# Emerging Technologies for Post-earthquake Reconnaissance

J. P. Bardet

**Civil Engineering Department**
**University of Southern California**

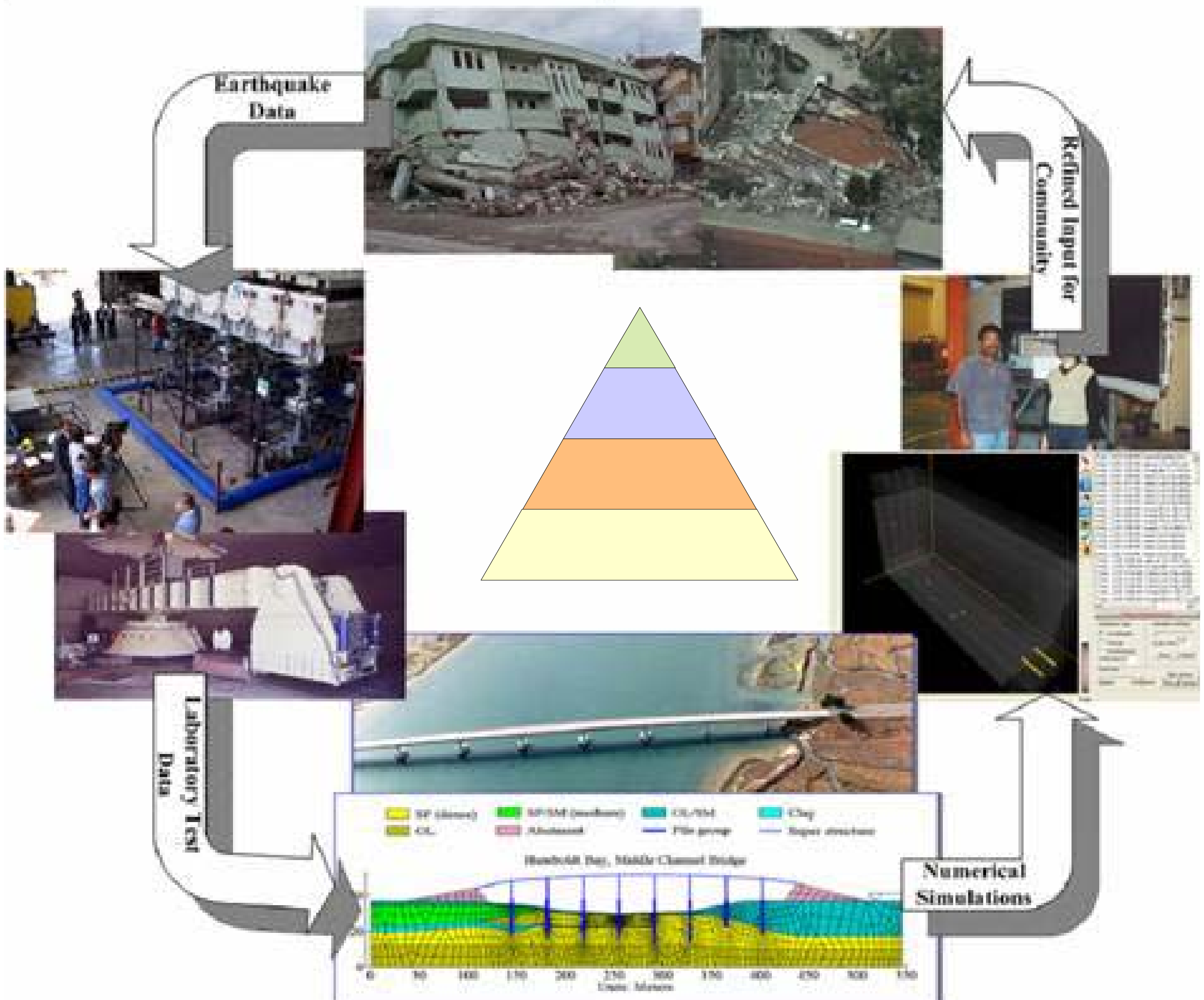
GEER Workshop
UC Berkeley
October 7-8, 2004

# Acknowledgements


- Special thanks to Dr. Cliff Astill, National Science Foundation (Small Grant for Exploratory Research, SGER)

- Many collaborators from the U.S., Japan, Turkey, Taiwan, etc. too numerous to be listed here.

# Post-earthquake reconnaissance and earthquake engineering



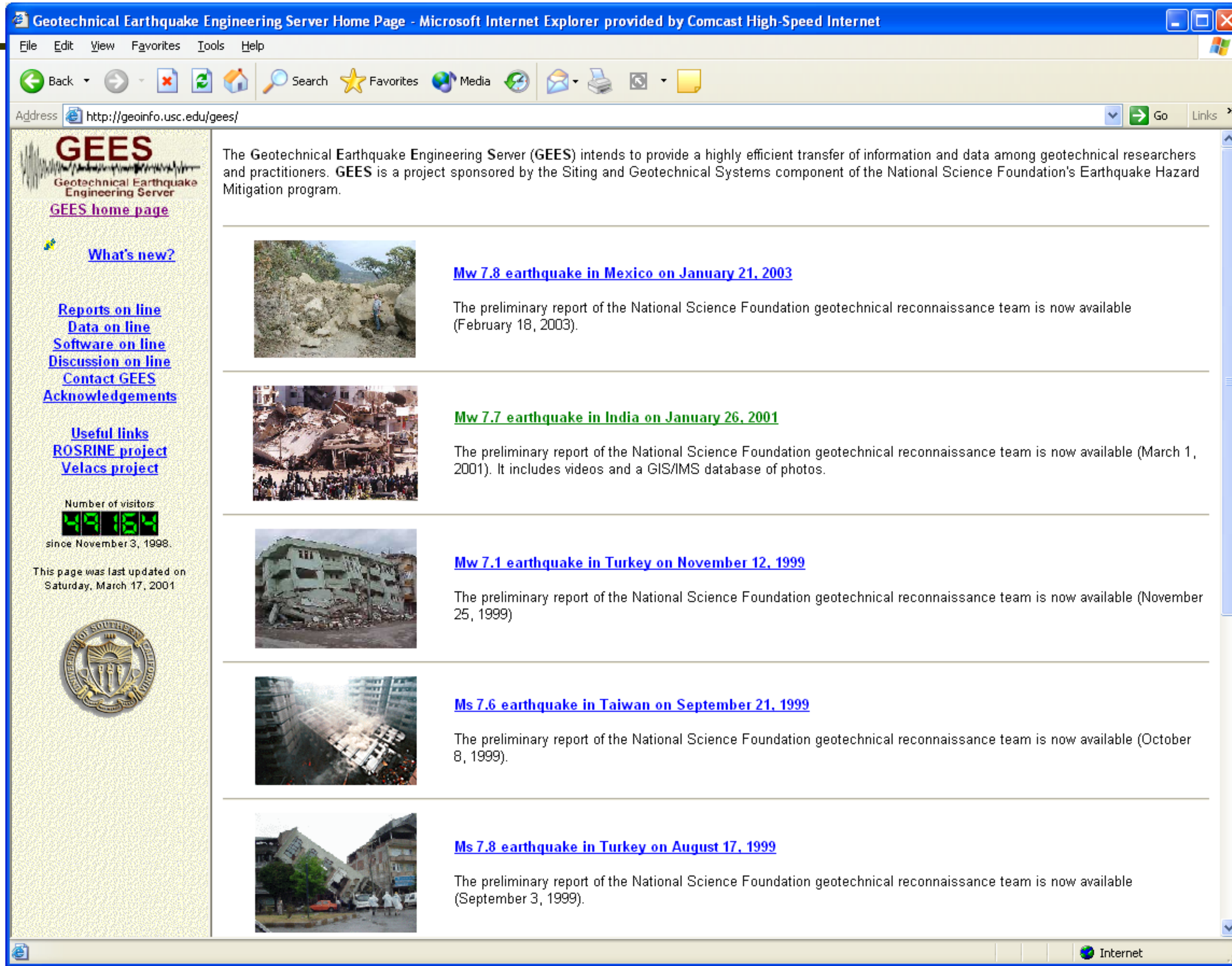

- Post earthquake reconnaissance will continue to impact the field of earthquake engineering, provided it documents scientifically the effects of earthquakes.

# OUTLINE

1. Background: GEES
2. GPS/GIS/Video/Photo Tools
3. NEES Data and Metadata
4. Collaboratory?

# Geotechnical Earthquake Engineering Server

# http://geoinfo.usc.edu/gees

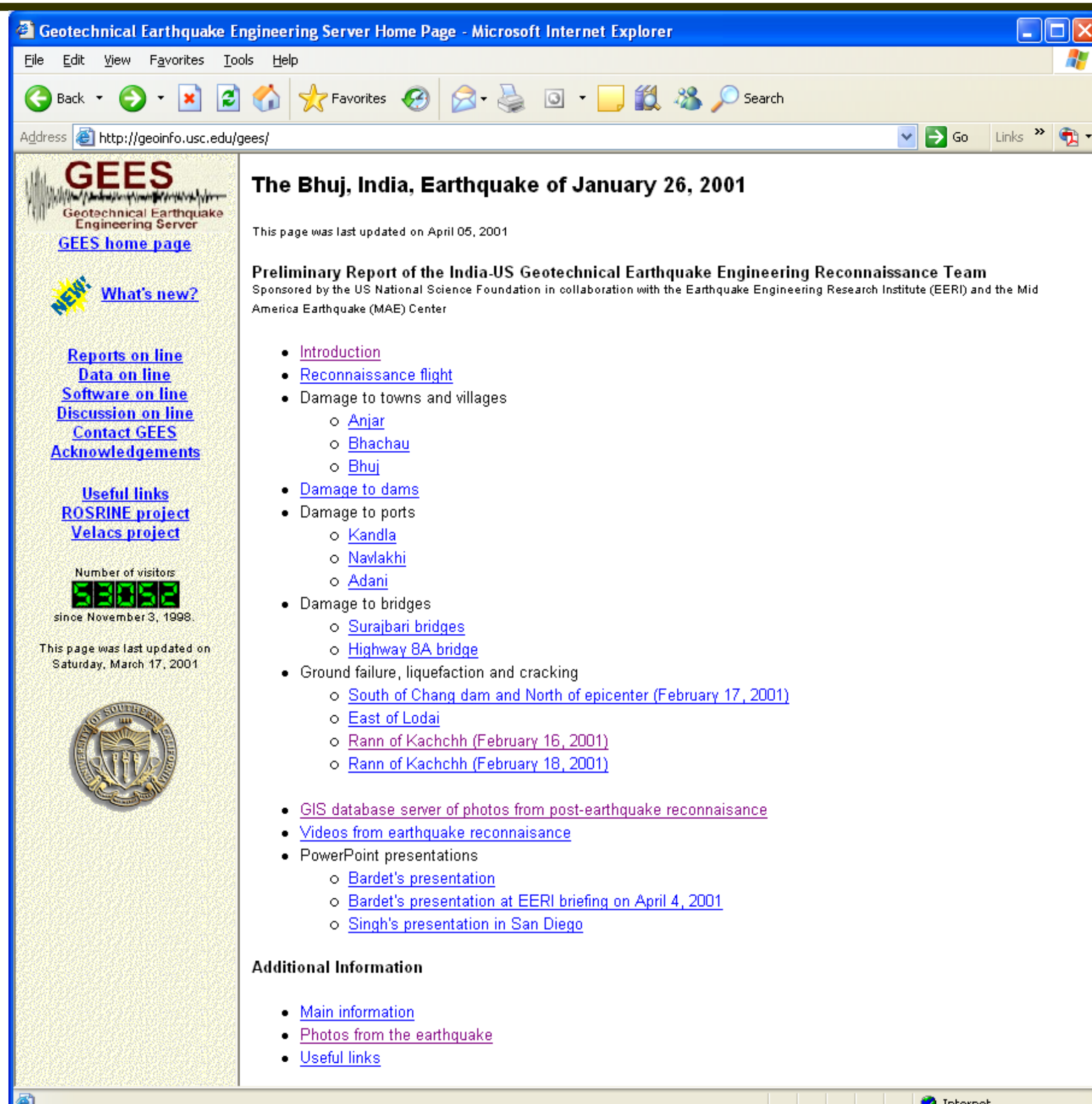


# GEES post-earthquake reconnaissances

| Earthquake name | Earthquake date | Arrival date of Reconnaissance team | Report release date | Days |
|---|---|---|---|---|
| Hyogoken-Nanbu, Japan | 01/17/95 | 01/27/95 | 02/05/95 | 9 |
| Kocaeli, Turkey | 08/17/99 | 08/24/99 | 09/03/99 | 10 |
| Chichi, Taiwan | 09/21/99 | 09/29/99 | 10/08/99 | 9 |
| Ducze, Turkey | 11/12/99 | 11/17/99 | 11/25/99 | 8 |
| Bhuj, India | 01/26/01 | 02/12/01 | 03/01/01 | 17 |

- January 1995 report was one of the first earthquake reconnaissance reports on the Internet (Mosaic was released in 1993).
- Reports have evolved since 1995.

# GEES - India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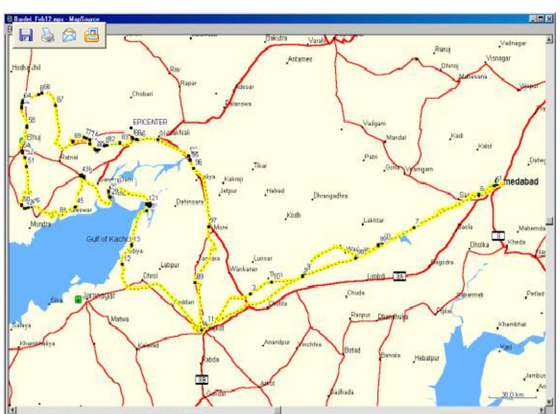
Acknowledgements
Useful links
ROSRINE project
Velacs project
Number of visitors
53052
since November 3, 1998.
This page was last updated on Saturday, March 17, 2001
The Bhuj, India, Earthquake of January 26, 2001
This page was last updated on April 05, 2001
Preliminary Report of the India-US Geotechnical Earthquake Engineering Reconnaissance Team
Sponsored by the US National Science Foundation in collaboration with the Earthquake Engineering Research Institute (EERI) and the Mid America Earthquake (MAE) Center
Introduction
Reconnaissance flight
Damage to towns and villages
Anjar
Bhachau
Bhuj
Damage to dams
Damage to ports
Kandla
Navlakhi
Adani
Damage to bridges
Surajbari bridges
Highway 8A bridge
Ground failure, liquefaction and cracking
South of Chang dam and North of epicenter (February 17, 2001)
East of Lodai
Rann of Kachchh (February 16, 2001)
Rann of Kachchh (February 18, 2001)
GIS database server of photos from post-earthquake reconnaisance
Videos from earthquake reconnaisance
PowerPoint presentations
Bardet's presentation
Bardet's presentation at EERI briefing on April 4, 2001
Singh's presentation in San Diego
Additional Information
Main information
Photos from the earthquake
Useful links
Internet

# GIS-GPS-Photo

Figure 1. In Ahmedabad, the aircraft used for flight over, and the aerial survey reconnaissance team. From left to right, Colonel H. Singh, J. P. Bardet, Capt. Rajiv Nanavaty, and J. P. Singh (2/12/01 6:18:56 PM, N23.06806 E72.61980).



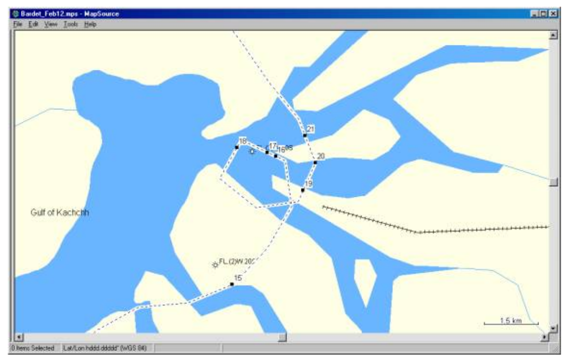



Figure 14. Closeup of tracklog and location of figures in the vicinity of Navalkhi port.

Figure 15. General view of Navalkhi port located in the Gulf of Kachchh, 25 km to the Southeast of Ghandidham (2/12/01 10:48:25 AM, N22.92851 E70.43793).

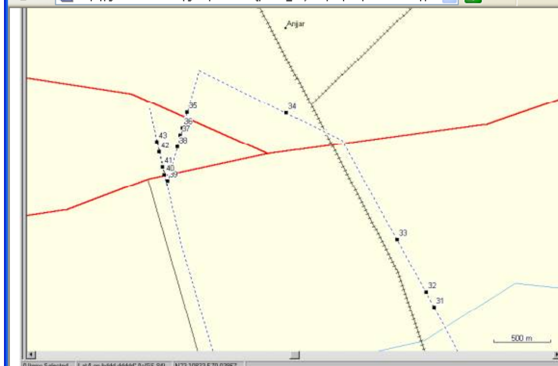
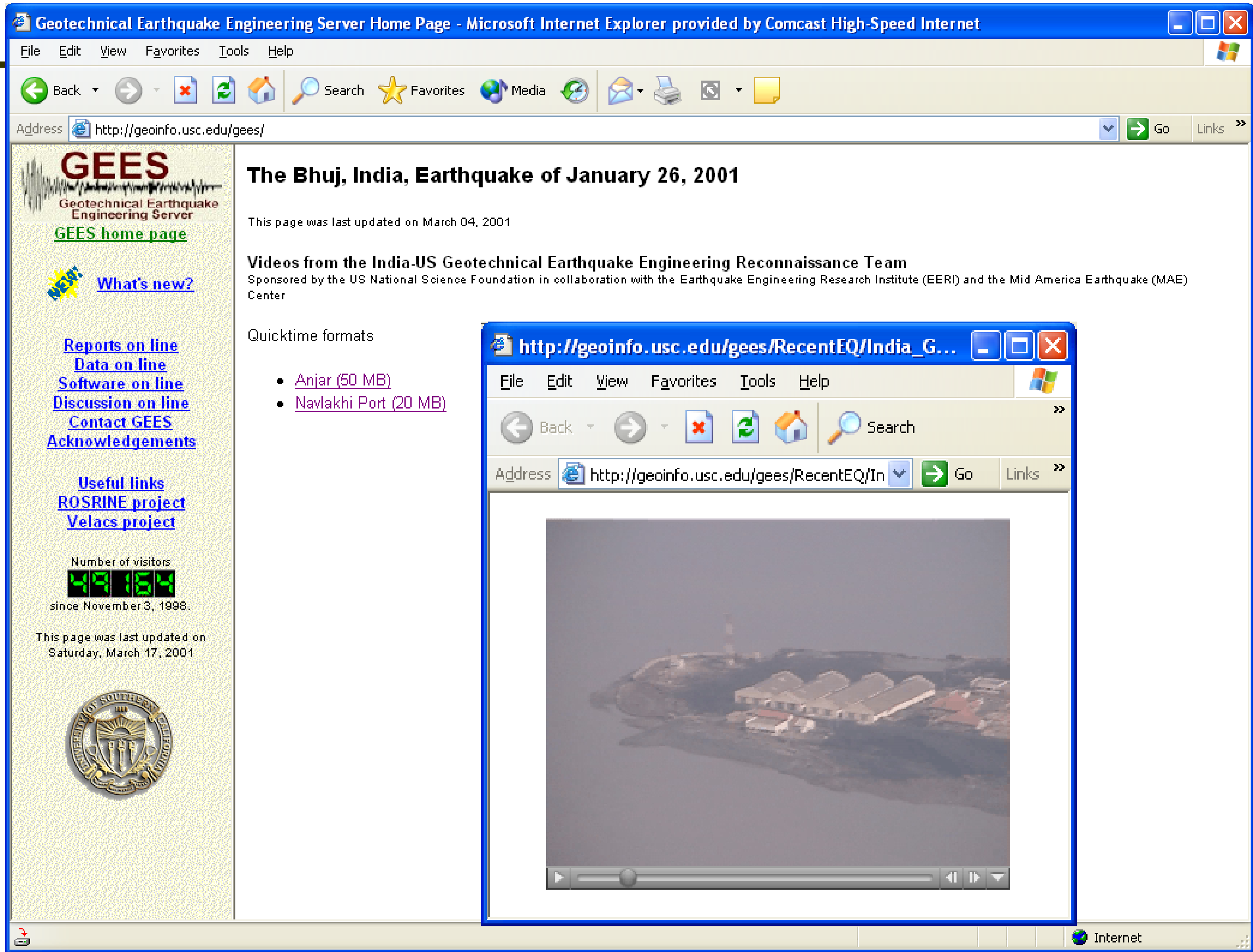



Figure 30. Closeup of tracklog and location of figures in the vicinity of Anjar.

Figure 31. Very few masonry buildings were left standing 2 km to the Southeast of the Anjar (2/12/01 11:14:50 AM, N23.10079 E70.05062).

# Video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Quicktime formats
Anjar (50 MB)
Navlakhi Port (20 MB)
http://geoinfo.usc.edu/gees/RecentEQ/India_G...
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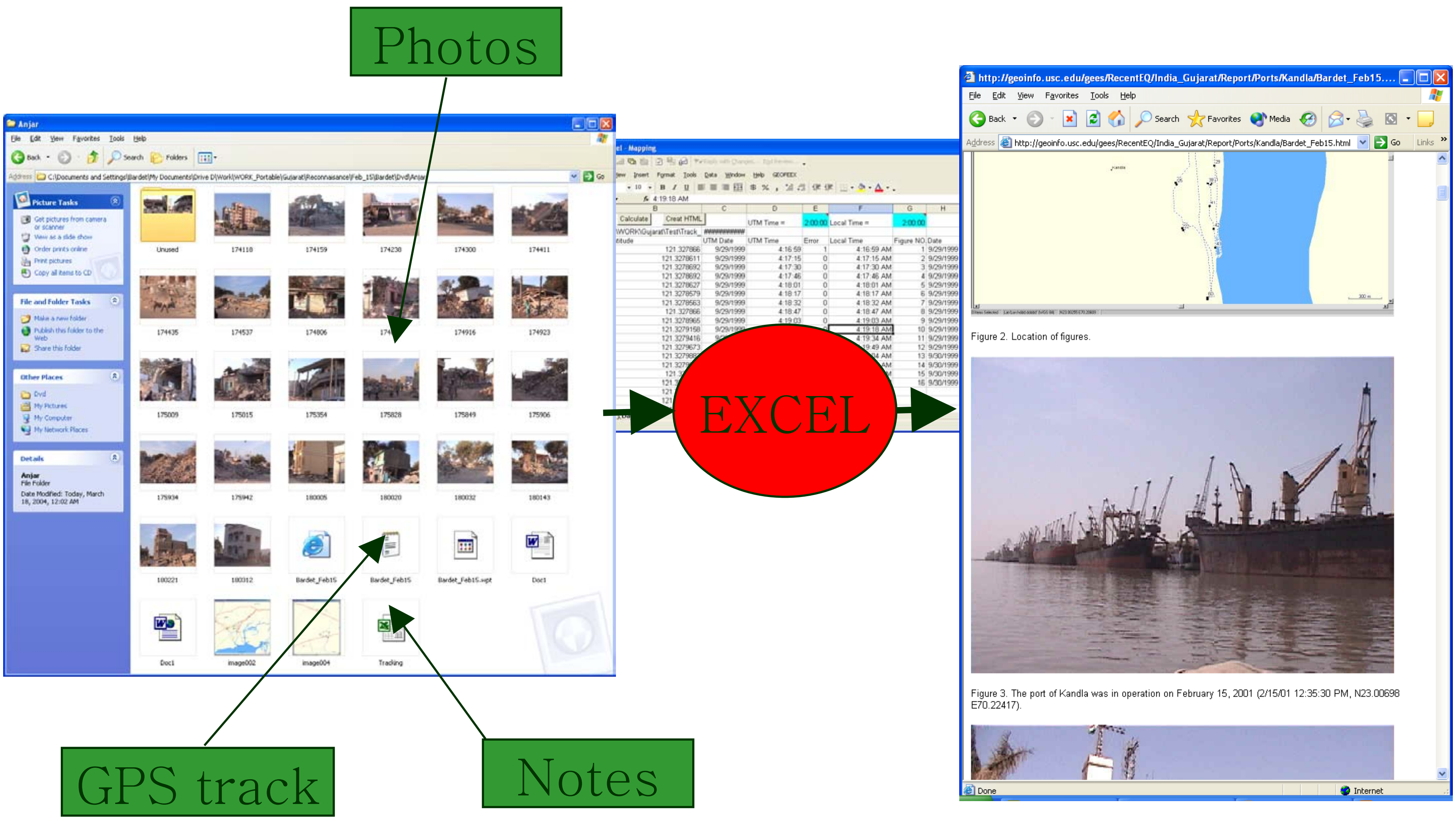
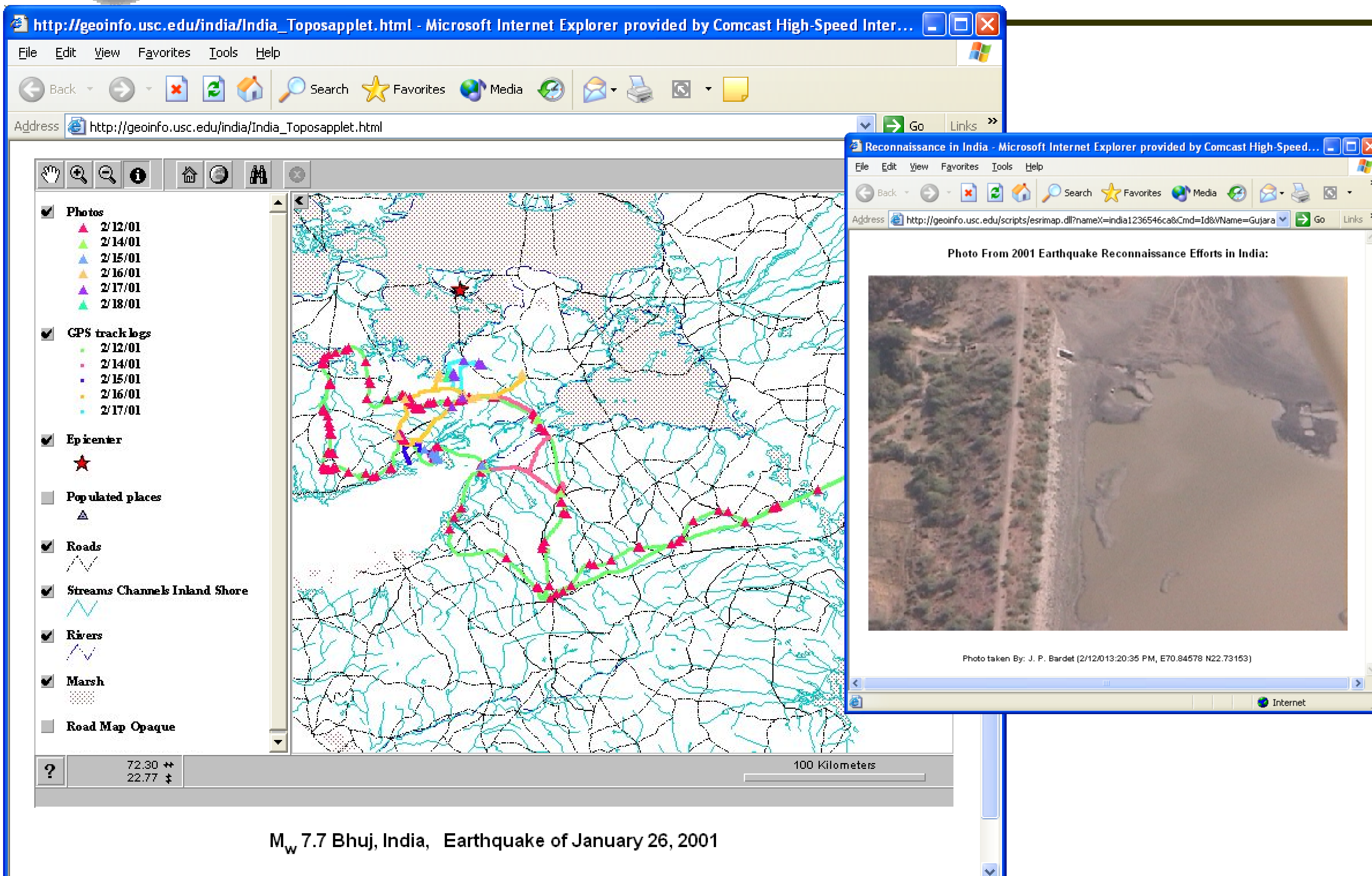
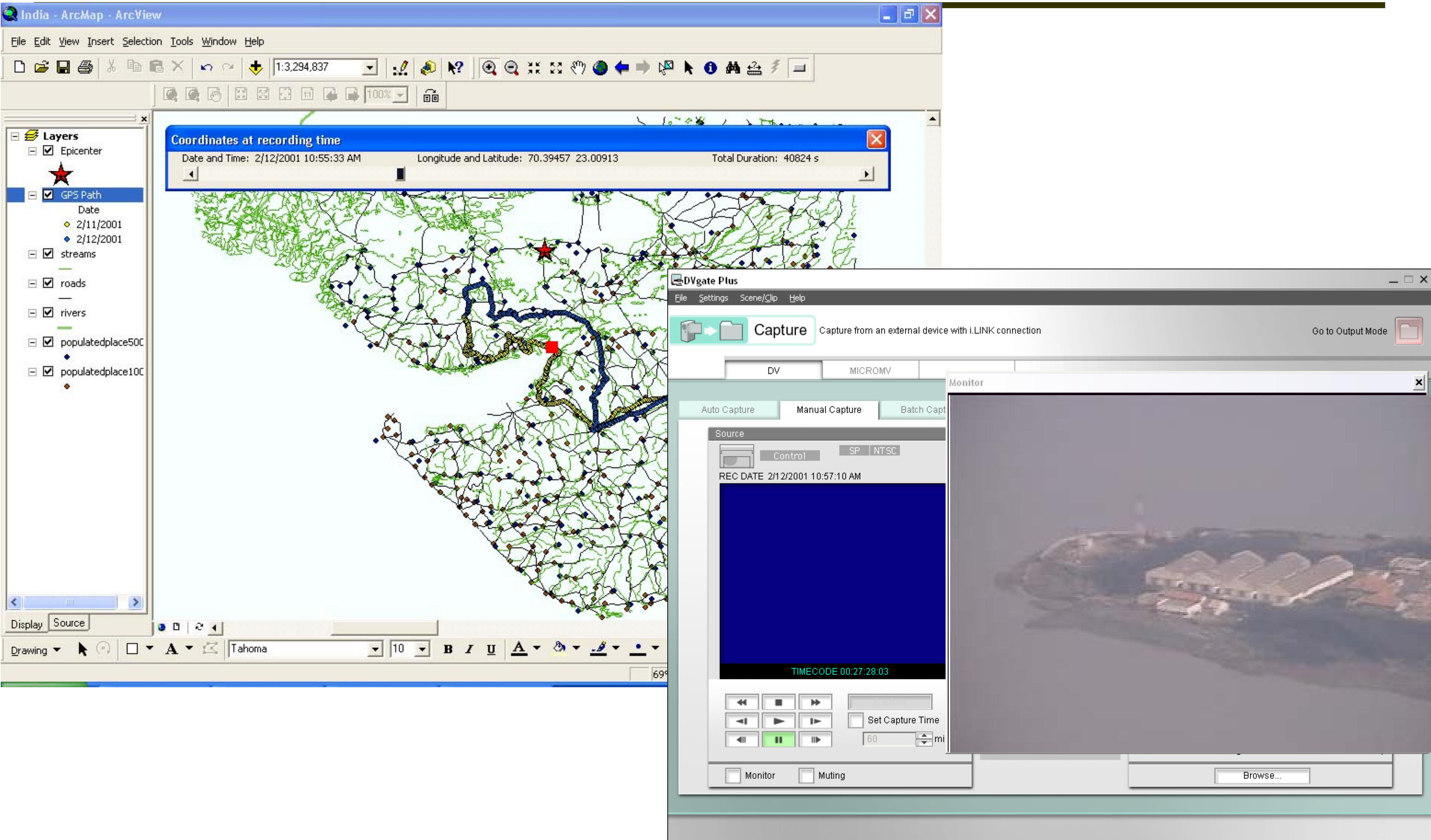
# Web-Report Generation using Excel



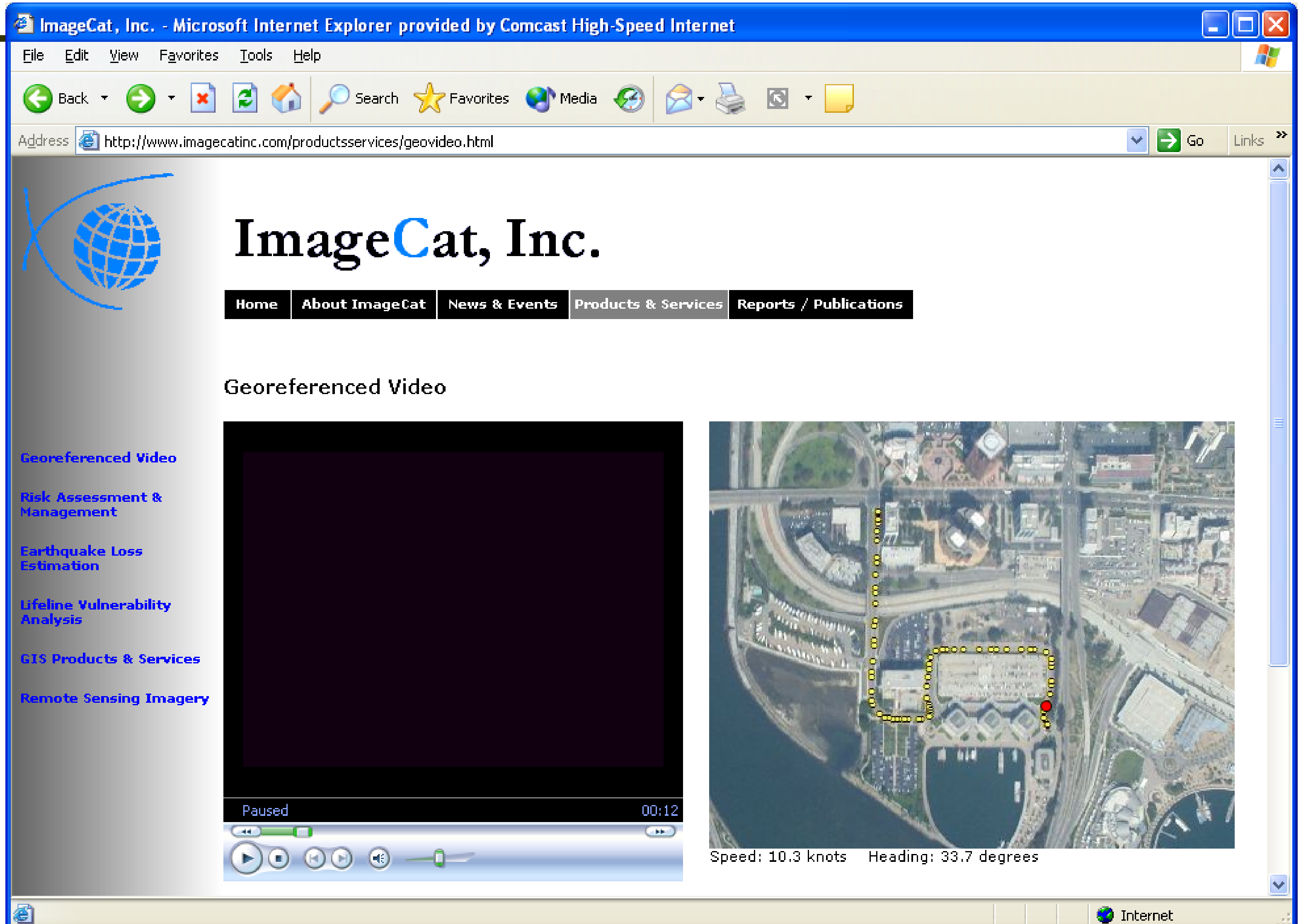
# GIS-IMS-Information integration



# Geo-referencing Videos in the field



# Geo-referenced Video on the Web



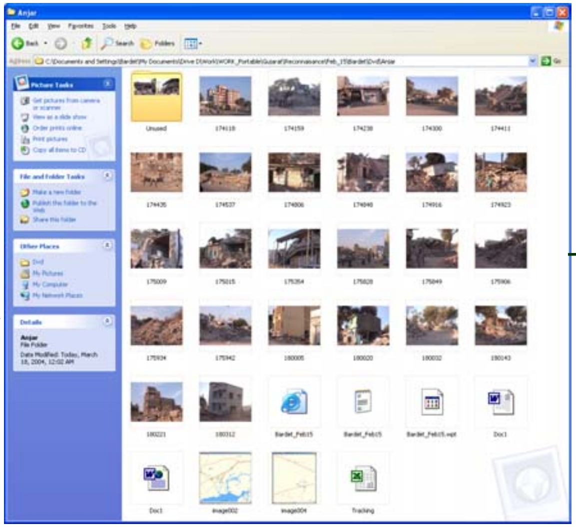
# Need for Metadata Web Reporting

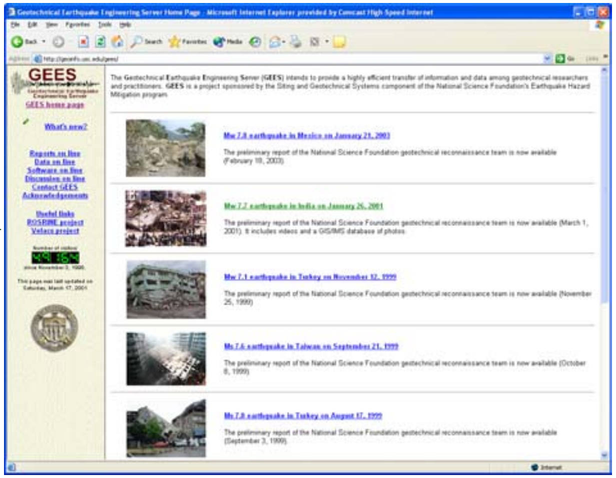
GPS

Photo

Video

Notes

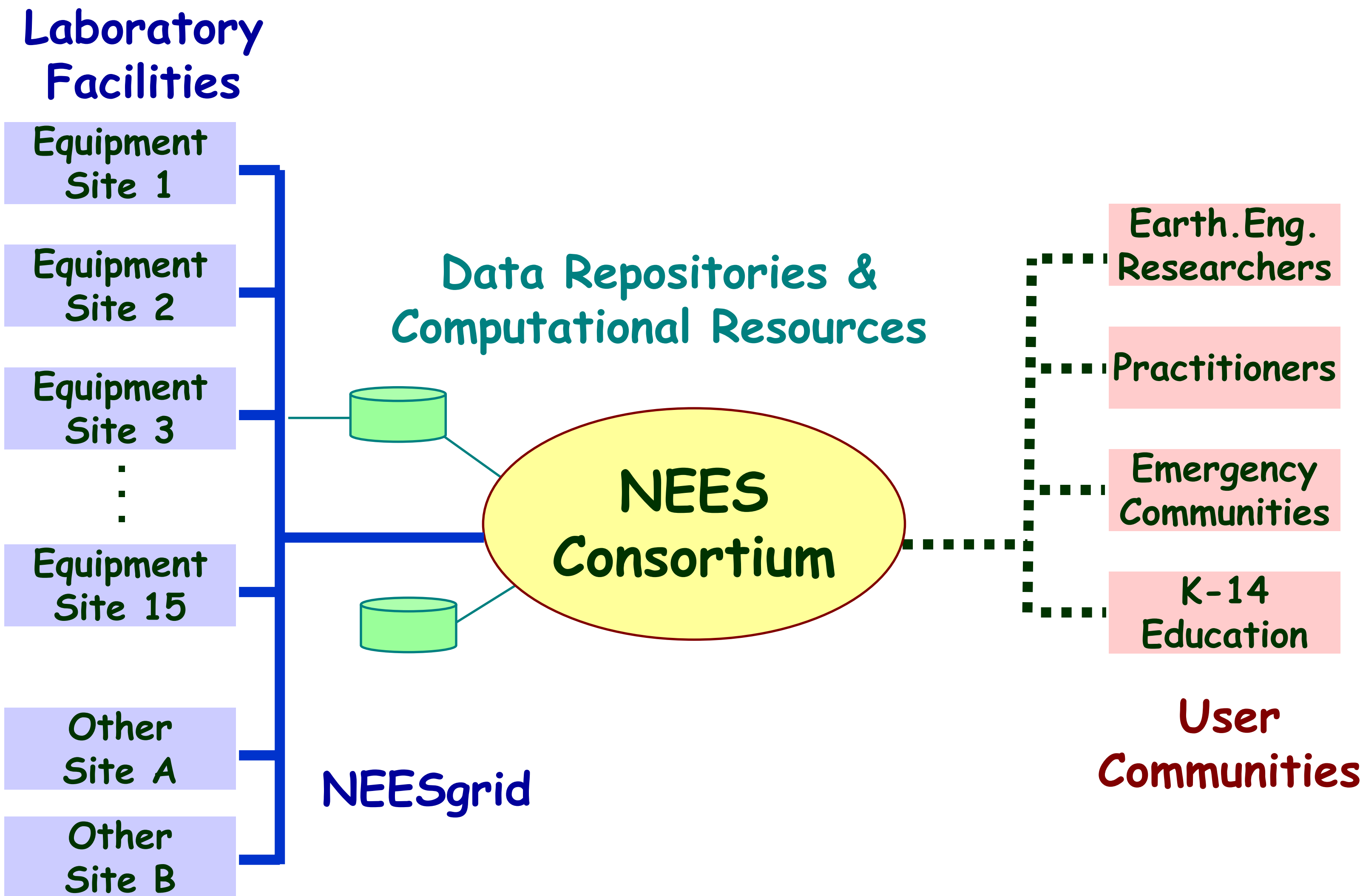




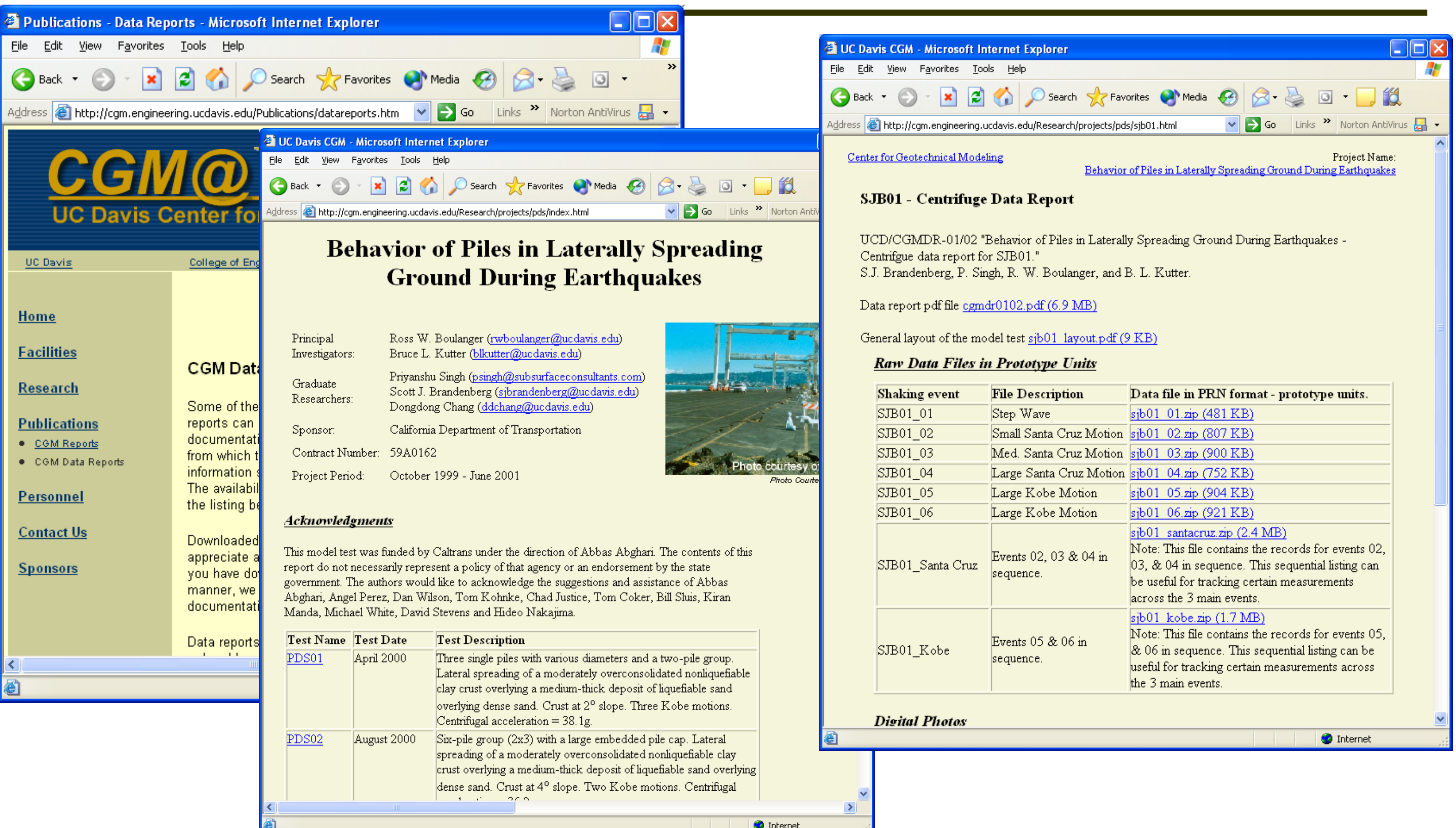
# Why new tools for post-earthquake reconnaissance?

- Capture perishable, relevant, quantitative and qualitative information after earthquakes
- Improve/accelerate dataflow from the field to the digital library and public
  - Integrate various data and tools:
    - Videos
    - Pictures
    - GPS (coordinates and time)
    - Voice
    - Electronic notebooks/PDA data
- Create a reverse dataflow from a command center to the field
  - Satellite imagery/remote sensing data
  - Other information
- Curate information for posterity

# NEES George E. Brown, Jr., Network for Earthquake Engineering Simulation

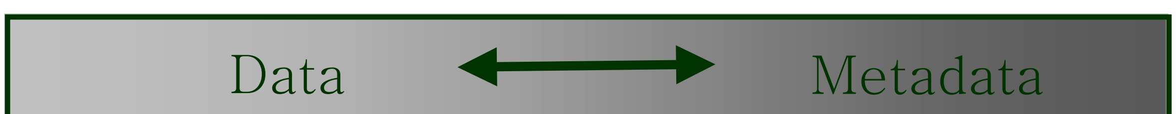


# The NEES Data Experience



# Metadata and Data

- Metadata = data about data
- Metadata has different meanings depending on expertise domains
- In Earthquake Engineering, metadata document the process of data generation so that one can understand how data were obtained
- Metadata models glue together various data
- Fuzzy distinction between data and metadata?



# Data Language: XML and XML Schemas

- The eXtensible Markup Language (XML) (http://www.w3.org/XML/) has become a standard for exchanging data.

- XML is a meta-markup language that consists of a set of rules for creating semantic tags used to describe data
  - <element attribute= …> ….</element>.

- XML
  - wide acceptance from the computer industry, Microsoft, AutoCAD, IBM and Oracle.
  - widely used for defining data models.
  - object-oriented structure and readability extensibility.
  -

- XML Schemas (http://www.w3.org/XML/Schema)
  - provide a means for defining the structure, content and semantics of data models.
  - components such as type definitions and element declarations.
  - used to assess the validity of well-formed attributes, and may specify default values for attributes and attribute types.

- The schema-validity assessment checks the constraints on attributes, and can be used to model the constraints imposed on data models.

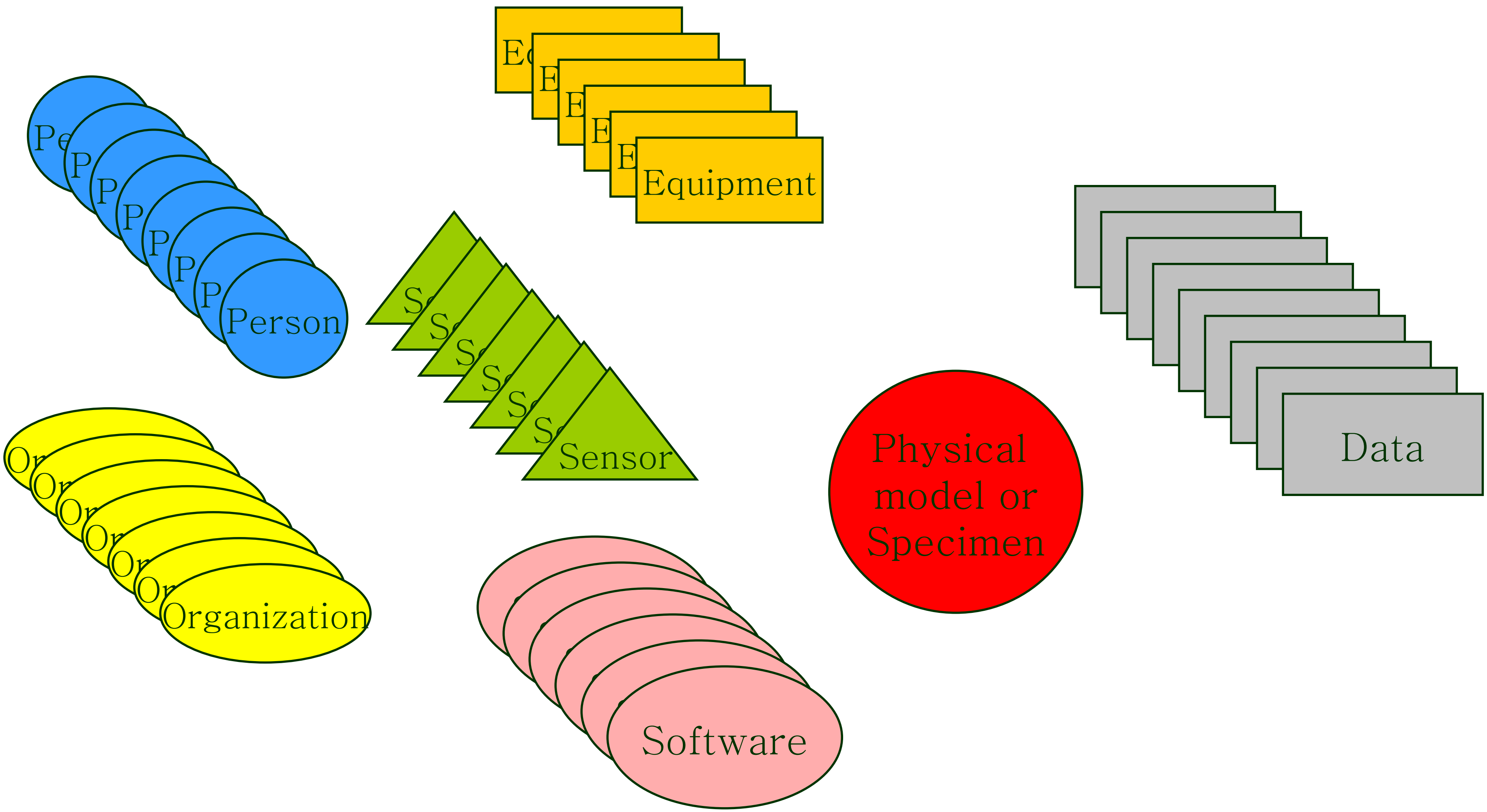
# Metadata Languages: RDF

- RDF = Resource Description Framework (http://www.w3.org/RDF/)
- developed by the World-Wide Web Consortium (W3C),
- Metadata interoperability across different communities.
- RDF provides a Syntax and Schema specification.
- RDF key concepts
  - graph data model
  - URI (Uniform Resource Identifier)-based vocabulary and node identification
  - data types
  - Literals
  - XML serialization syntax
  - expression of simple facts and entailment.
- RDF extends the XML model and syntax for describing resources.
- RDF utilizes the XML namespaces and allows to identify uniquely a set of properties.

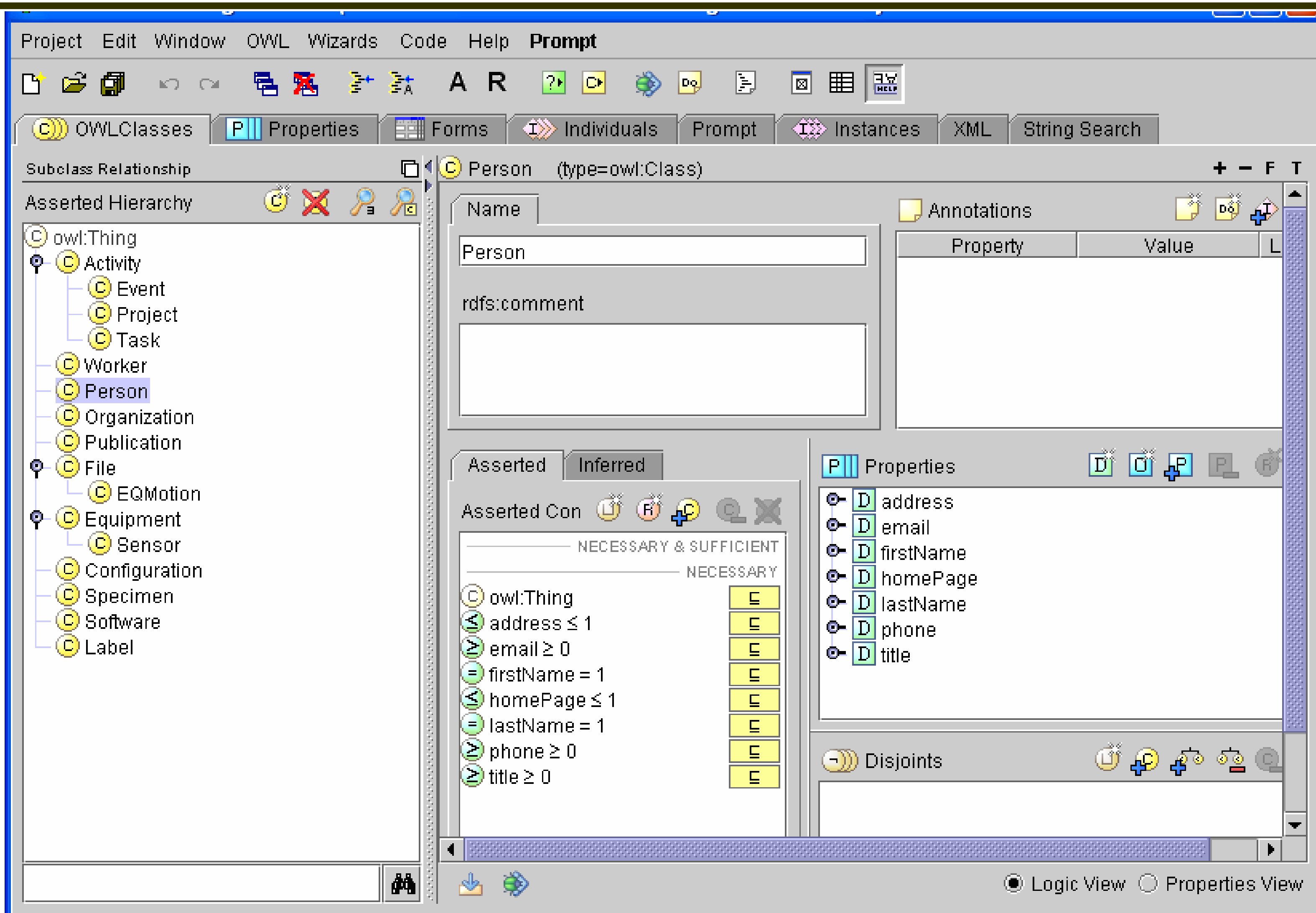
# Metadata Languages: OWL

- Ontologies define a common vocabulary for researchers who need to share information in a technical domain.
- Machine-interpretable definitions of basic concepts in a domain and relations among them.
- Originated in Artificial-Intelligence, ontologies have become common on the World-Wide Web to categorize information on large Web sites (e.g., Yahoo!) and products for sale (e.g., Amazon.com).
- Many disciplines now develop ontologies which domain experts can use to share and annotate information
  - SNOMED in Medicine
- OWL (Web Ontology Language) is for processing the content of information instead of just presenting information to humans.
- OWL facilitates greater machine interpretability of Web content than XML and RDF by providing additional vocabulary and a formal semantics.

# How to define and relate NEES objects



# Metadata modeling using Protégé

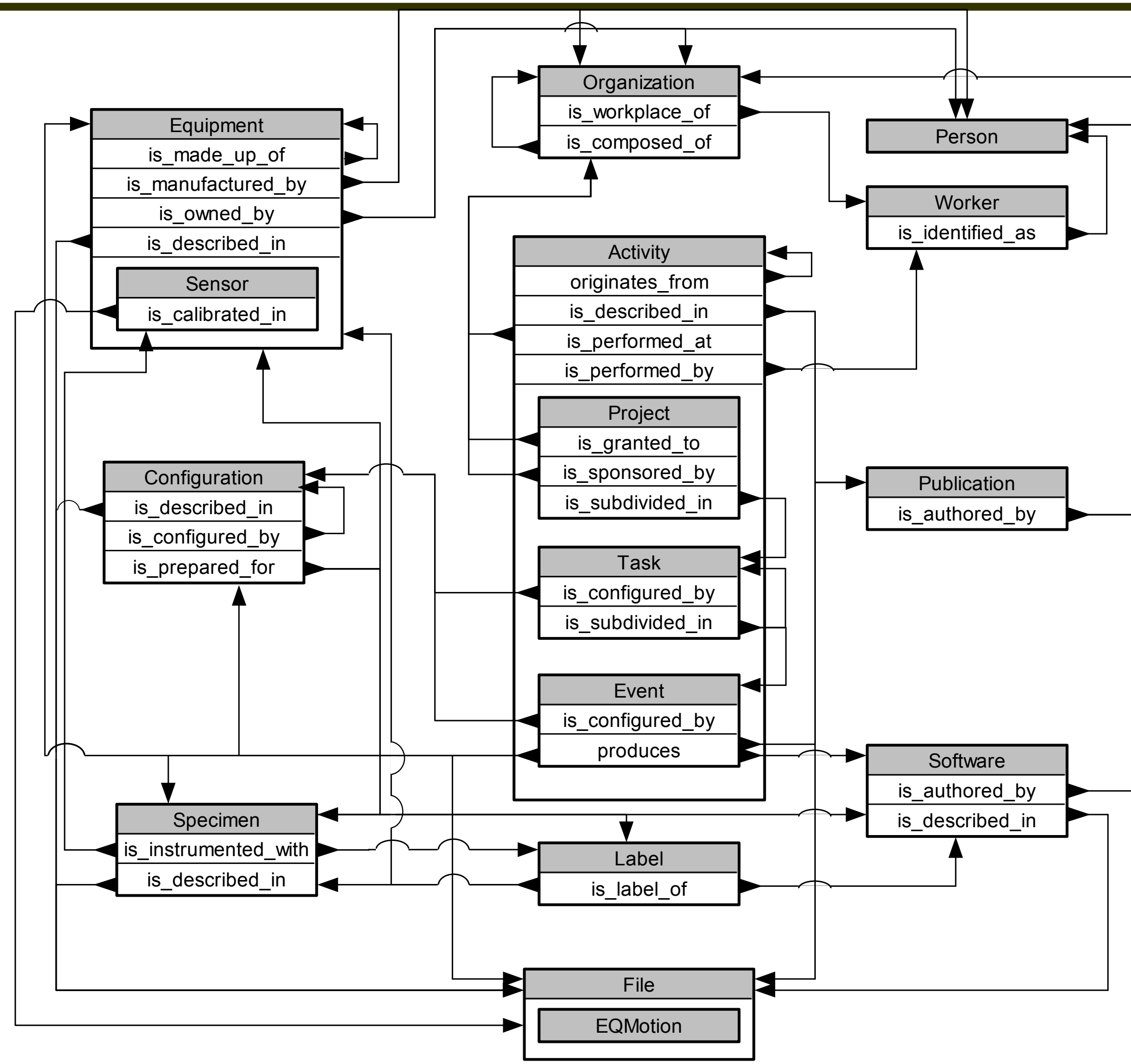


# NEES Metadata Attributes and Relationships

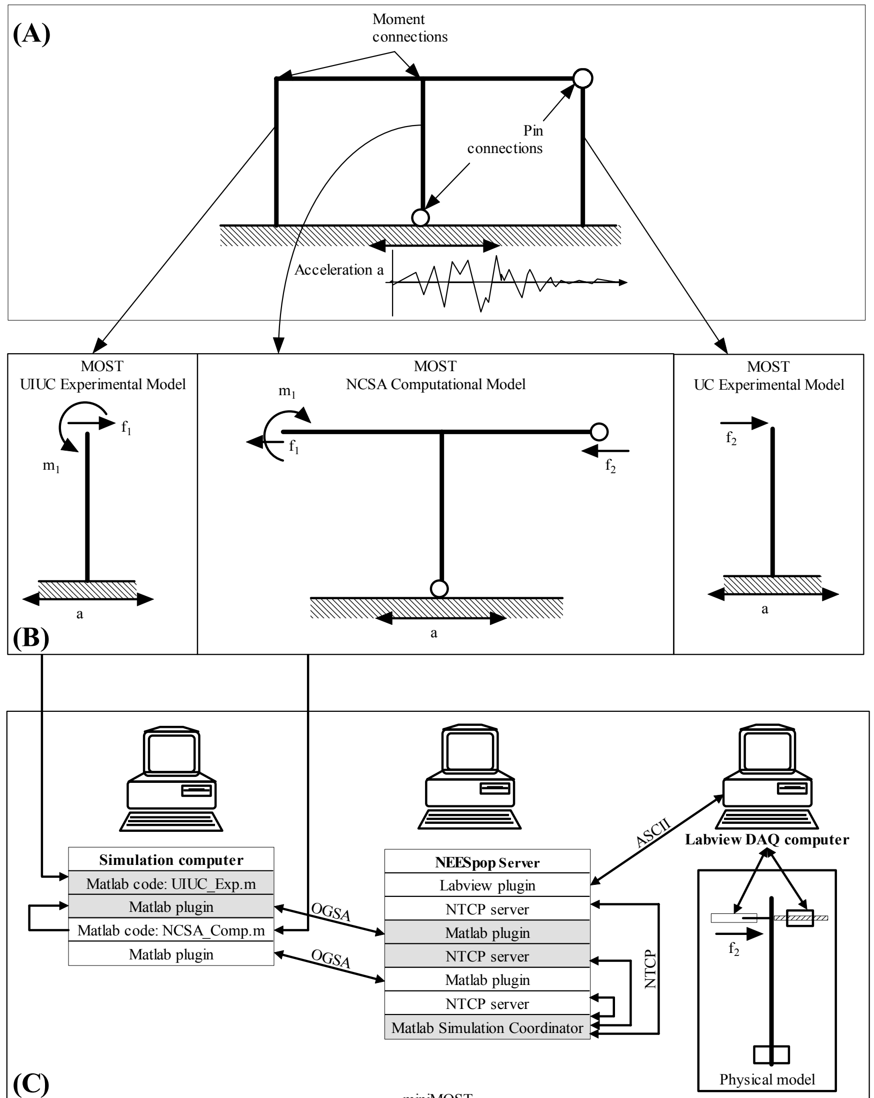
| Attribute | Brief definition | Data type | Used by Class(es) |
|---|---|---|---|
| *acknowledgements* | acknowlegements in a Project | String | Project |
| *address* | mailing address for Person and Organization | String | Person, Organization |
| *contractID* | a contract number different NEESCode | | Project |
| *description* | a descriptive text, consisting of a few sentences and corresponding to name. | String | File, Specimen, Equipment, Sensor, Configuration Organization, Software, Activity, Organization, Publica |
| *email* | email address | | Person |
| *endDate* | date of planned completion for Task and Project | Date | Project, Task |
| *endDateTime* | date and time of actual completion for Event | DateTime | Event |
| *fileType* | type of file | String Enumeration | File |
| *firstName* | first name of a Person | String | Person |
| *homePage* | web page | URI | Person, Organization, Software |
| *keyWords* | key workds characterizing a Project and/or Publication | String | Publication, Project |
| *lastName* | last name of a Person | String | Person |
| *maxValue* | maximum value of time series in earthquake motion file | Float | EQMotion |
| *name* | a short description like a figure caption or a section heading, usually complemented by *description*. | String | File, Organization, Configuration, Activity, Specime |
| *NEESCode* | a code reserved for the NEES consortium | | |
| *objectives* | a list of Projects objectives | | |
| *otherInformation* | additional information for a Sensor | | |
| *partNumber* | model number for equipment | | |
| *phone* | phone number including type of phone | | |
| *publicationYear* | year of publication for a Publication | | |
| *releaseDate* | release date for a Software | | |
| *role* | role of a person in a Site and/or Activity | | |
| *samplingRate* | sampling rate in time series of earthquake motion | | |
| *scaleFactor* | scale factor applied to scale time series of earthquake motion | | |
| *sensorRange* | range of a sensor including units | | |
| *sensorType* | type of sensor | | |
| *serialNumber* | serial number unique to a piece of equipment | | |
| *startDate* | date at the scheduled start of a Project and/ Task | | |
| *startDateTime* | date and time at the actual start of an Event | | |
| *title* | tilte of a Person | | |
| *uom* | unit of measure for the time series in EQMotion | | |
| *URI* | Universal Record Identifier | | |

| Class calling | Attribute | Point to instances of |
|---|---|---|
| Publication, Software | *is_authored_by* | Person, Organization |
| Sensor | *is_calibrated_in* | File |
| Organization | *is_composed_of* | Organization |
| Task, Event, Configuration | *is_configured_by* | Configuration |
| Configuration, Specimen, Software, Equipment, Project, Task, Event | *is_described_in* | File, Publication |
| Worker | *is_identified_as* | Person |
| Project | *is_granted_to* | Organization |
| Specimen | *is_instrumented_with* | Sensor, Label |
| Label | *is_label_of* | Specimen, Equipment, Sensor, Software |
| Equipment | *is_made_up_of* | Equipment |
| Equipment | *is_manufactured_by* | Organization, Person |
| Equipment | *is_owned_by* | Person, Organization |
| Project, Task, Event | *is_performed_at* | Organization |
| Project, Task, Event | *is_performed_by* | Worker |
| Configuration | *is_prepared_for* | Label, Specimen, Equipment, Sensor, Software |
| Project | *is_sponsored_by* | Organization |
| Project, Task | *is_subdivided_in* | Task, Event |
| Organization | *is_workplace_of* | Worker |
| Project, Task, Event | *originates_from* | Project, Task, Event |
| Event | *produces* | File, Software, Specimen, Equipment, Publication, Configuration |

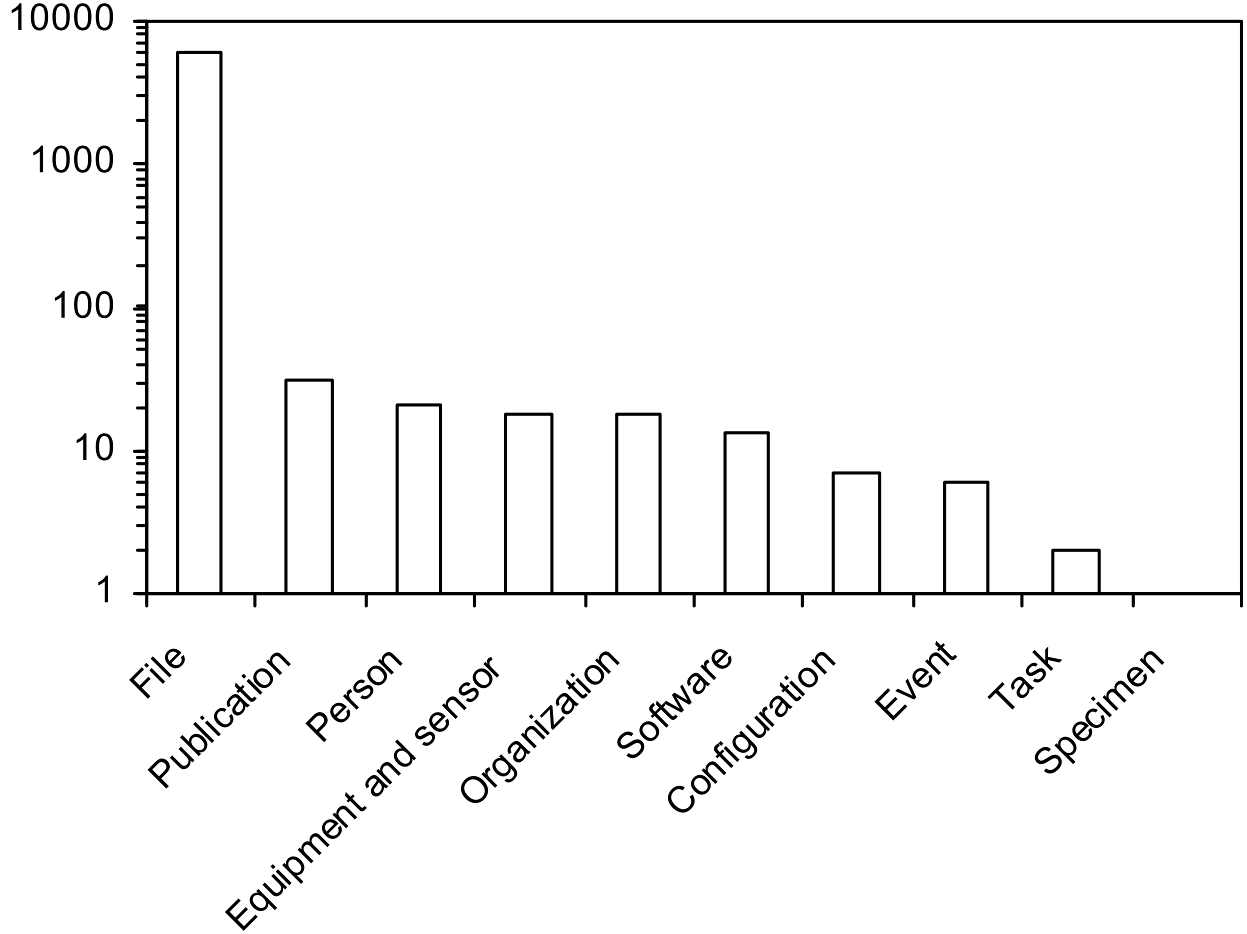
# NEES Metadata Relationships



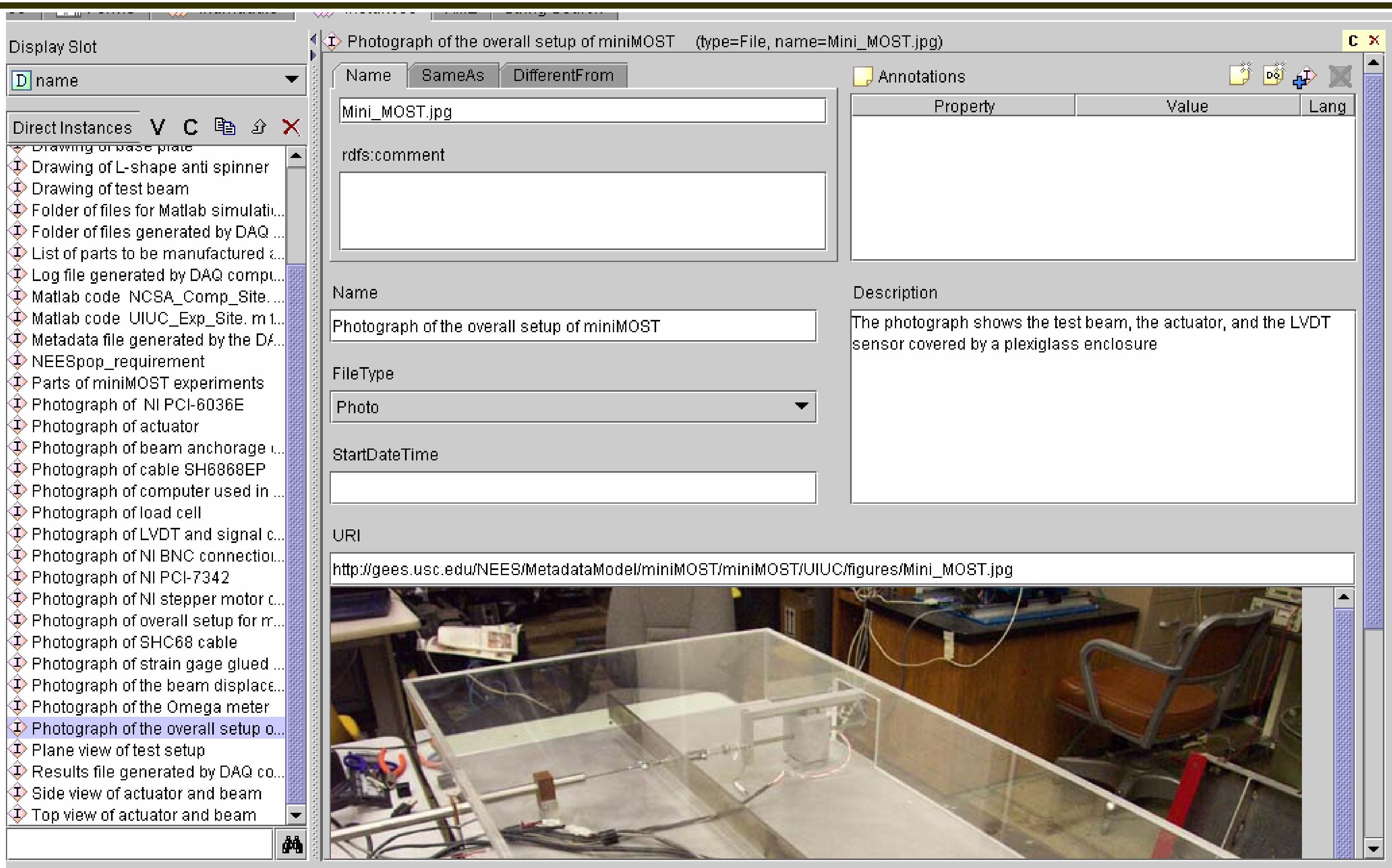
# NEES miniMOST Experiment



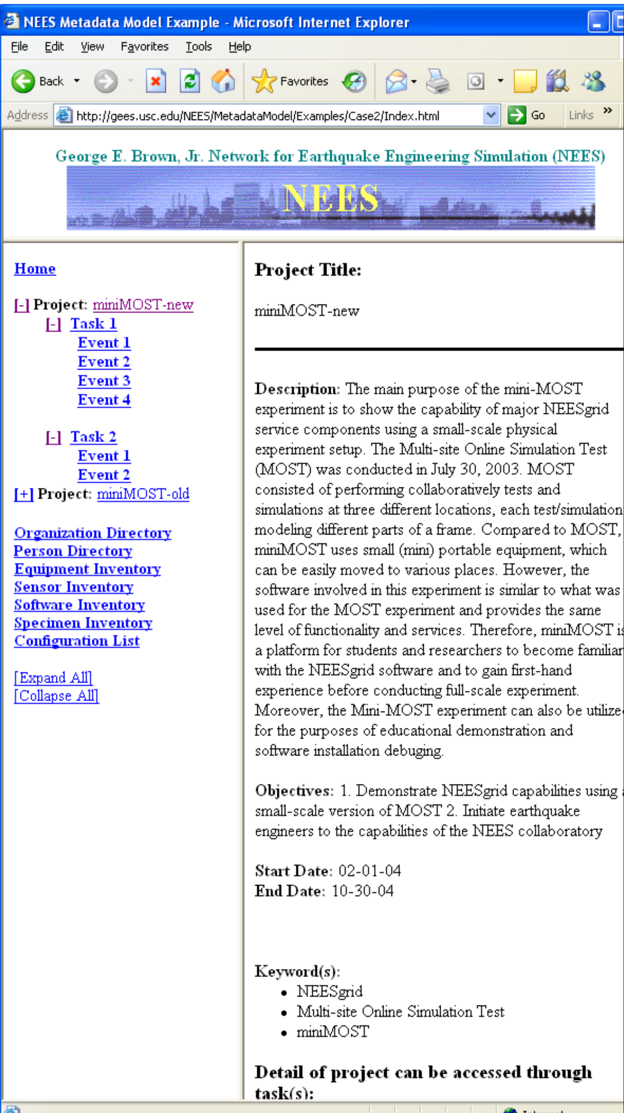
# NEES objects for miniMOST



# NEES miniMOST



# NEES miniMOST Web report



NEES Metadata Model Example - Microsoft Internet Explorer

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Address http://gees.usc.edu/NEES/MetadataModel/Examples/Case2/Index.html

George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES)

NEES

Home

[-] Project: miniMOST-new
- [-] Task 1
  - Event 1
  - Event 2
  - Event 3
  - Event 4
- [-] Task 2
  - Event 1
  - Event 2

[+] Project: miniMOST-old

Organization Directory
Person Directory
Equipment Inventory
Sensor Inventory
Software Inventory
Specimen Inventory
Configuration List

[Expand All]
[Collapse All]

**Project Title:**

miniMOST-new

**Description:** The main purpose of the mini-MOST experiment is to show the capability of major NEESgrid service components using a small-scale physical experiment setup. The Multi-site Online Simulation Test (MOST) was conducted in July 30, 2003. MOST consisted of performing collaboratively tests and simulations at three different locations, each test/simulation modeling different parts of a frame. Compared to MOST, miniMOST uses small (mini) portable equipment, which can be easily moved to various places. However, the software involved in this experiment is similar to what was used for the MOST experiment and provides the same level of functionality and services. Therefore, miniMOST i a platform for students and researchers to become familiar with the NEESgrid software and to gain first-hand experience before conducting full-scale experiment. Moreover, the Mini-MOST experiment can also be utilize for the purposes of educational demonstration and software installation debugging.

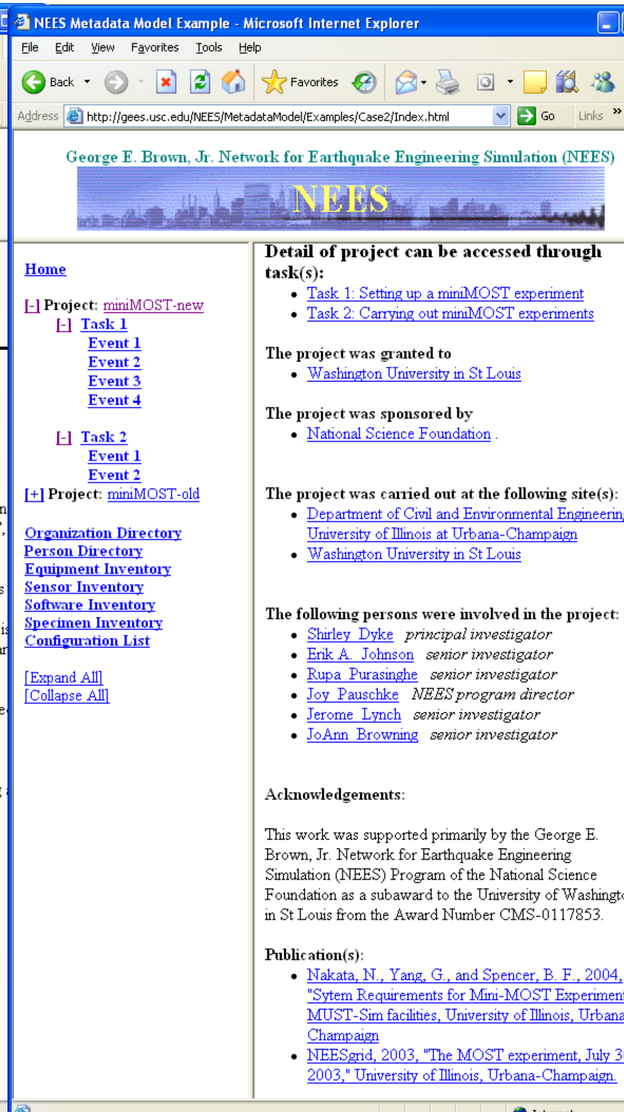
**Objectives:** 1. Demonstrate NEESgrid capabilities using small-scale version of MOST 2. Initiate earthquake engineers to the capabilities of the NEES collaboratory

**Start Date:** 02-01-04
**End Date:** 10-30-04

Keyword(s):
- NEESgrid
- Multi-site Online Simulation Test
- miniMOST

**Detail of project can be accessed through task(s):**

Internet



NEES Metadata Model Example - Microsoft Internet Explorer

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Address http://gees.usc.edu/NEES/MetadataModel/Examples/Case2/Index.html

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NEES

Home

[-] Project: miniMOST-new
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- [-] Task 2
  - Event 1
  - Event 2

[+] Project: miniMOST-old

Organization Directory
Person Directory
Equipment Inventory
Sensor Inventory
Software Inventory
Specimen Inventory
Configuration List

[Expand All]
[Collapse All]

**Detail of project can be accessed through task(s):**
- Task 1: Setting up a miniMOST experiment
- Task 2: Carrying out miniMOST experiments

**The project was granted to**
- Washington University in St Louis

**The project was sponsored by**
- National Science Foundation .

**The project was carried out at the following site(s):**
- Department of Civil and Environmental Engineering University of Illinois at Urbana-Champaign
- Washington University in St Louis

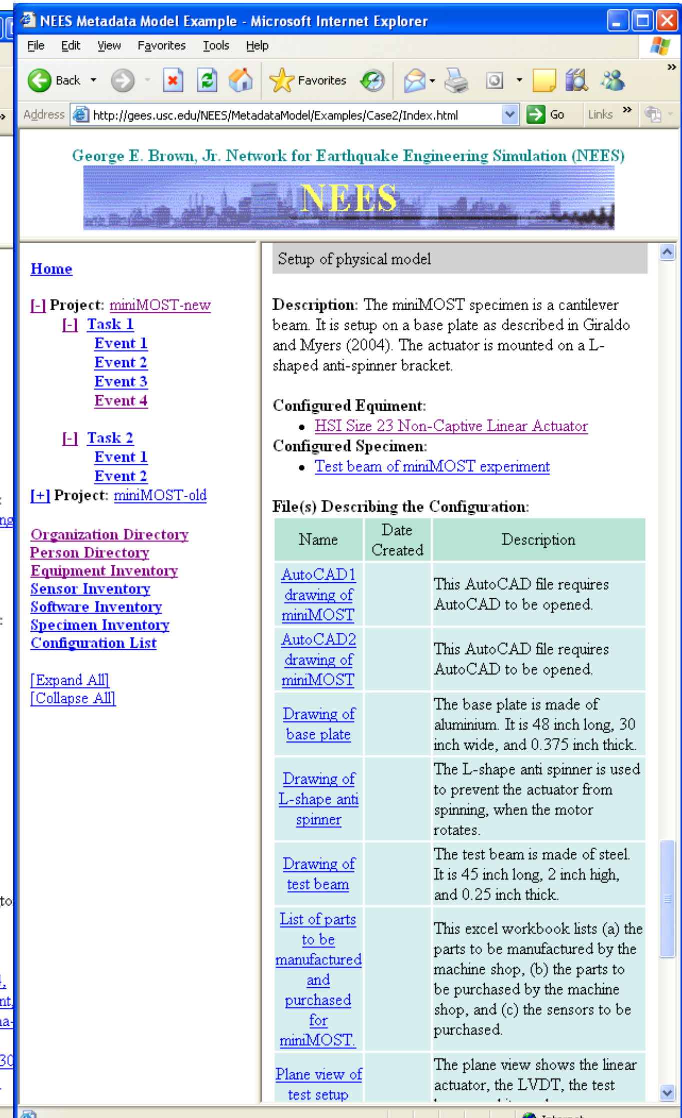
**The following persons were involved in the project:**
- Shirley Dyke *principal investigator*
- Erik A. Johnson *senior investigator*
- Rupa Purasinghe *senior investigator*
- Joy Pauschke *NEES program director*
- Jerome Lynch *senior investigator*
- JoAnn Browning *senior investigator*

Acknowledgements:

This work was supported primarily by the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) Program of the National Science Foundation as a subaward to the University of Washingto in St Louis from the Award Number CMS-0117853.

**Publication(s):**
- Nakata, N., Yang, G., and Spencer, B. F., 2004, "Sytem Requirements for Mini-MOST Experiment MUST-Sim facilities, University of Illinois, Urbana-Champaign
- NEESgrid, 2003, "The MOST experiment, July 30 2003," University of Illinois, Urbana-Champaign.

Internet



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NEES

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  - Event 4
- [-] Task 2
  - Event 1
  - Event 2

[+] Project: miniMOST-old

Organization Directory
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[Expand All]
[Collapse All]

Setup of physical model

**Description:** The miniMOST specimen is a cantilever beam. It is setup on a base plate as described in Giraldo and Myers (2004). The actuator is mounted on a L-shaped anti-spinner bracket.

**Configured Equiment:**
- HSI Size 23 Non-Captive Linear Actuator

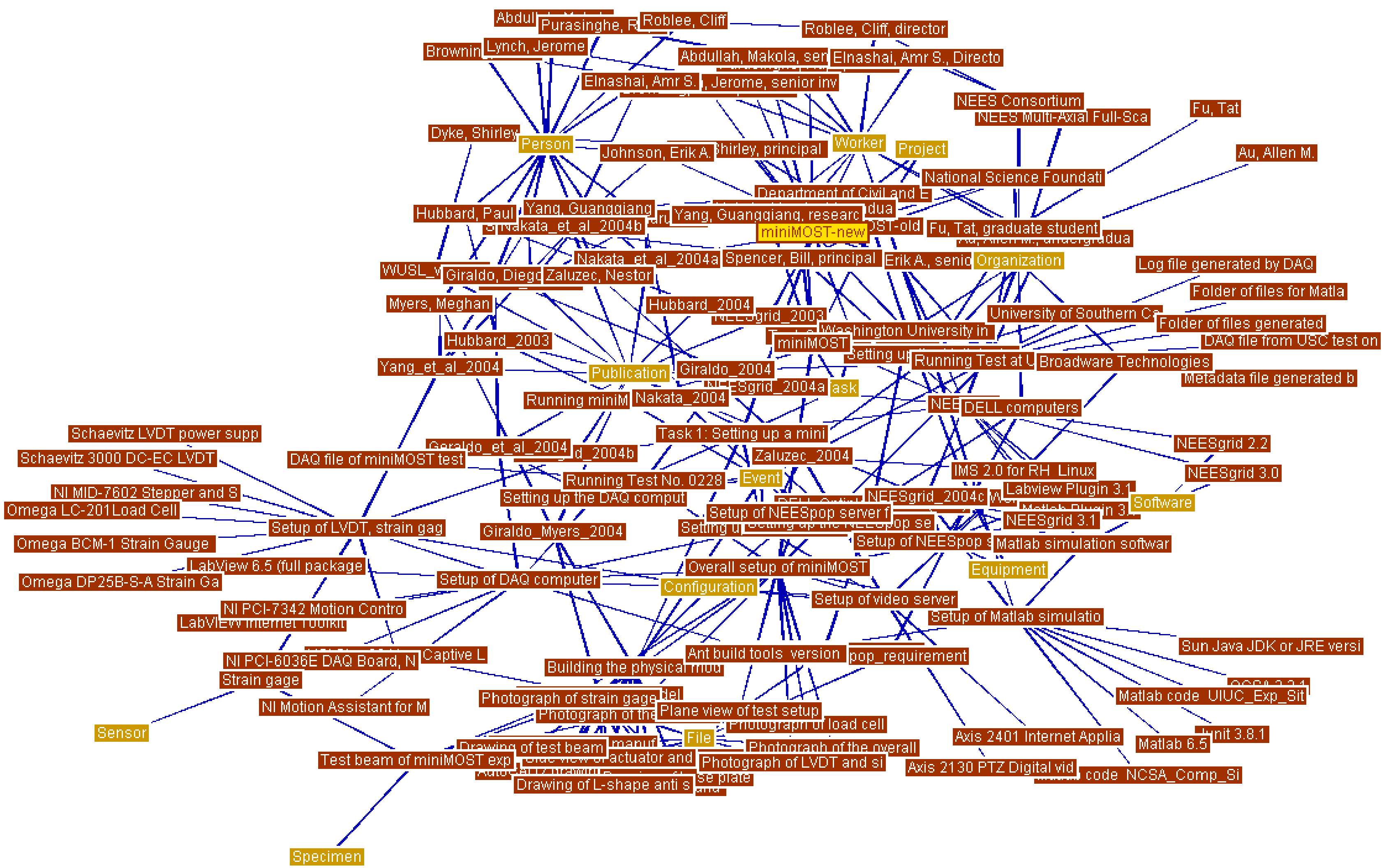
**Configured Specimen:**
- Test beam of miniMOST experiment

**File(s) Describing the Configuration:**

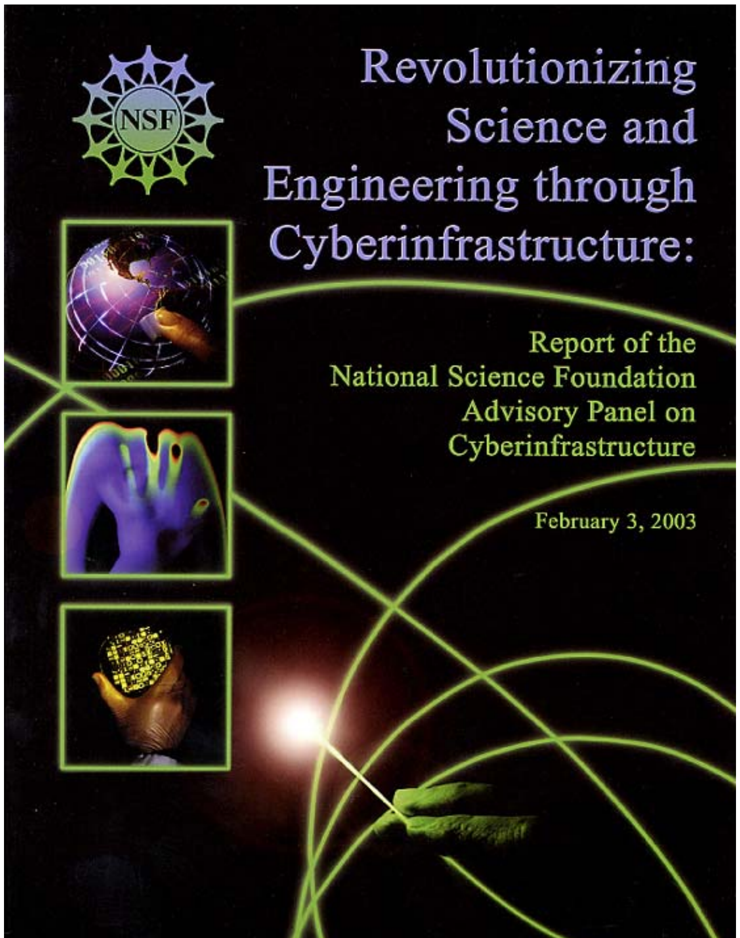
| Name | Date Created | Description |
|---|---|---|
| AutoCAD1 drawing of miniMOST | | This AutoCAD file requires AutoCAD to be opened. |
| AutoCAD2 drawing of miniMOST | | This AutoCAD file requires AutoCAD to be opened. |
| Drawing of base plate | | The base plate is made of aluminium. It is 48 inch long, 30 inch wide, and 0.375 inch thick. |
| Drawing of L-shape anti spinner | | The L-shape anti spinner is used to prevent the actuator from spinning, when the motor rotates. |
| Drawing of test beam | | The test beam is made of steel. It is 45 inch long, 2 inch high, and 0.25 inch thick. |
| List of parts to be manufactured and purchased for miniMOST | | This excel workbook lists (a) the parts to be manufactured by the machine shop, (b) the parts to be purchased by the machine shop, and (c) the sensors to be purchased. |
| Plane view of test setup | | The plane view shows the linear actuator, the LVDT, the test |

Internet

# NEES miniMOST Relationships



# The Atkins Report

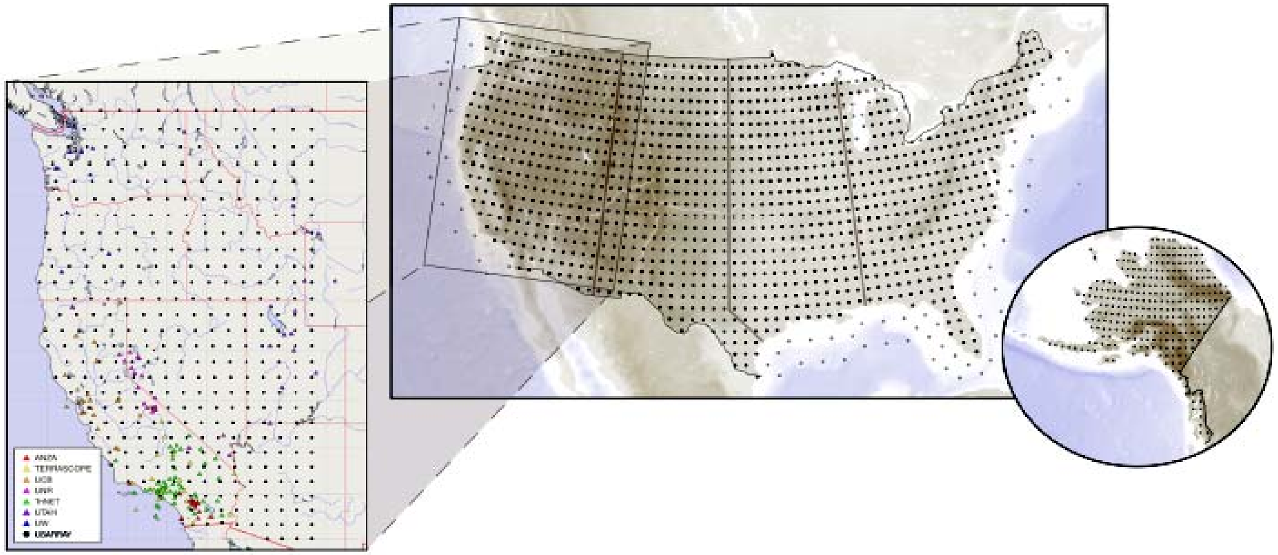



Vision:

- to provide an integrated system of hardware and software resources and services that
- enables scientists and engineers to explore important research and education opportunities *that otherwise would not be possible.*

**Daniel E. Atkins, Panel Chair, Michigan   http://www.cise.nsf.gov/evnt/reports/toc.htm**

# Collaboratory: Earthscope



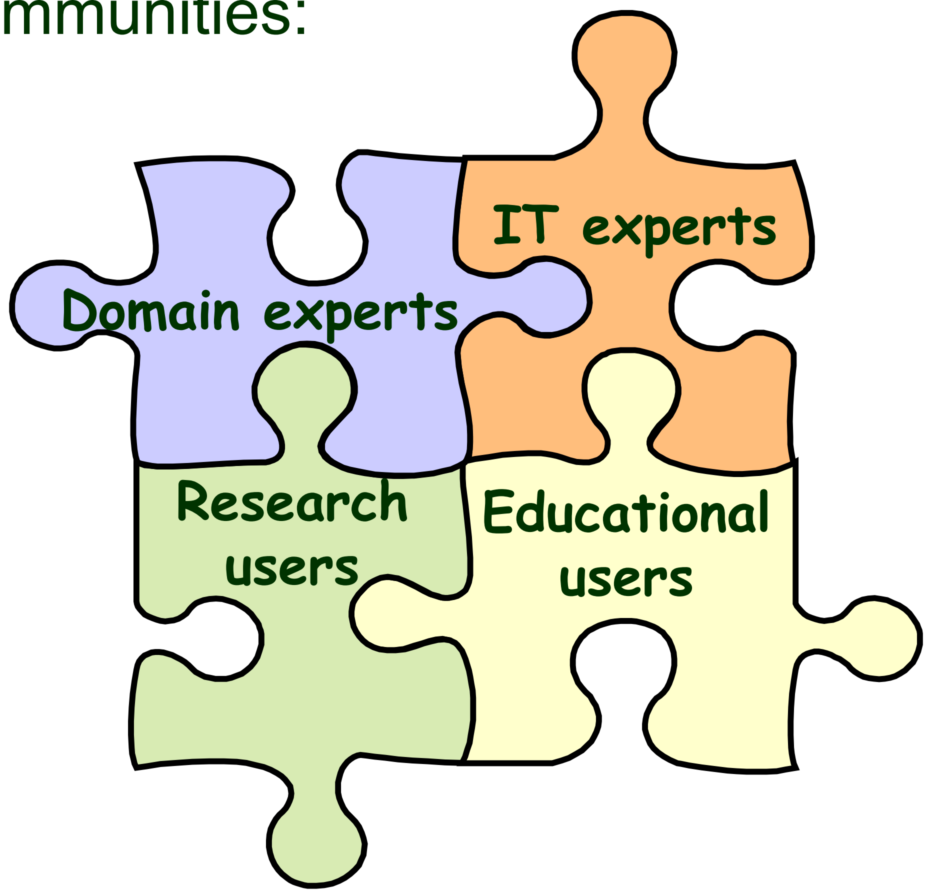
- Explore the underlying geologic structures of north America.
- Generate basic scientific understanding of the evolution of the north American continent.
- Combined with new satellite and GPS systems, EarthScope will provide a dynamic picture of forces and processes that shape the earth, including those that control earthquakes and volcanic eruptions
- EarthScope will enhance the fundamental understanding necessary for improved experimentation, simulation and prediction through NEES.

# Lessons Learned From NEES

CyberInfrastructure is fundamentally a “human problem.”

Projects must engage all key communities:

- IT experts
  - ✓ Know what is possible
  - ✓ Can exploit IT advances
- Domain experts
  - ✓ Know what’s appropriate
  - ✓ Can help avoid pitfalls
- Researchers and educational users
  - ✓ Understand priorities
  - ✓ Ultimately determine if infrastructure is usable



# Conclusions/ Discussion Topics (1/2)

- Post-earthquake reconnaissance reports have evolved since 1994.
- Have we sufficiently preserved the information/data collected from past earthquakes? Can our students re-experience what we discovered in the field?
- The volume of information collected from earthquake reconnaissance will increase drastically in the future. How will we cope with it?
- Recommendation: Develop metadata/data models that capture time-stamped and geo-referenced events from various tools and ingest them into comprehensive data sets for immediate use by field researchers and later on for digital libraries.

# Conclusions/ Discussion Topics (2/2)

- Field investigators need more efficient reconnaissance tools with transparent data logging.
- Recommendations:
  - Improve/simplify tools for post-earthquake reconnaissance
  - Create a communication center/digital library with downloadable information needed by earthquake reconnaissance, e.g., maps, GPS maps, PDA, laptop tools
  - Create a reverse dataflow from a command center to the field
- Coordinate post-earthquake reconnaissance with NEES data repository, other collaboratory and digital library.
- What about a GEER collaboratory?