaming 100%

Eye alt 1675 ft



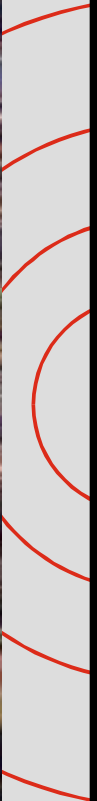
Pointer: 51°30'52.92" N 0°05'02.24" W elev: 112 ft

© 2006 Europa Technologies  
Image © 2006 The GeoInformation Group

Streaming: ||||| 100%

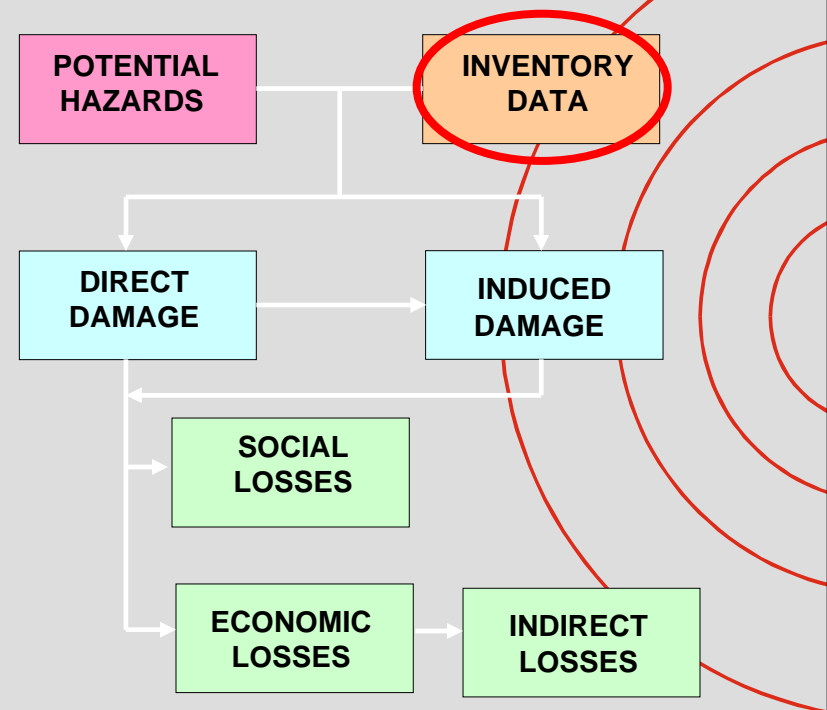
Google

Eye alt: 1556 ft

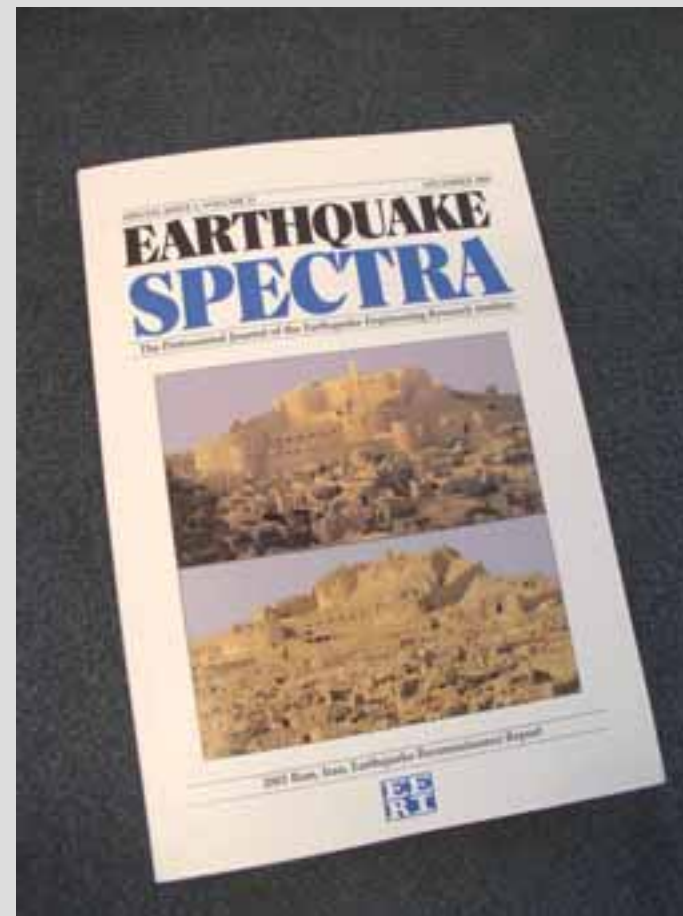
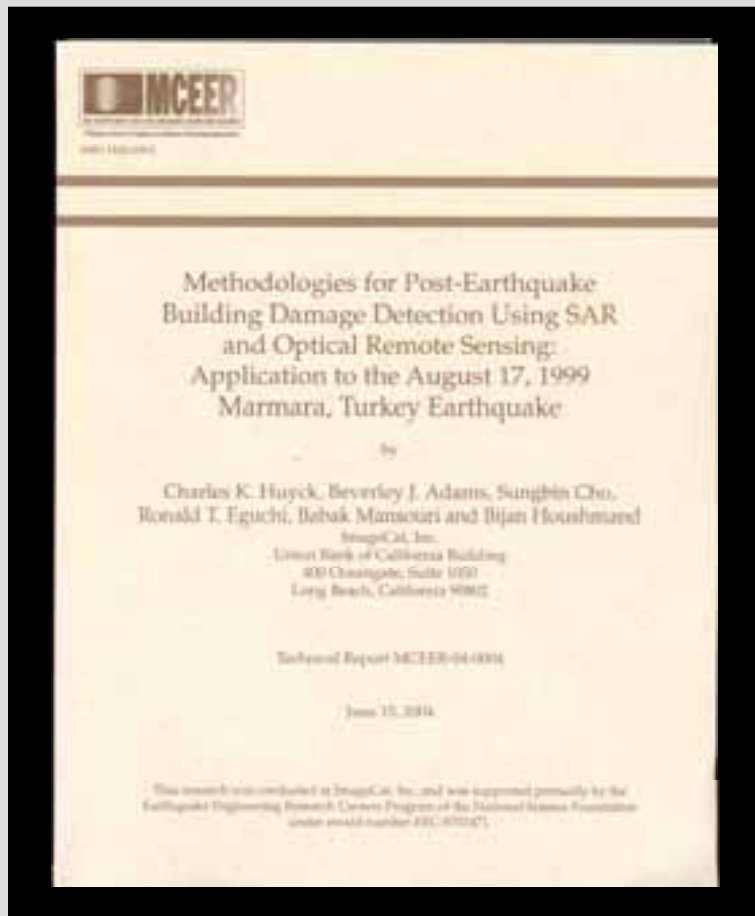


# Integration of remote sensing technologies into loss estimation

- Inventory models continue to be a “weak link” in loss estimation process
- Remote sensing technologies offer an alternative to more traditional, time-intensive methods



## 2. Post-Earthquake Damage Assessment



# 3-Tiered Approach

## TIER 1. Regional

Change detection using moderate-resolution imagery provides a “quick look” regional damage assessment

## TIER 2. Neighborhood

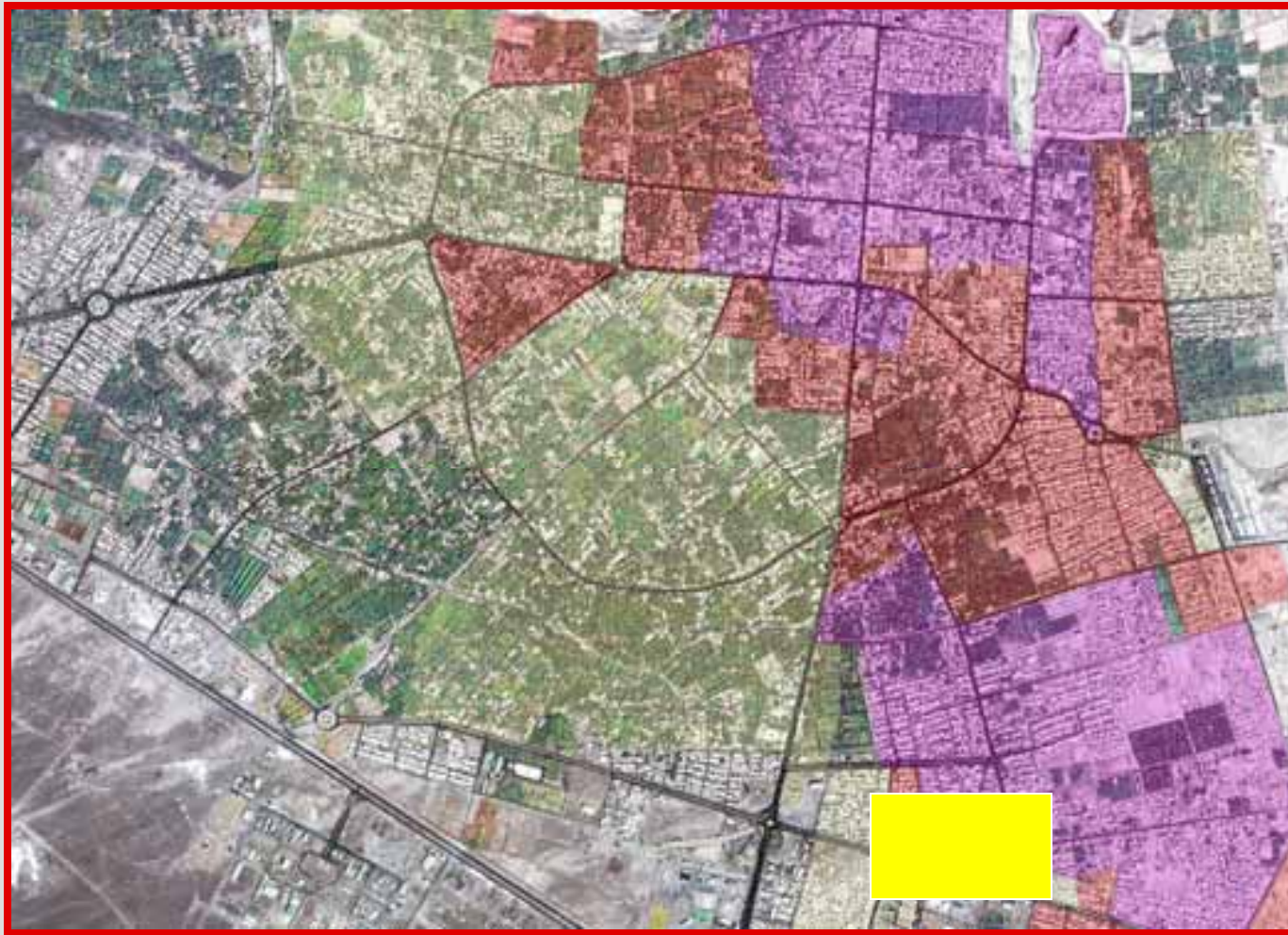
Detailed analysis of high-resolution imagery determines the level of damage within affected communities

## TIER 3. Per-building

Results support the prioritization and coordination of field-based activities – e.g. response and recovery, and field reconnaissance

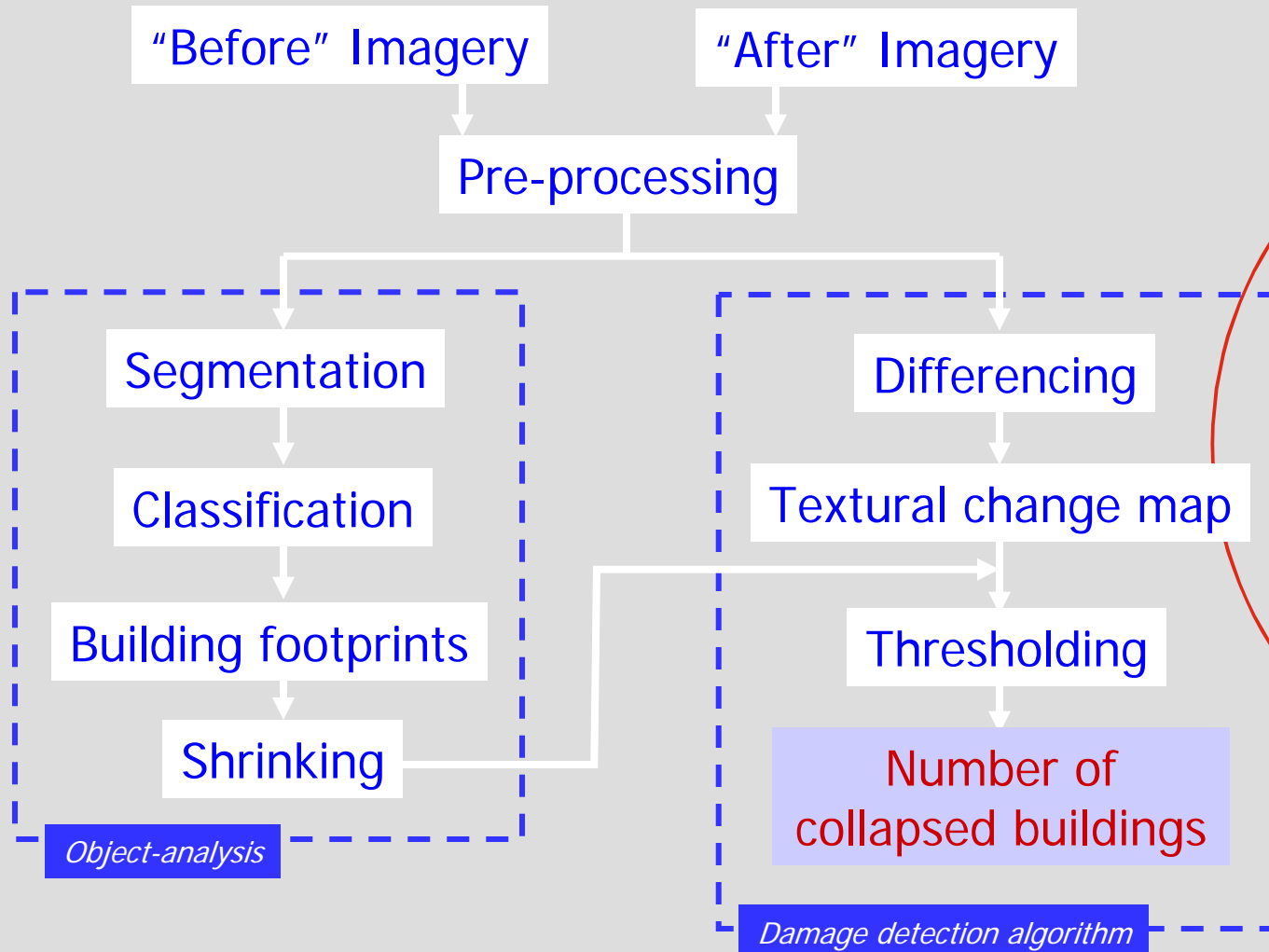


# Bam, Iran - 2003

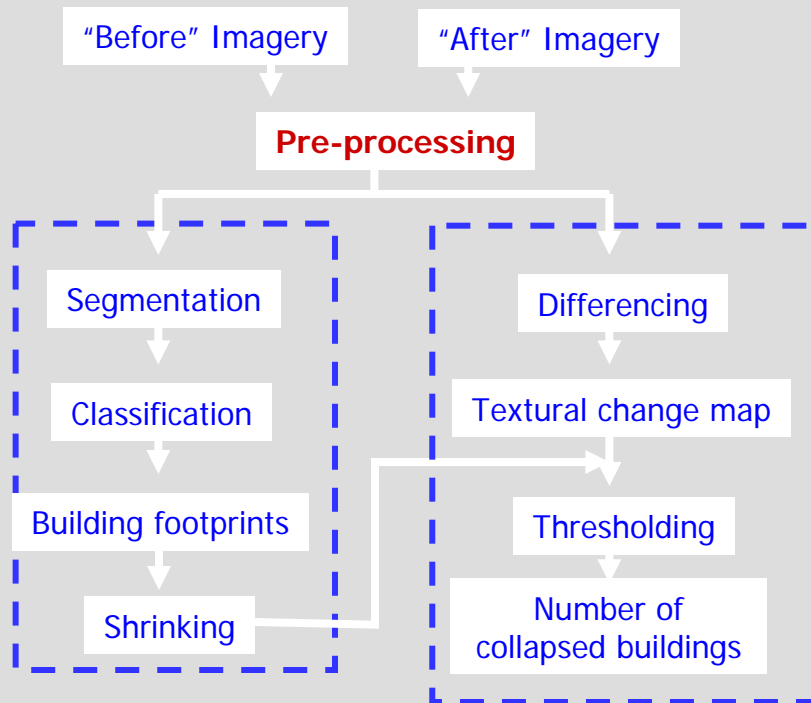


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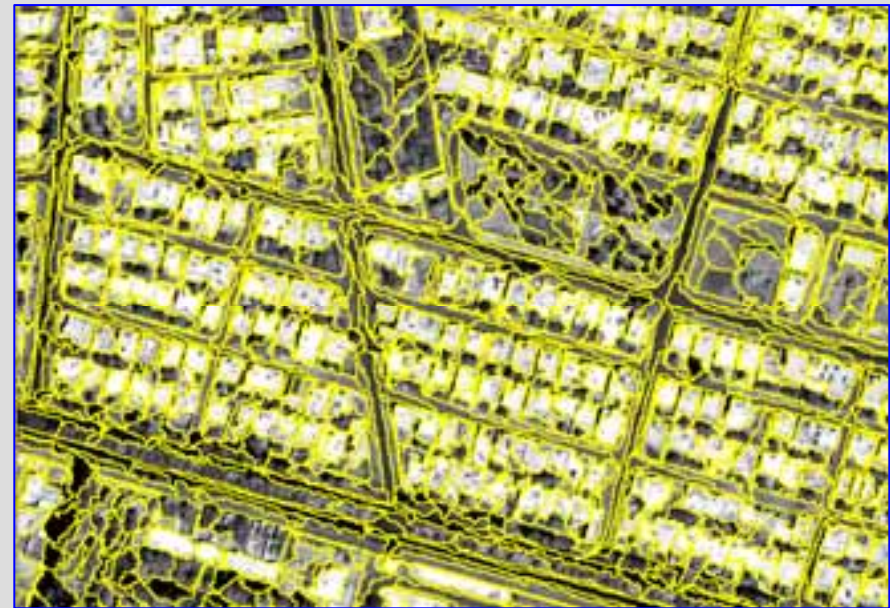
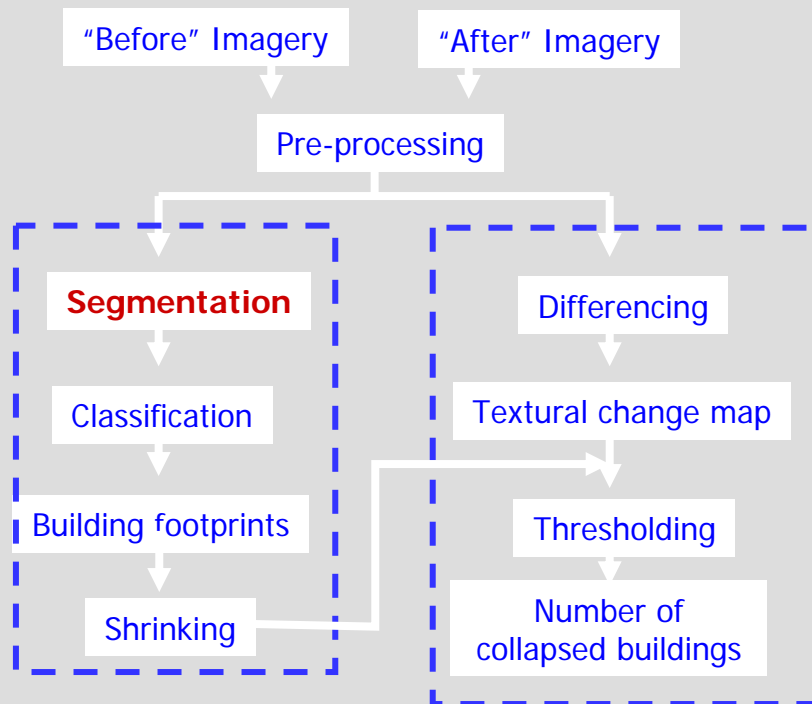
# Counting Collapsed Buildings



# Pre-processing

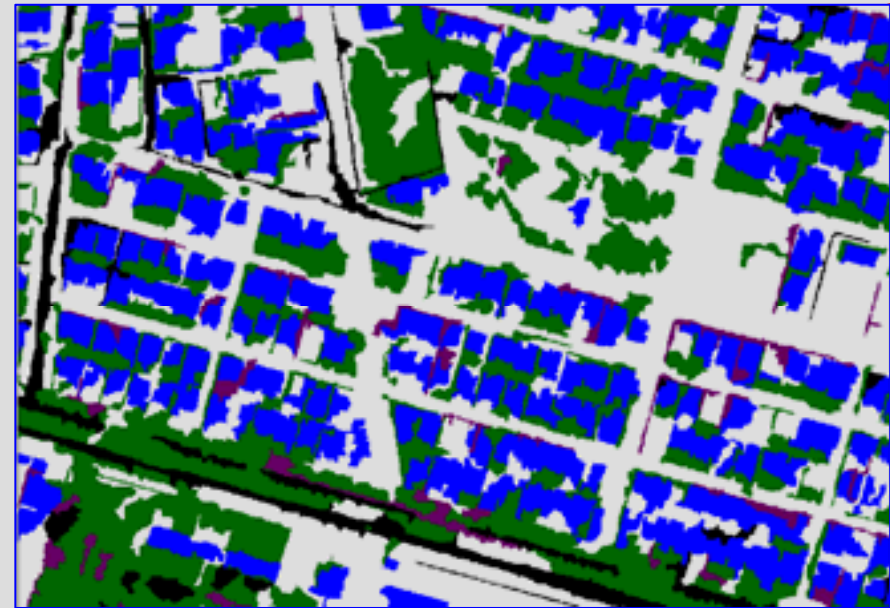
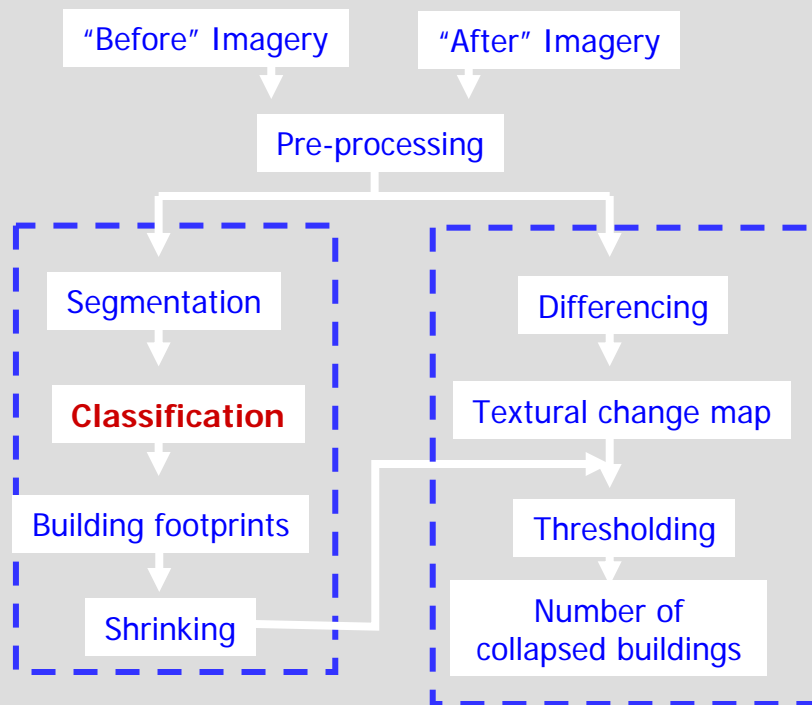


# Segmentation



**Scale = 30**  
**Color = 0.1**  
**Smoothness = 1.0**

# Classification



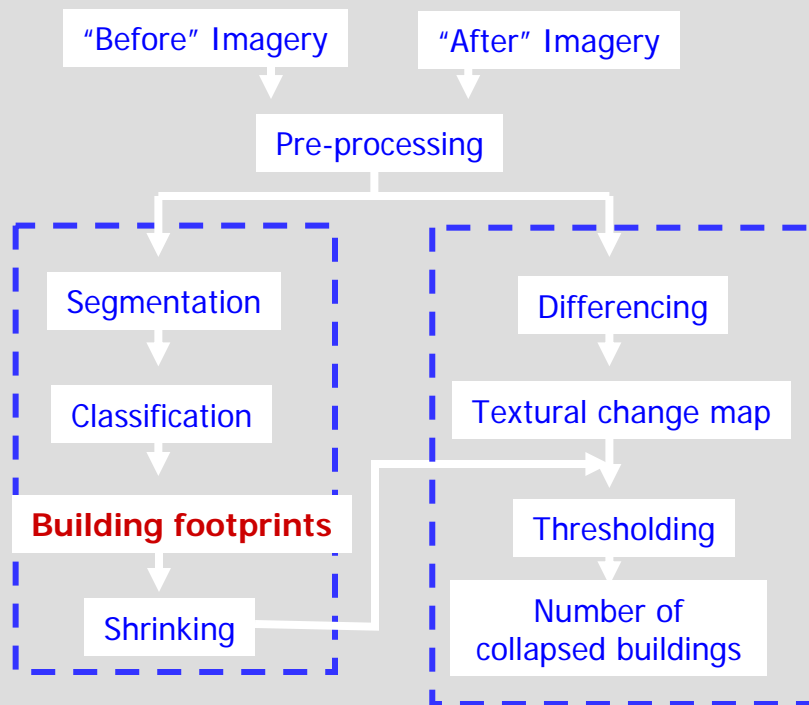
900 training objects



Building  
Vegetation  
Shadow  
Other

Accuracy = 75%

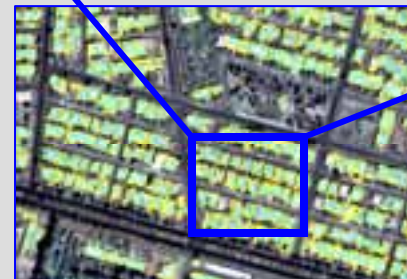
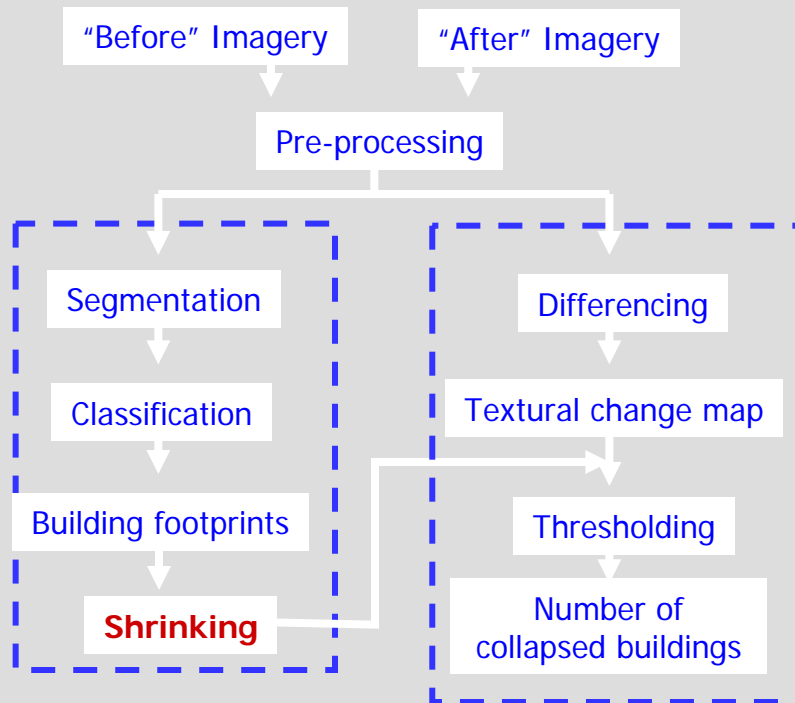
# Building Footprints



 Buildings

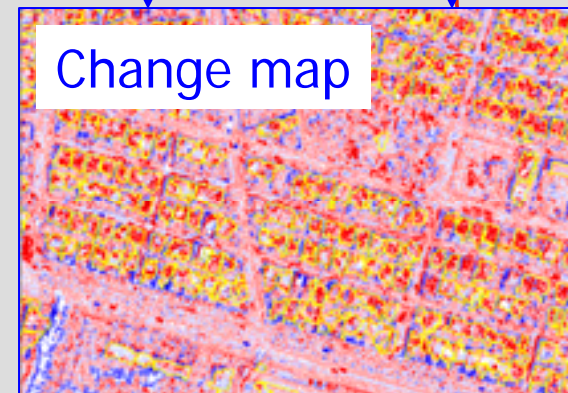
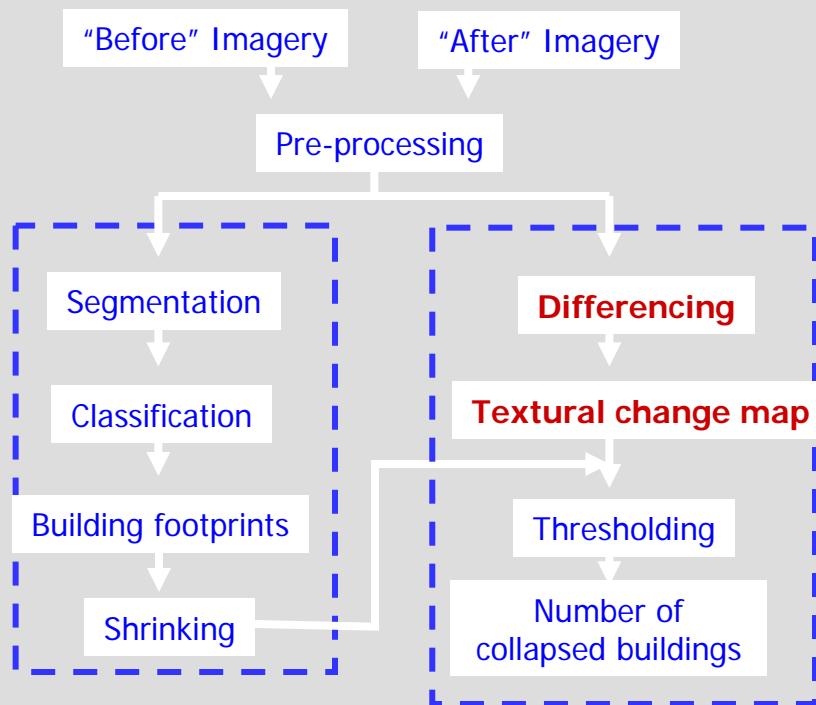
Total estimated buildings = 19,211

# Shrinking

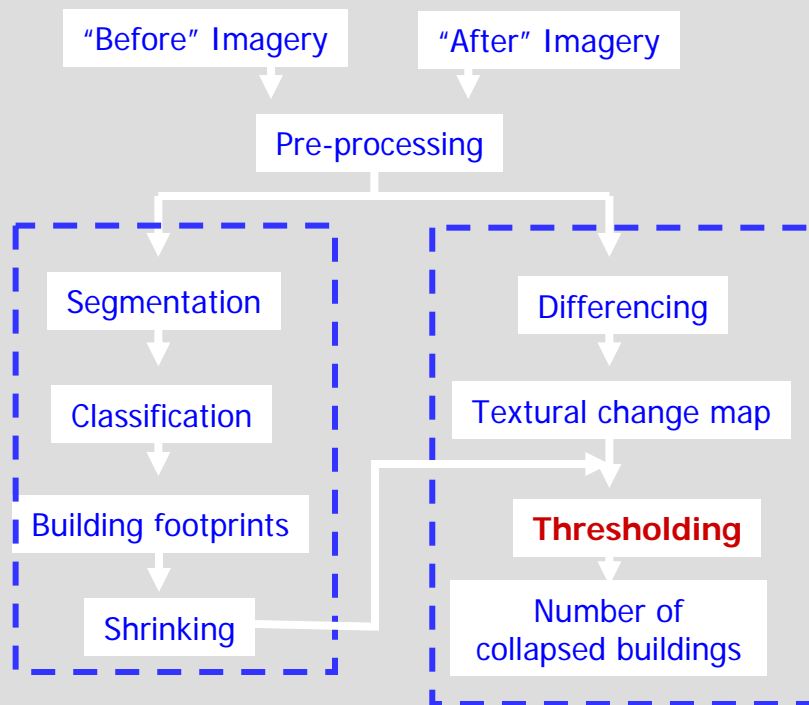


Shrink factor = 3m

# Differencing (Texture)

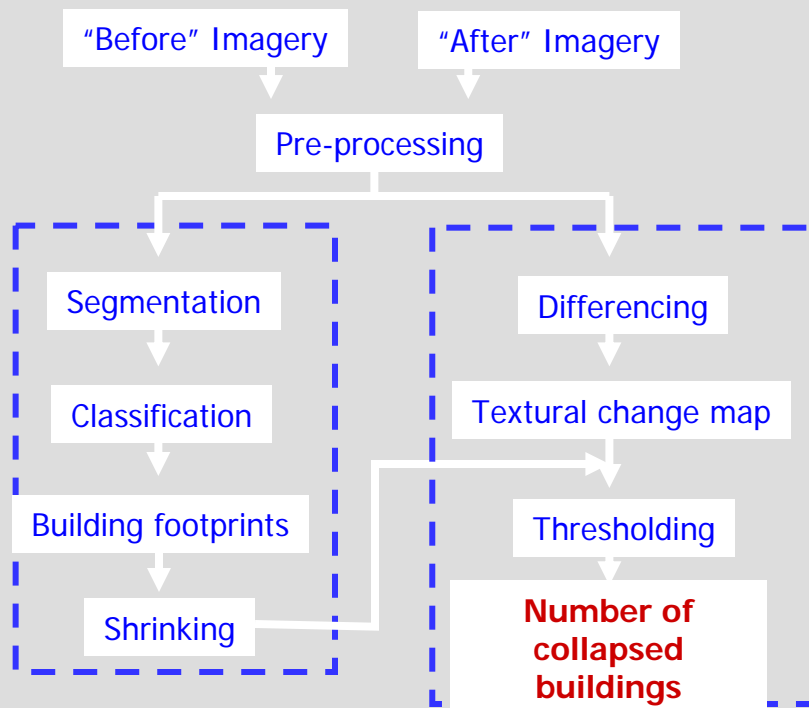


# Thresholding



Collapsed  
Not collapsed

# Number of collapsed buildings

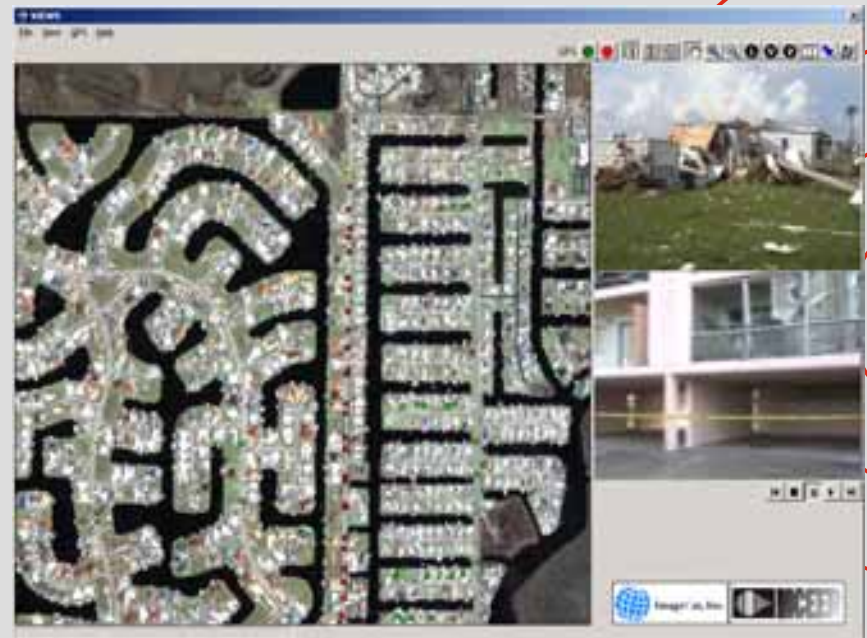


**Collapsed buildings = 6,481**  
**Not collapsed buildings = 9,021**  
**Not classified = 3,709**

**Accuracy = 79%**

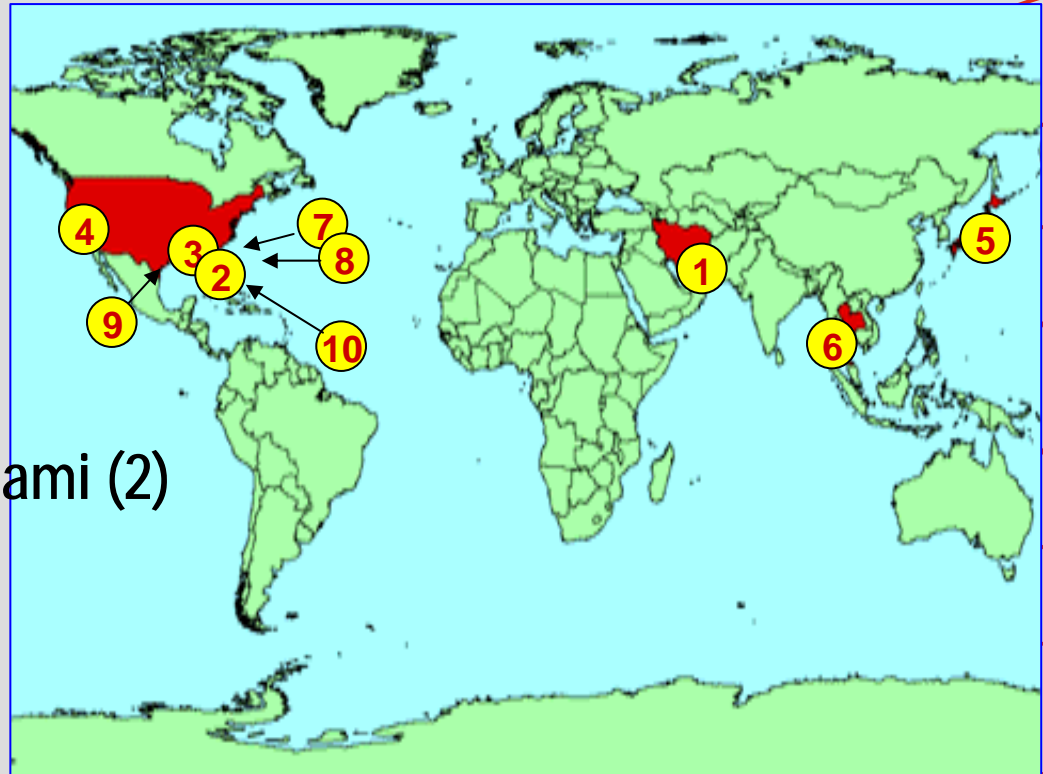
### 3. Post-disaster Reconnaissance - Implementation of VIEWS System

- Notebook-based data collection and visualization system
- Integrates GPS-registered digital video, digital photos, and observations with high-resolution satellite imagery

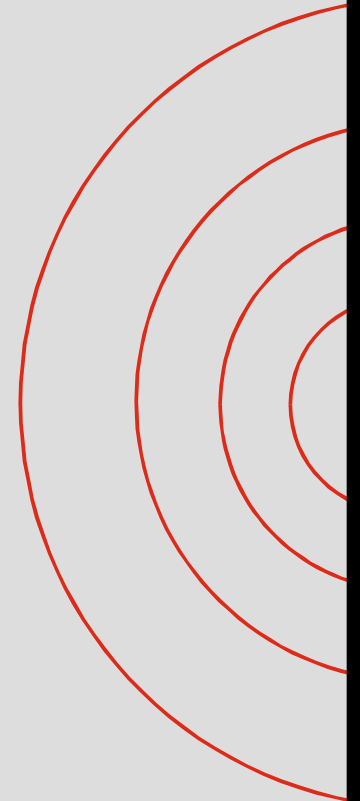


# 2004-2006 VIEWS Deployments

- ① Bam, Iran earthquake
- ② Hurricane Charley
- ③ Hurricane Ivan
- ④ Parkfield earthquake
- ⑤ Niigata, Japan earthquake
- ⑥ Thailand, Indian ocean tsunami (2)
- ⑦ Hurricane Dennis
- ⑧ Hurricane Katrina (4 )
- ⑨ Hurricane Rita
- ⑩ Hurricane Wilma



# VIEWS Example - Hurricane Charley

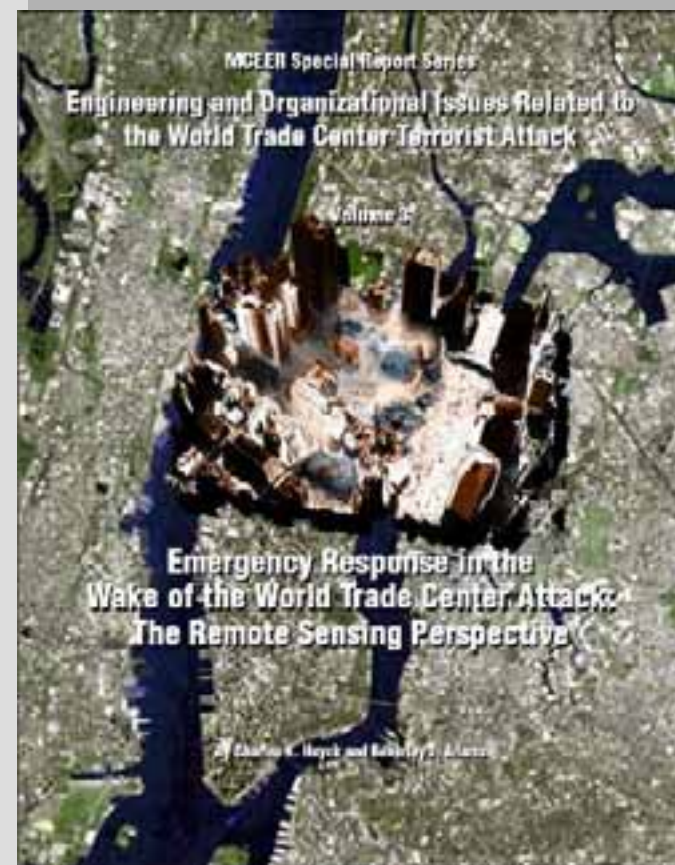


## 4. Multi-Hazard Assessment

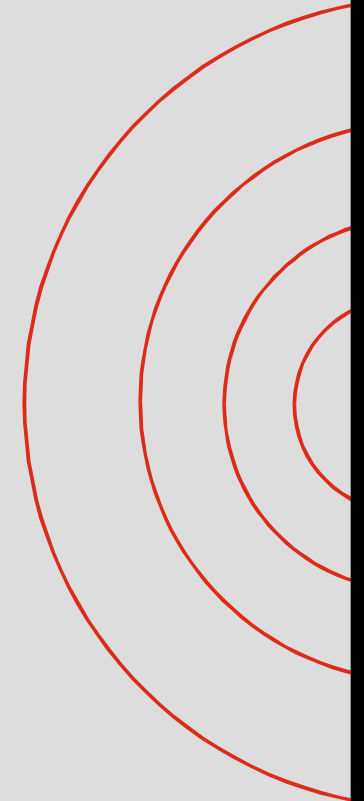
- World Trade Center Attacks
- 2004 Indian Ocean Earthquake and Tsunami
- 2004/2005 Hurricanes, including Hurricane Katrina

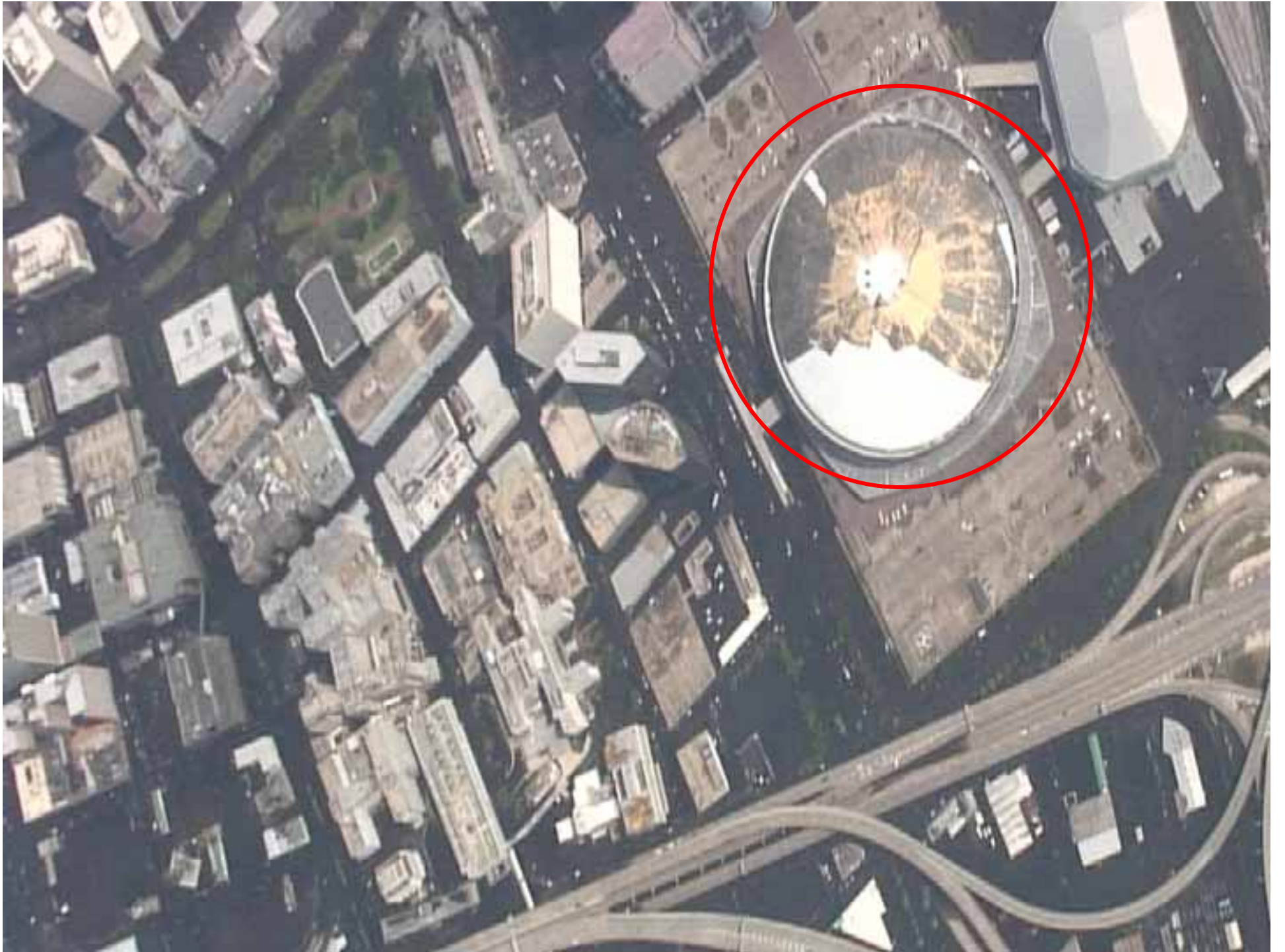
# World Trade Center Attacks

- Acquisition and delivery needs to be streamlined
- Image processing algorithms designed for damage detection need to be developed in preparation for future events
- Remote sensing data will prove to be even more effective if personnel are trained their effective use



# VIEWS Deployment in New Orleans after Hurricane Katrina







# 2004 Indian Ocean Earthquake and Tsunami

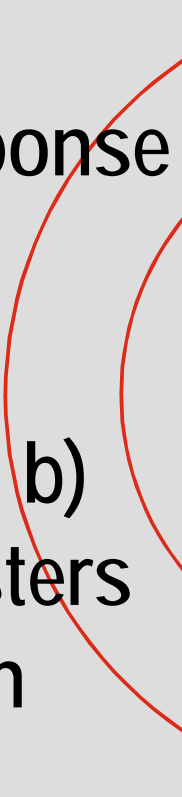
- Chang and Adams studied the dynamics of community resilience after disasters – recovery
- Remote sensing used to characterize and then categorize damage in two domains: built environment and wetlands



# 1 Year from now ...

- The nation will have survived another active hurricane season – 16 named storms; 10 hurricanes; six category 3 or higher
- GoogleEarth will be named best web-based tool for the year
- Cars will be named Best Picture of the Year

## 5 Years from now ...

- Use of remotely-sensed data will be commonplace among emergency response organizations
  - Typical uses will include: a) creating “intelligent” models of all mega-cities, b) provide real-time coverage of all disasters via the internet; and c) essential tool in monitoring disaster recovery
- 

## 20 Years from now

- A constellation of high-resolution optical satellites will offer 24/7 coverage of every urbanized area of the world
- An infrastructure for a global emergency response system will have been in operation for over a decade
- Michel Bruneau will be named Teacher of the Year by over 1000 of his most enthusiastic students; making him SUNY Teacher of the millennium

Thank you very much ...

