Geohazards in Transportation
in the Appalachian Region

August 5, 2009
Lexington, KY

Seismic Hazard Mitigation of Transportation Structures

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Department of Civil Engineering, and
Kentucky Transportation Center

University of Kentucky
Lexington, Kentucky USA

Outline

- Introduction
- Hazard Mitigation
- Conclusions

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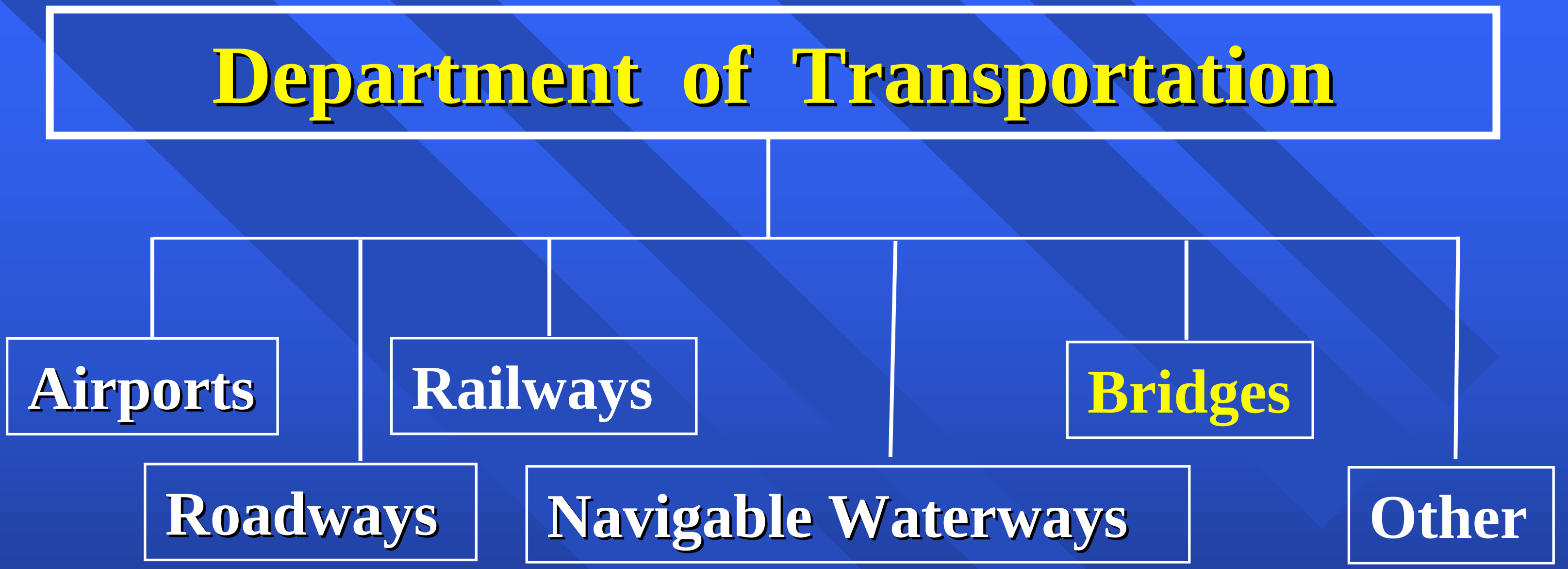
- **Introduction**
  - Hazard Mitigation
  - Conclusions

Disaster and Emergency Management


Department of Transportation
Airports
Roadways
Railways
Navigable Waterways
Bridges
Other

Hazards on Bridges and Highway Structures

- Man-Made Hazards
- Natural Hazards

Man-Made Hazard

A man-made hazard is an accidental or intentional event of unusual magnitude that threatens the activities of people or people themselves.

Man-Made Hazards

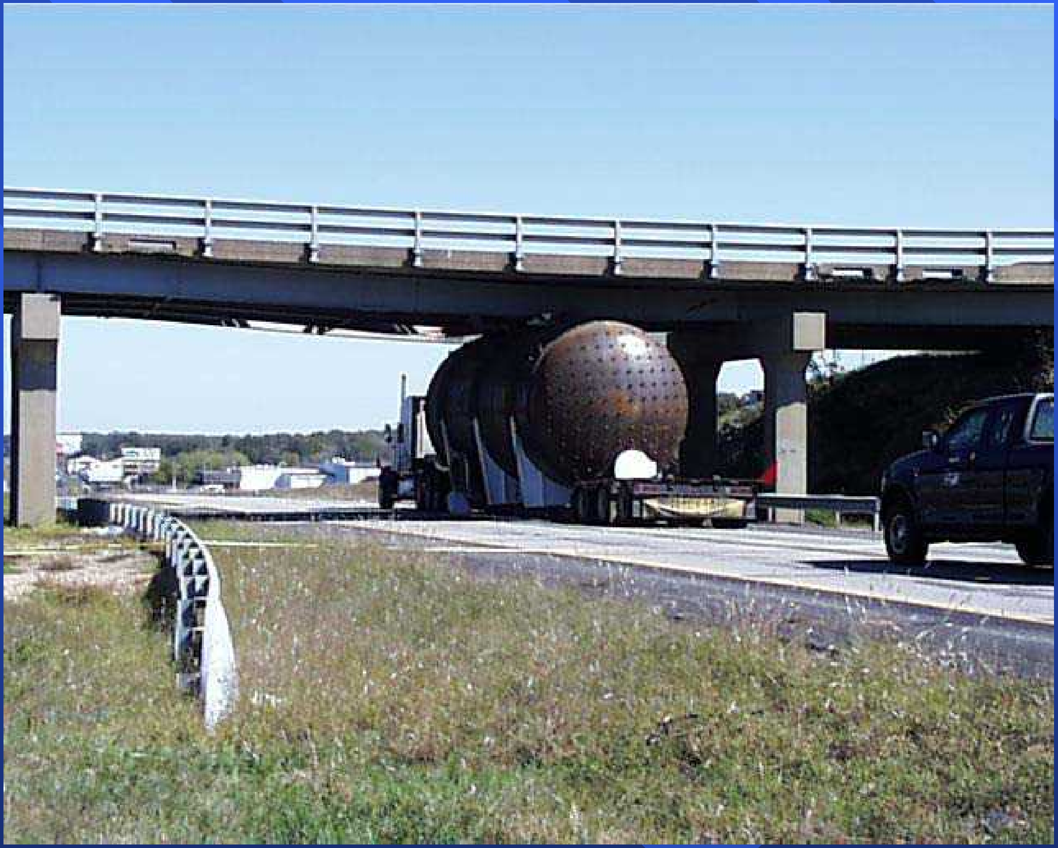
- Biological
- Blast
- Chemical
- Fire
- Impact
- Nuclear
- War
- Other


Pike County, Kentucky, USA

Pike County, Kentucky, USA

Pike County, Kentucky, USA

Truck Impact



I-44, Lebanon, Missouri

Truck Impact

I-44, Lebanon, Missouri

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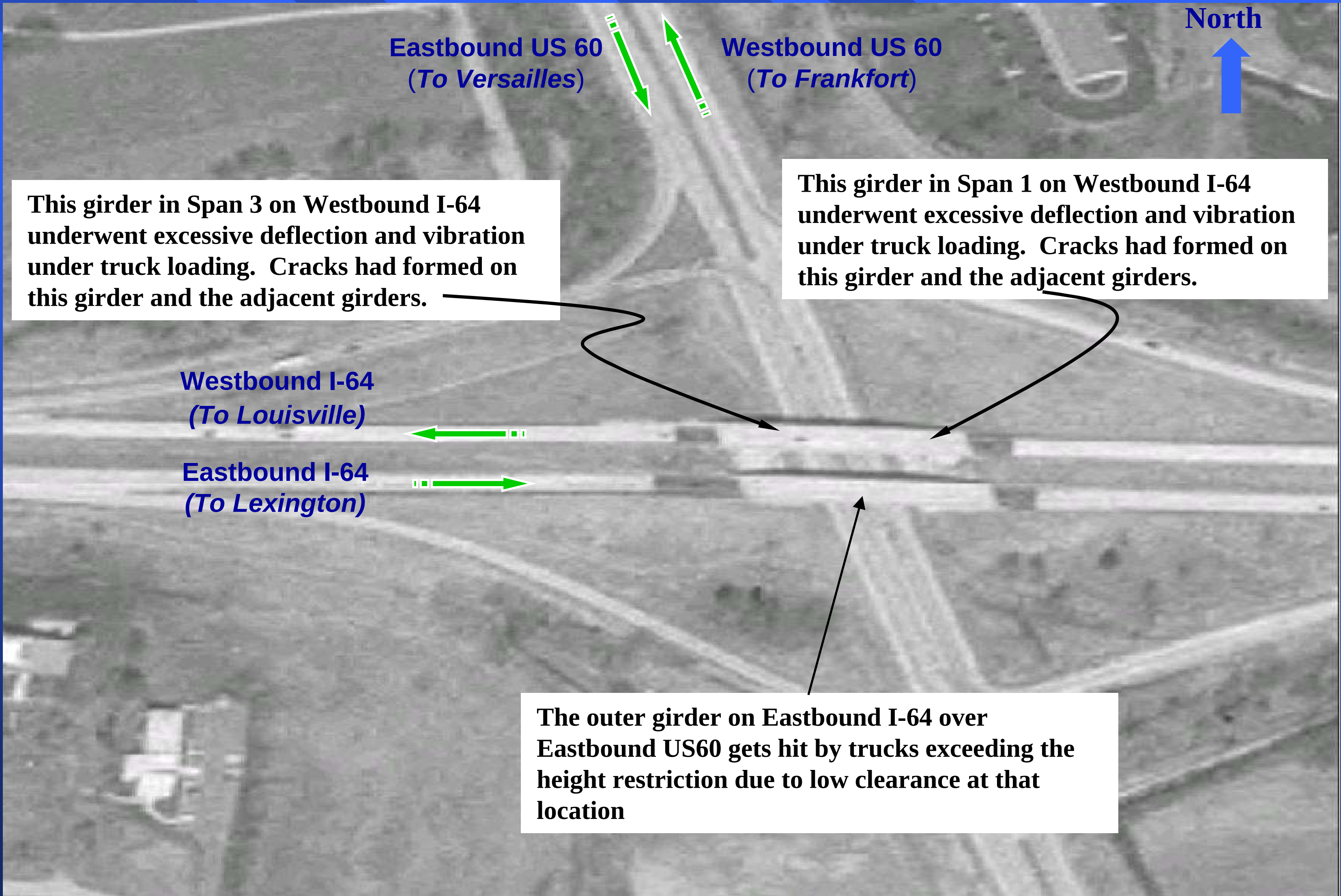
Truck Impact

I-44, Lebanon, Missouri

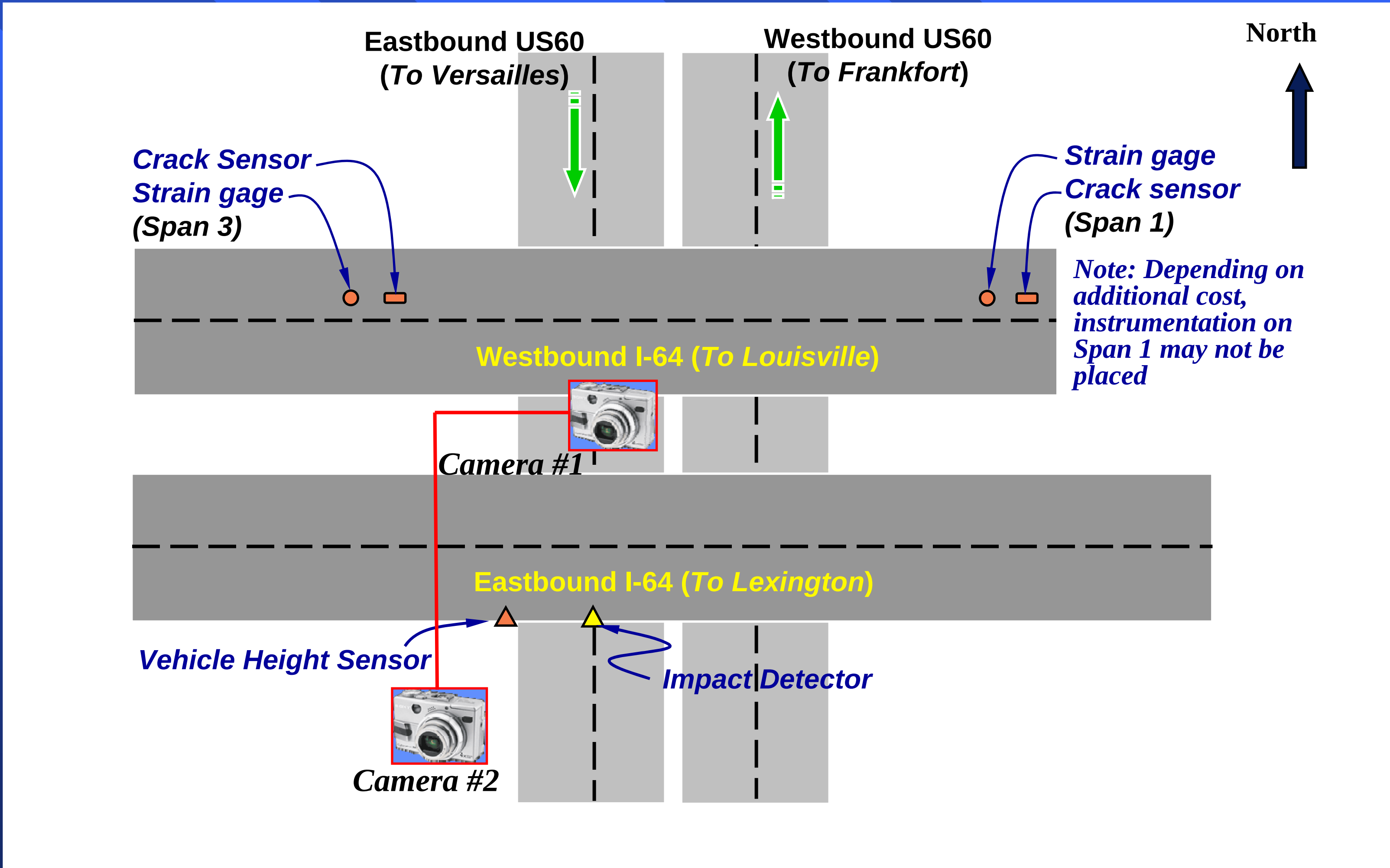
Activities in Kentucky

I-64 Parallel Bridges over US60

I-64 Parallel Bridges over US60



Possible Instrumentation Plan



Truck Fire

I-65/I-59/I-20 Interchange in Birmingham, Alabama

Truck Fire

I-65/I-59/I-20 Interchange in Birmingham, Alabama

Tanker Truck Fire - MacArthur Maze Freeway
Oakland, California
29 April, 2007

Special to the Chronicle / Philip Liborio Gangi

Tanker Truck Fire - MacArthur Maze Freeway
Oakland, California
29 April, 2007

Tanker Truck Fire - MacArthur Maze Freeway
Oakland, California
29 April, 2007

Special to the Chronicle / Robert Campbell

BARGE IMPACT ON BRIDGES

Lexington Herald Leader – Monday, May 27, 2002

JERRY WILLIS | ASSOCIATED PRESS

Emergency crews surveyed the scene of the bridge collapse where Interstate 40 crosses the Arkansas River near Webbers Falls, Okla.

Barge collapses Oklahoma bridge

MOTORISTS TRAPPED AS VEHICLES FALL INTO RIVER

HERALD-LEADER WIRE SERVICES

WEBBERS FALLS, Okla. — A barge struck the Interstate 40 bridge over the Arkansas River early yesterday, causing a 600-foot section of the span to collapse into the river.

Officials said as few as seven people or as many as 20 might have died in the 7:45 a.m. collapse, but the fear that the remainder of the bridge would collapse slowed recovery efforts.

The barge's crew said their pilot, Joe Dedmon, 61, of Florence, Miss., was at the helm at the time of the accident and appeared to suffer a seizure just before the collision, investigators said.

He had no previous medical conditions, according to Joel Henderson of Magnolia Marine Transportation Co., which owns the tugboat and barges.

See BRIDGE, A9

Lexington Herald Leader
September 16, 2001

A2 **Nation&World**

★ Lexington Herald-Leader
Sunday, September 16, 2001

Barges smash bridge; cars plummet 85 feet

By Lynn Brezosky
ASSOCIATED PRESS

RIC VASQUEZ/ASSOCIATED PRESS

A Coast Guard ship helped with the rescue and recovery of drivers near the Queen Isabella Causeway off South Padre Island, Texas. A tug boat and barges smashed the bridge.

PORT ISABEL, Texas — A group of barges smashed a 240-foot section out of the only bridge leading to popular South Padre Island early yesterday, and at least four people died after their vehicles plunged into the water 85 feet below.

An unknown number of people were missing. Thirteen were rescued from the Laguna Madre, part of the Intracoastal Waterway shipping route along the Gulf Coast, and three were hospitalized.

Five vehicles were located in the 50-foot-deep water, and divers took pictures of their license plates for identification, said Cameron County Sheriff Conrado Cantu. The sheriff said as many as 10 vehicles could be in the water.

Rhonda Fife stood near the four-lane bridge yesterday afternoon and said she had not heard from her 18-year-old daughter, Tiffany, since she went to the island with friends late Friday.

"Nobody called, and they always call," Fife said, her voice trembling.

Michael Burke, whose two sons had gone out with Tiffany, anxiously waited with Fife.

"I just want to know where my kids are at. I hope they're all right and just can't call me," Burke said.

Recovery efforts were suspended late yesterday afternoon when the third 80-foot section of the bridge collapsed, said Adrian Rivera, a spokesman for the Department of Public Safety. The search is resuming this morning.

The Coast Guard was notified around 2:30 a.m. that the tug Brown Water V and its four barges, loaded with coiled steel and phosphate, had struck the 2.37-mile-long span, the longest bridge in Texas. None of the cargo spilled.

The crash dropped two adjacent 80-foot segments of the Queen Isabella Causeway into the channel near the center of the span.

The tug operator was questioned and passed a sobriety test, officials said.

Three people died at the scene, and a fourth died at a hospital. One victim was identified as Port Isabel Fire Marshal Robert Harris, said Desi Najera, an emergency management coordinator.

One man was hospitalized in guarded condition, and two of the injured were in good condition.

The state hired two boats to serve as ferries, and was considering bringing a state-owned vehicle ferry from Corpus Christi, Texas, said Randall Dillard of the Texas Department of Transportation.

South Padre Island has 2,000 permanent residents, and island hotels were about 70 percent booked for the weekend.

Most tourists on the island came to celebrate Mexico's Diez y Seis de Septiembre independence day.

In addition, thousands of volunteers had been expected yesterday to help with beach cleanup, part of Adopt-A-Beach day, said local home builder Clayton Brashear.

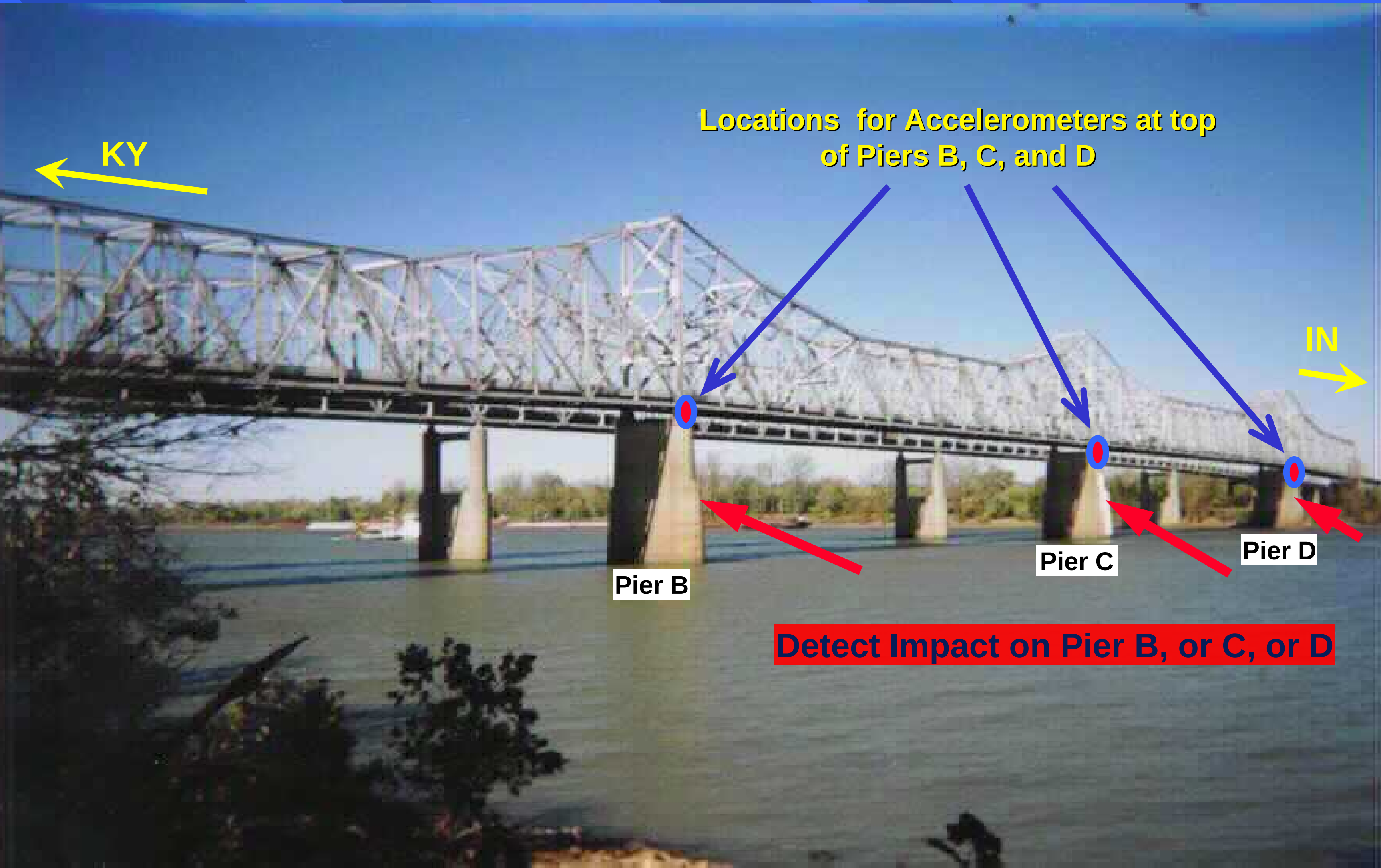
The island is a spring break mecca, when crowds of up to 200,000 students stay on the island or in nearby cities.

The barges were owned by American Commercial Lines LLC of Jeffersonville, Ind., and were being pushed by a tugboat owned by Brown Water Marine Services Inc. of Rockport, Texas, said American Commercial assistant vice president Jim Adams.

Amtrak Accident Scene, 1993

Activities in Kentucky

Instrumentation Plan - US 41N Bridge



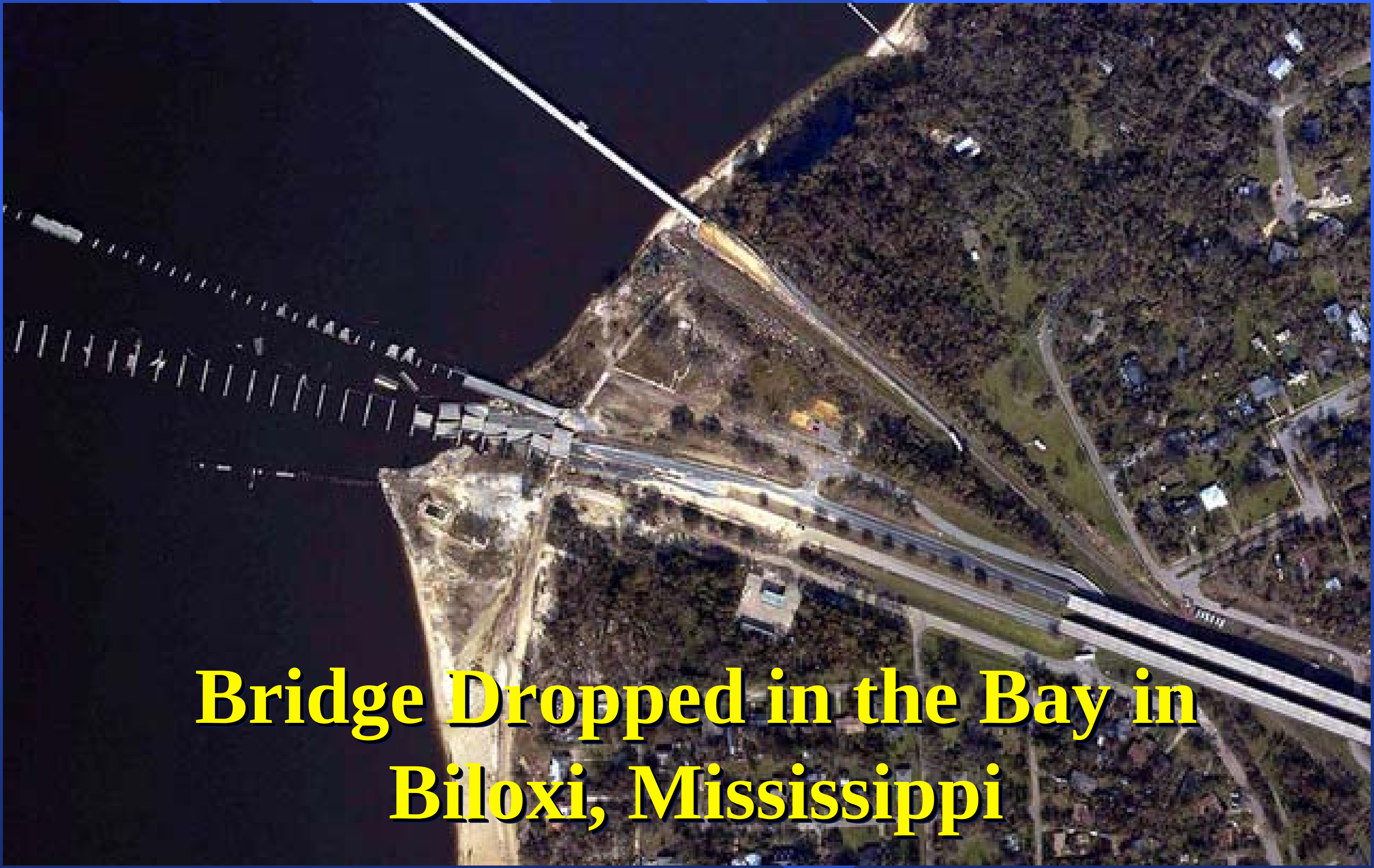
Natural Hazard

"A natural hazard is an unexpected or uncontrolled natural event of unusual magnitude that threatens the activities of people or people themselves."

Source: www.naturalhazards.org

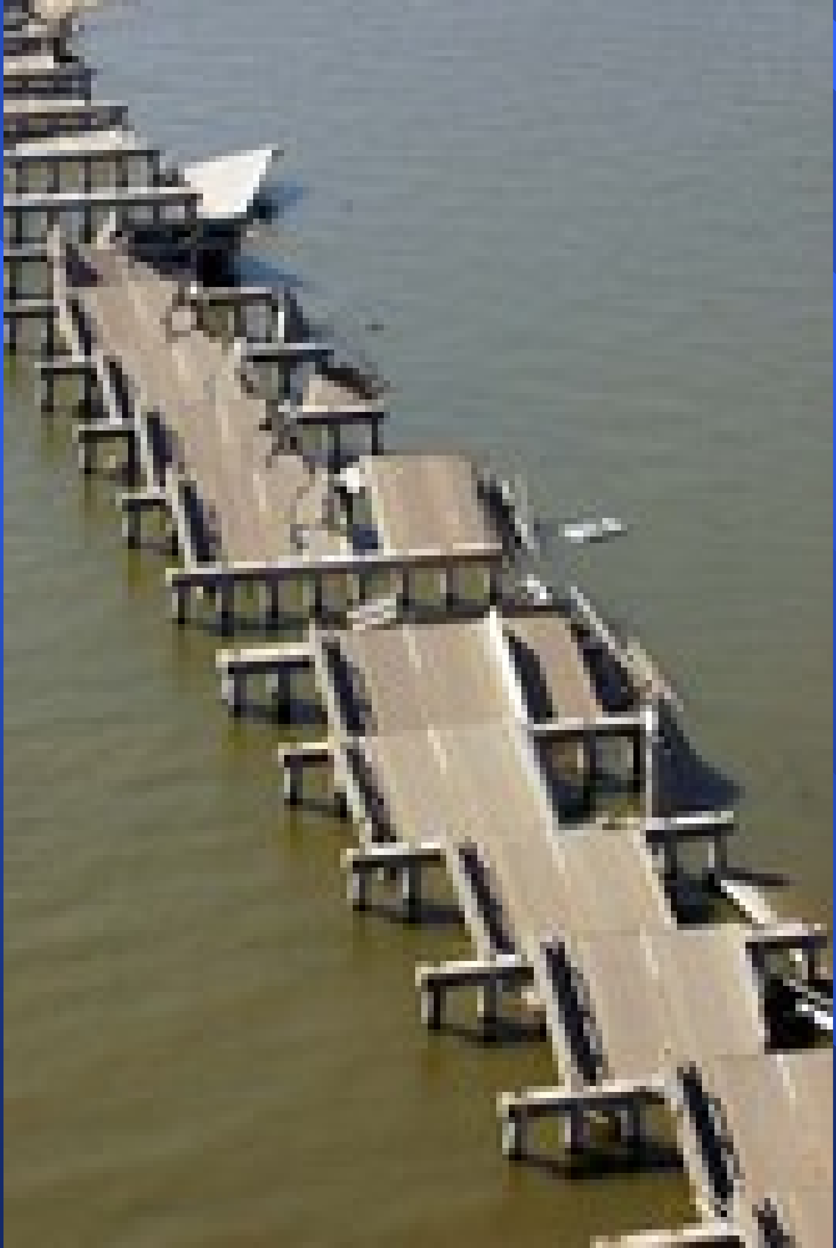
Natural Hazards

- Drought
- Earthquake
- Typhoon
- El Nino
- Fog
- Flood
- Hurricane
- Tornadoes
- Tsunamis
- Volcano
- Other



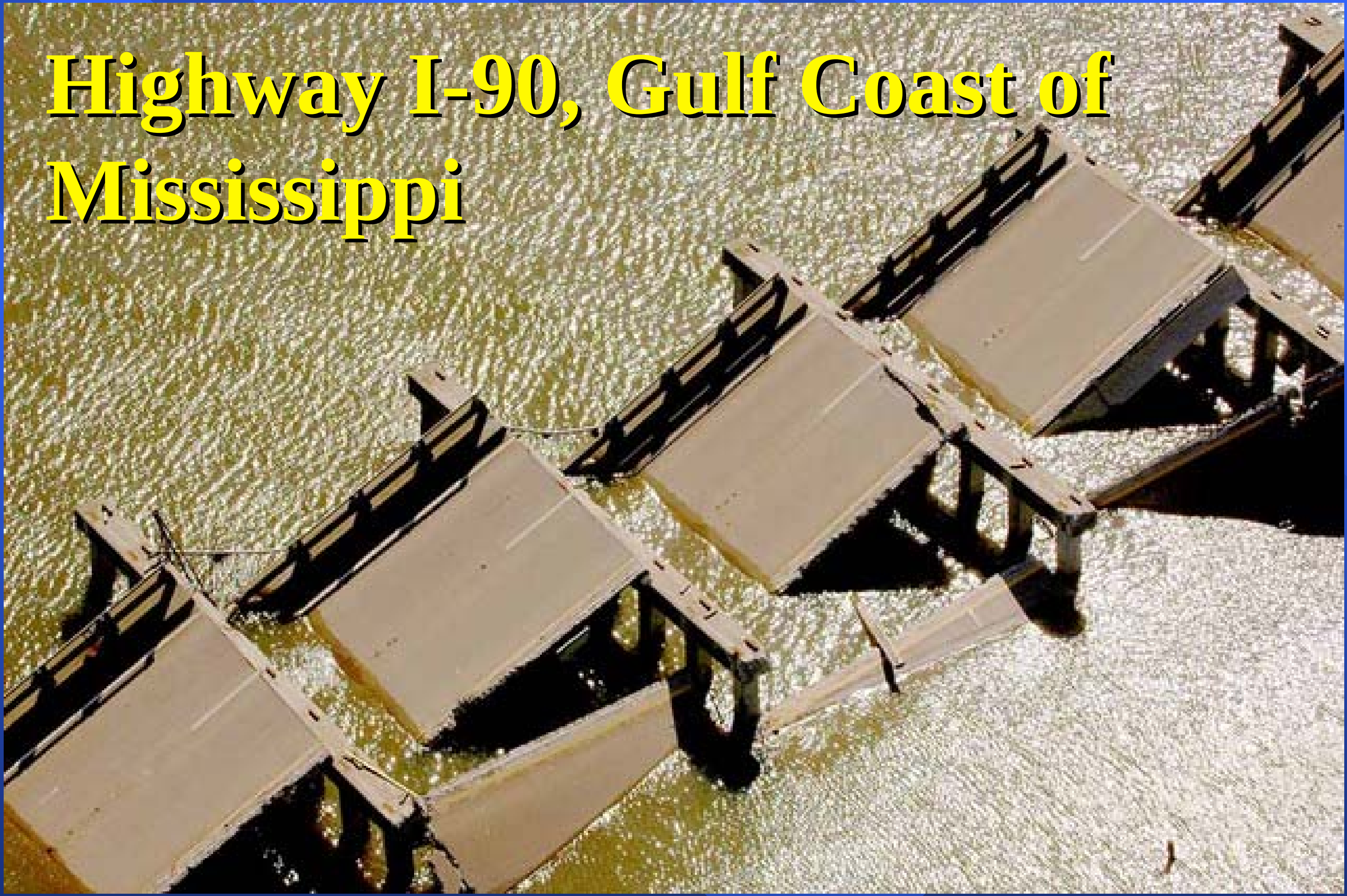
Hurricane Katrina, August 2005

Hurricane Katrina, August 2005



Highway I-90, Gulf Coast of Mississippi

Hurricane Katrina, August 2005



Hurricane Katrina, August 2005

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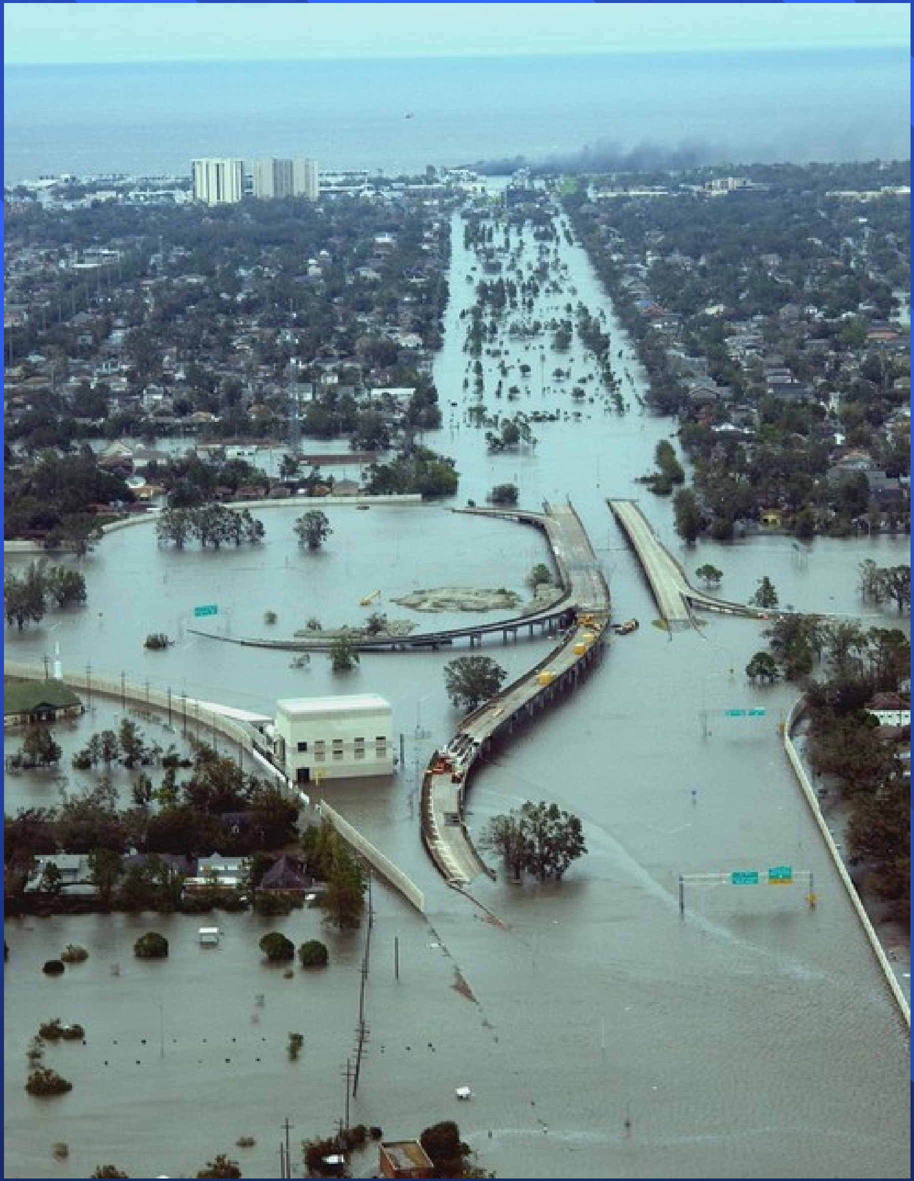

Flooded Roadway in New Orleans, Louisiana

Hurricane Katrina, August 2005

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- Earthquake
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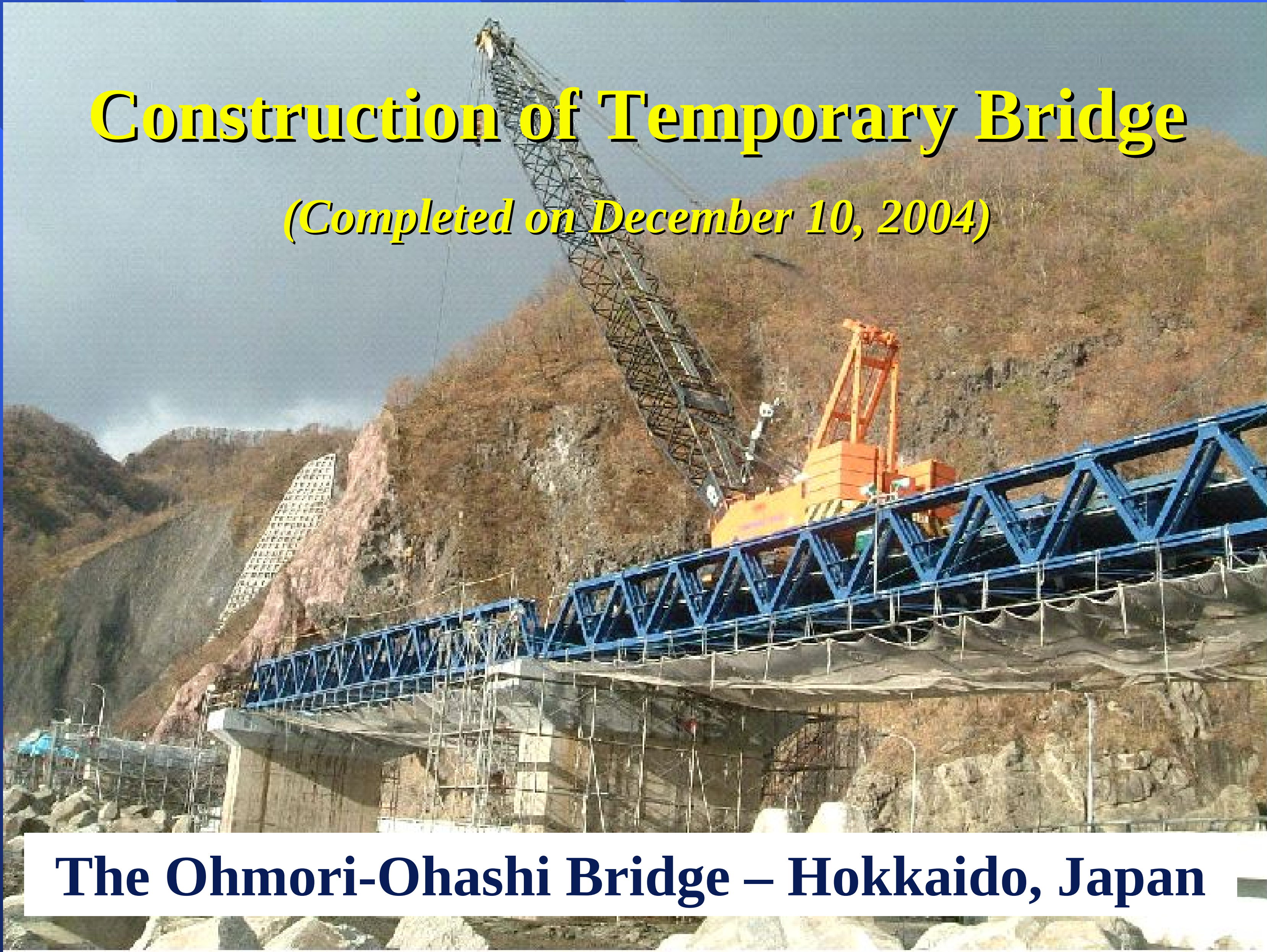
- Other

Typhoon #18, September 8, 2004

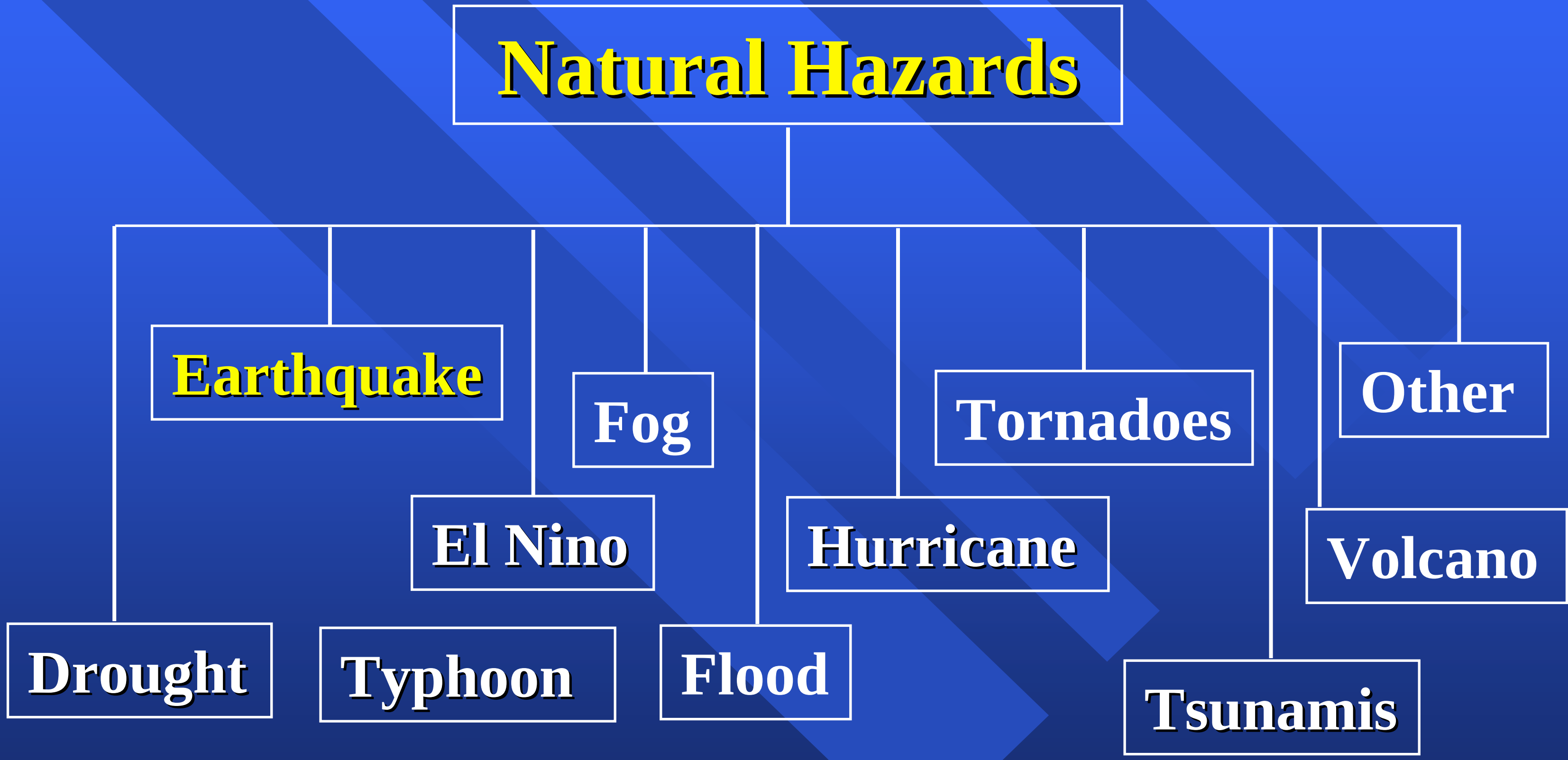
The Ohmori-Ohashi Bridge – Hokkaido, Japan

Construction of Temporary Bridge

(Completed on December 10, 2004)



The Ohmori-Ohashi Bridge – Hokkaido, Japan


Natural Hazards
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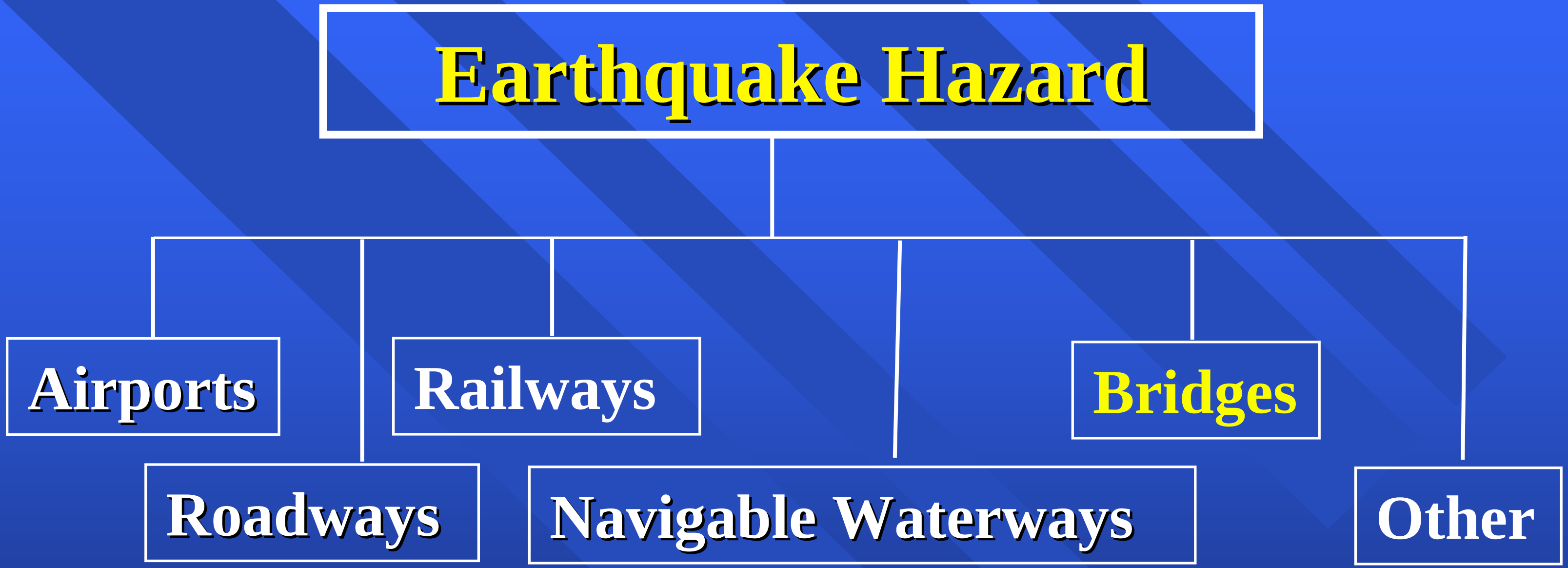
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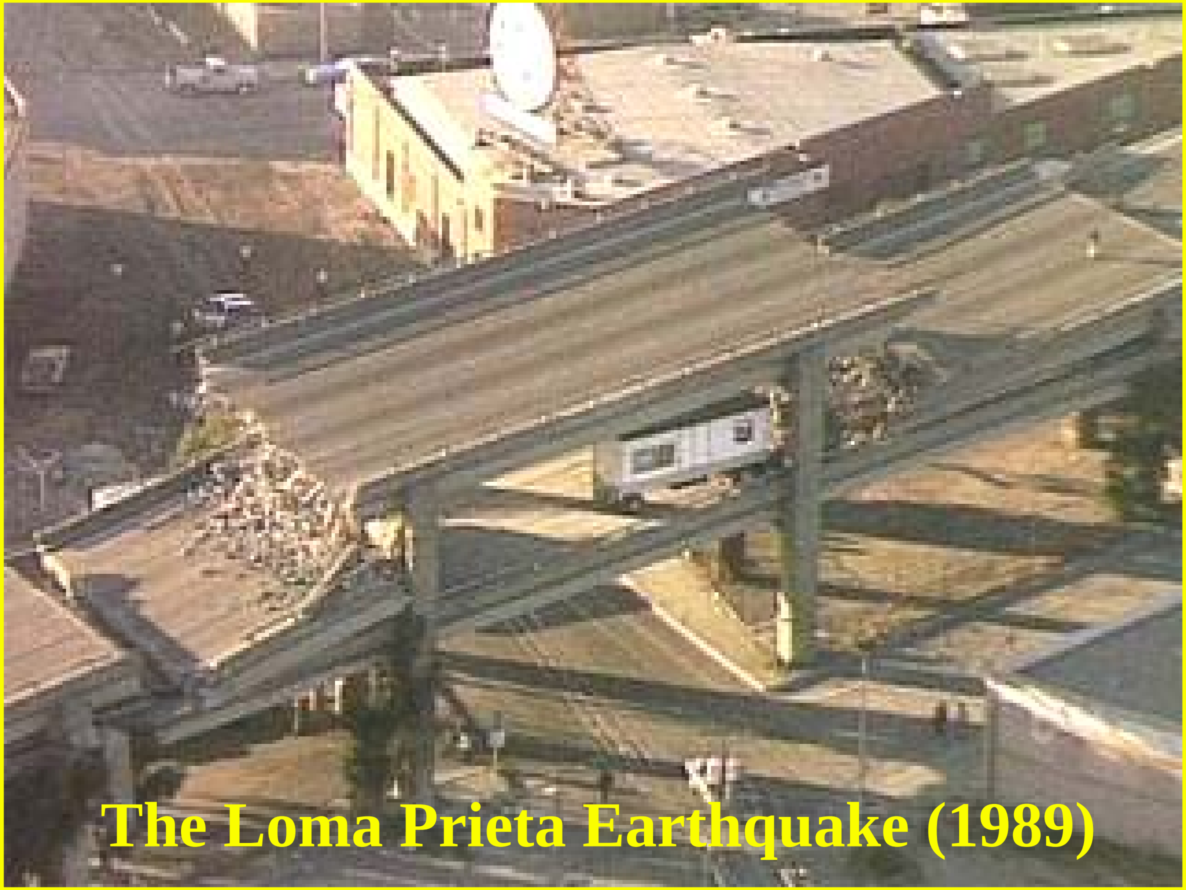
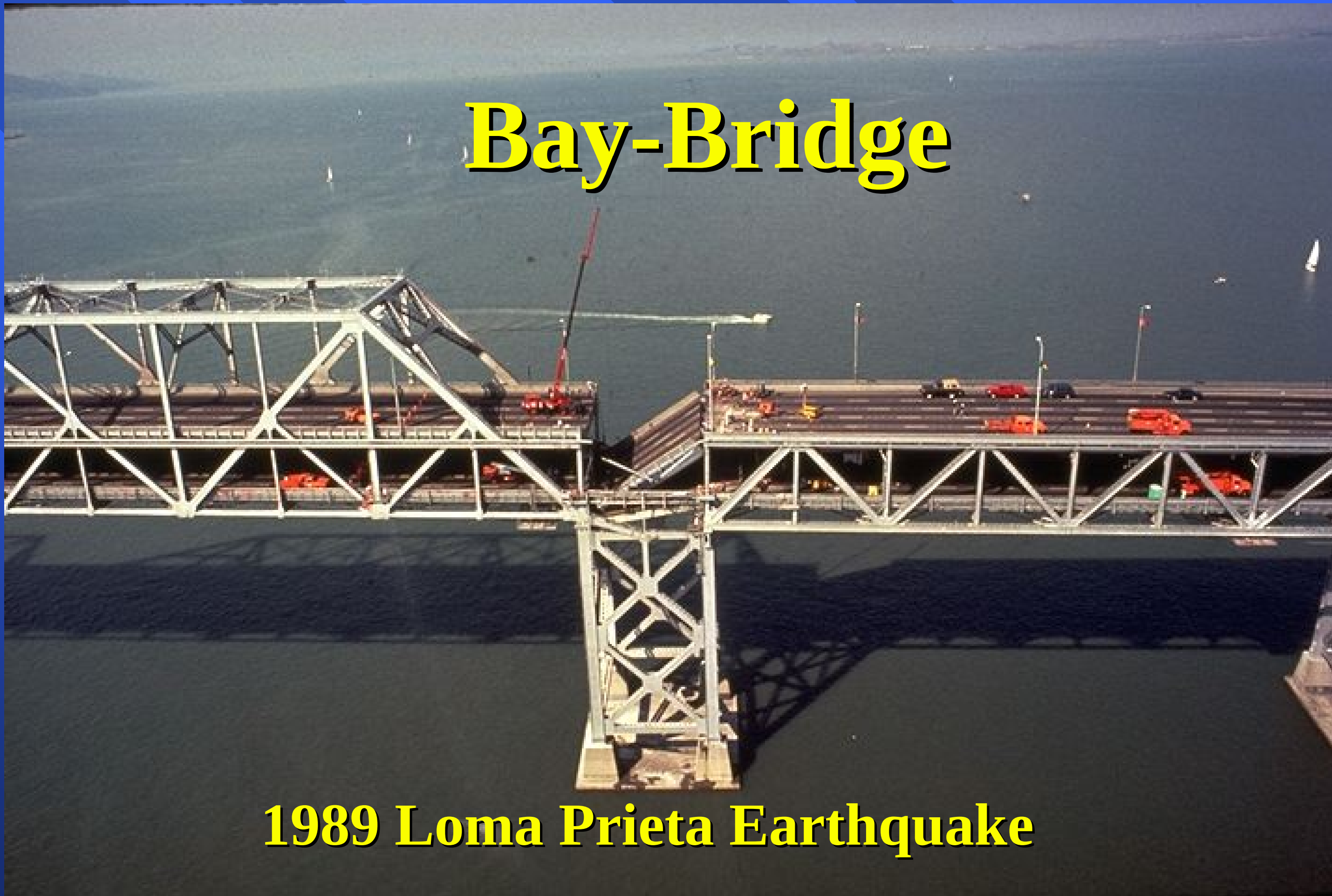
Earthquake Hazard on Bridges

Elevated Portion of I-880



Bay-Bridge



1989 Loma Prieta Earthquake

The Northridge Earthquake (1994)

Chi-Chi Earthquake, Taiwan (1999)

Tangshan Earthquake - China

July 28, 1976 at 03:42 AM

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- **Hazard Mitigation**
- Conclusions

How Do We Cope With Earthquakes?

Earthquakes are very difficult to predict and are unpreventable. Therefore, mitigation of earthquakes requires designing structures (including buildings, roadways, bridges, etc.) that can withstand repeated shaking.

Source: www.naturalhazards.org

Earthquake Mitigation for Bridges and Highway Structures

- Pre-Event
- ~~During-Event~~
- Post-Event

Earthquake Mitigation of Bridges and Highway Structures

- **Pre-Event**
  - Seismic Evaluation & Retrofit
  - Post-Earthquake Planning
  - Other
- **During-Event**
- **Post-Event**

Earthquake Mitigation of Bridges and Highway Structures:

- **Pre-Event**
  - **Seismic Evaluation and Retrofit**
  - Post-Earthquake Planning
  - Other
- During-Event
- Post-Event

Seismic Evaluation and Retrofit:

- Seismic Input
- Prioritization
- Seismic Evaluation
- Recommendation
- Seismic Retrofit
- Other

Earthquake Mitigation of Bridges and Highway Structures:

- **Pre-Event**
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• Seismic Input

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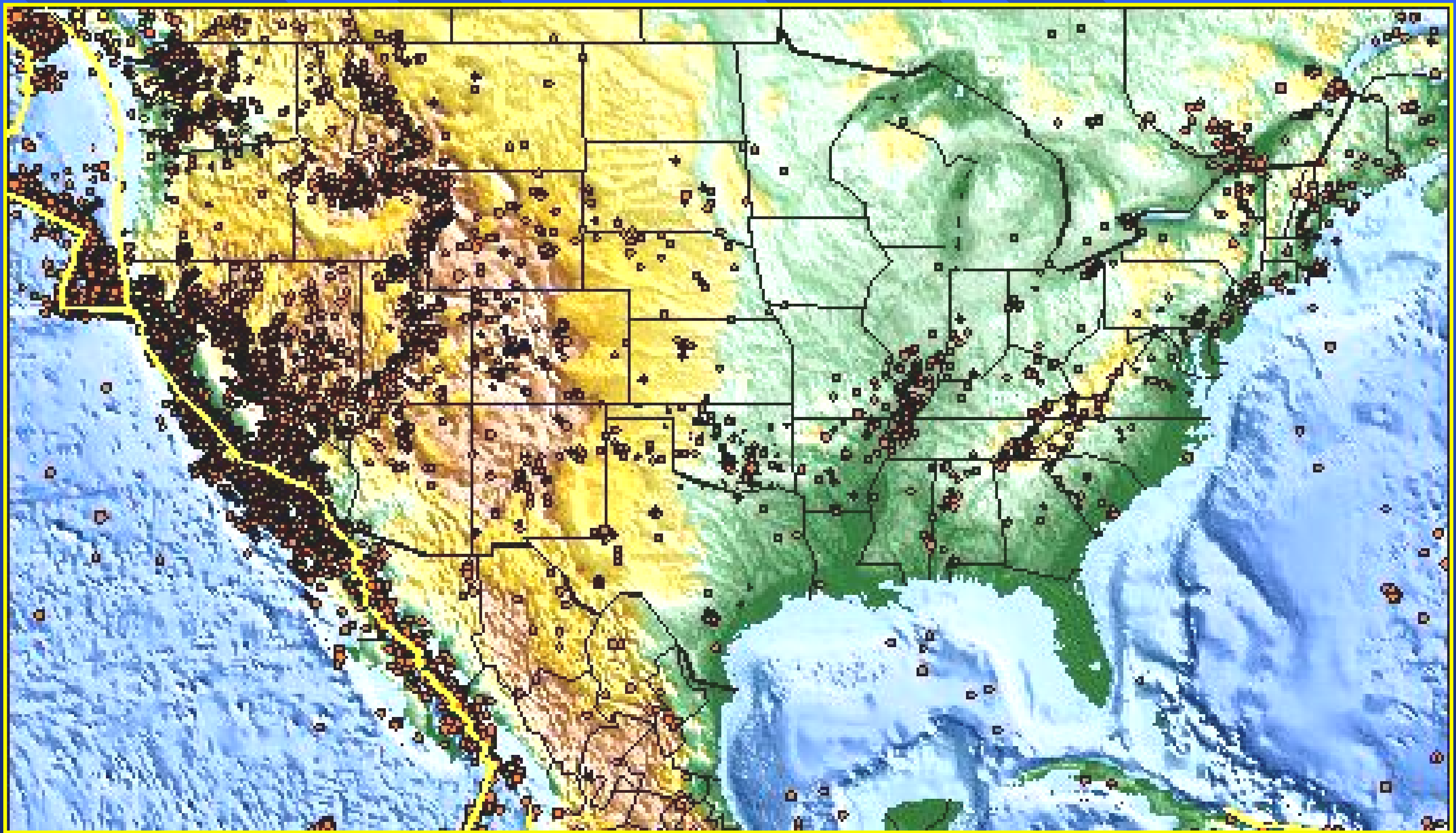
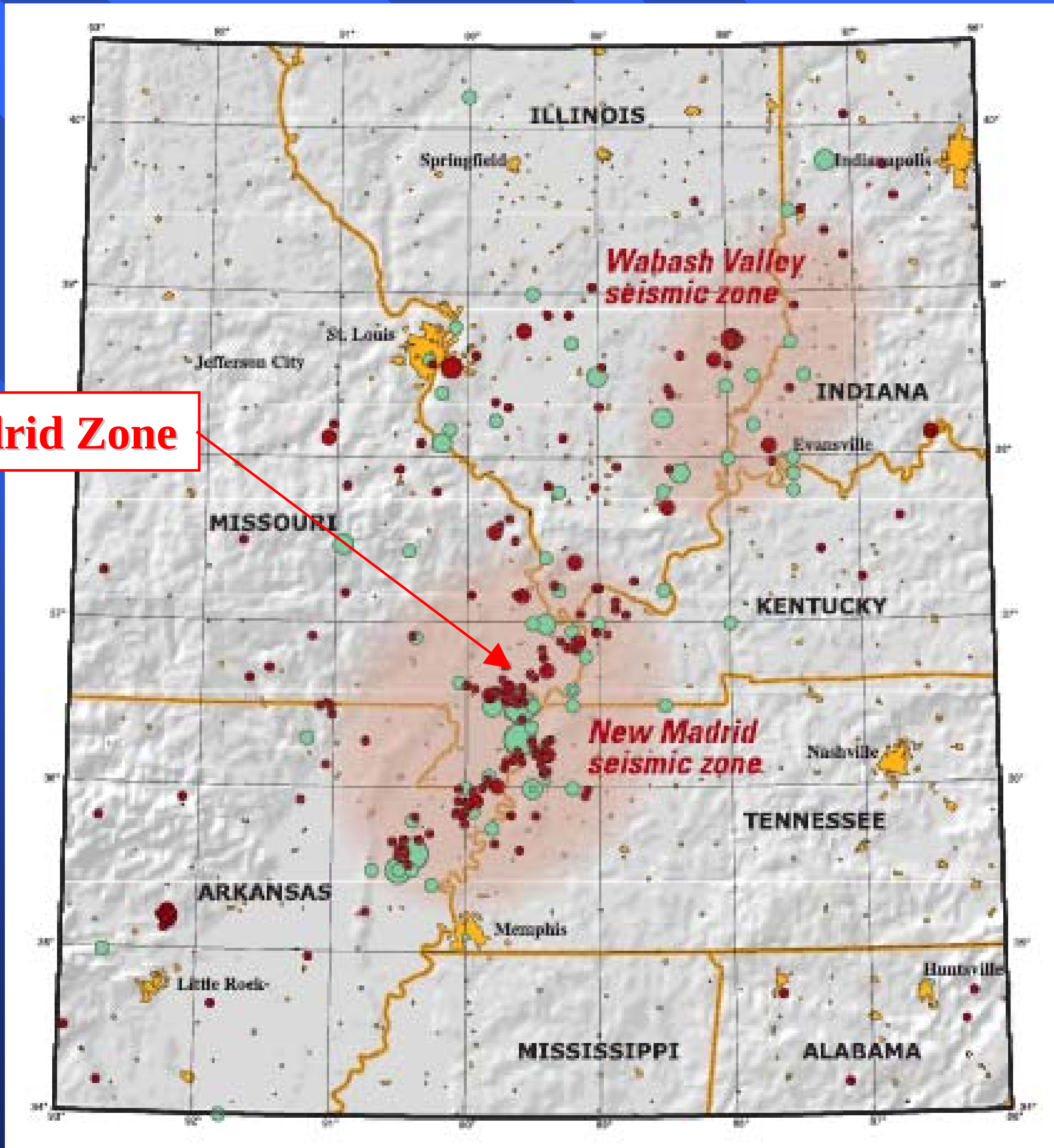
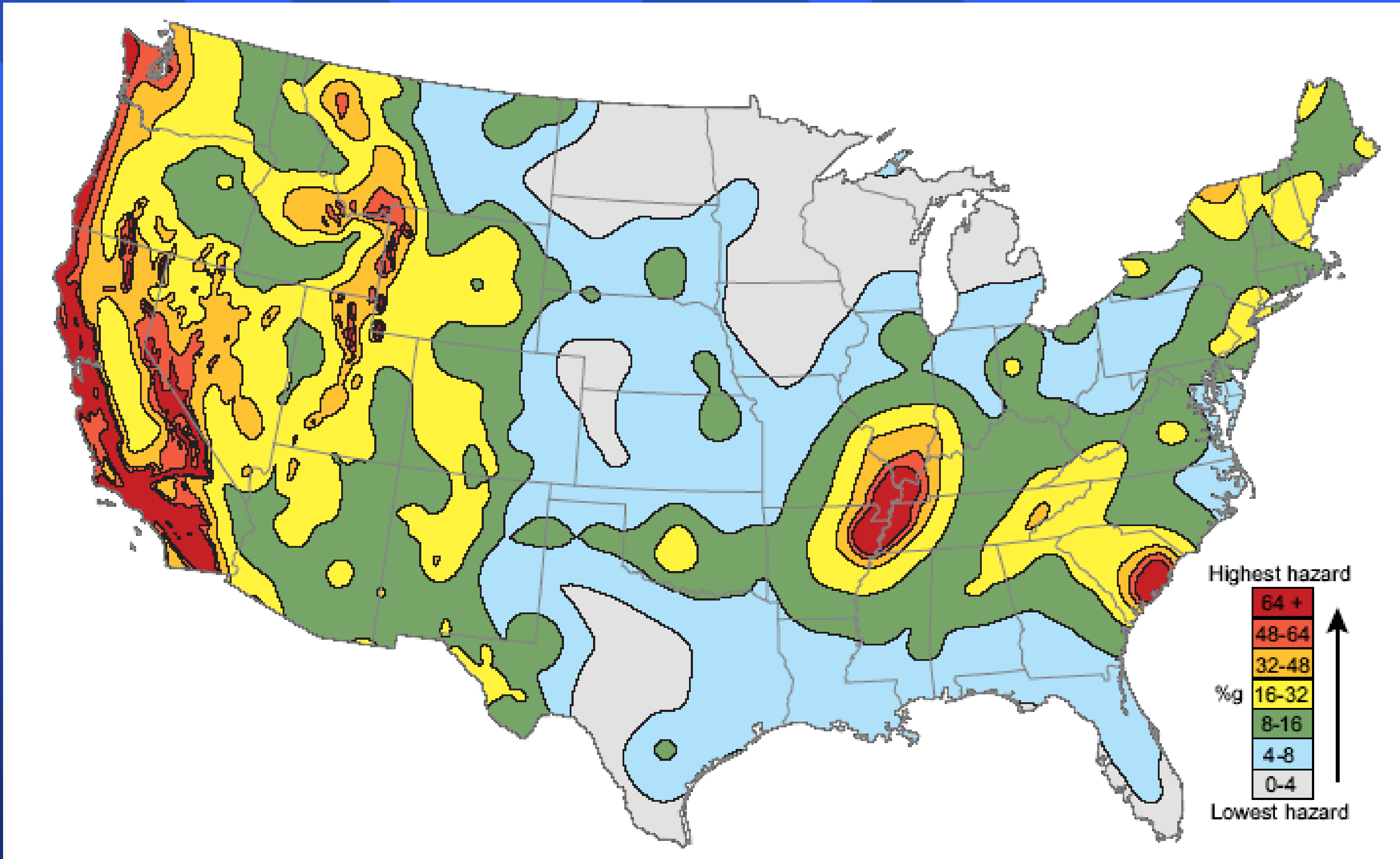
Seismicity in the United State



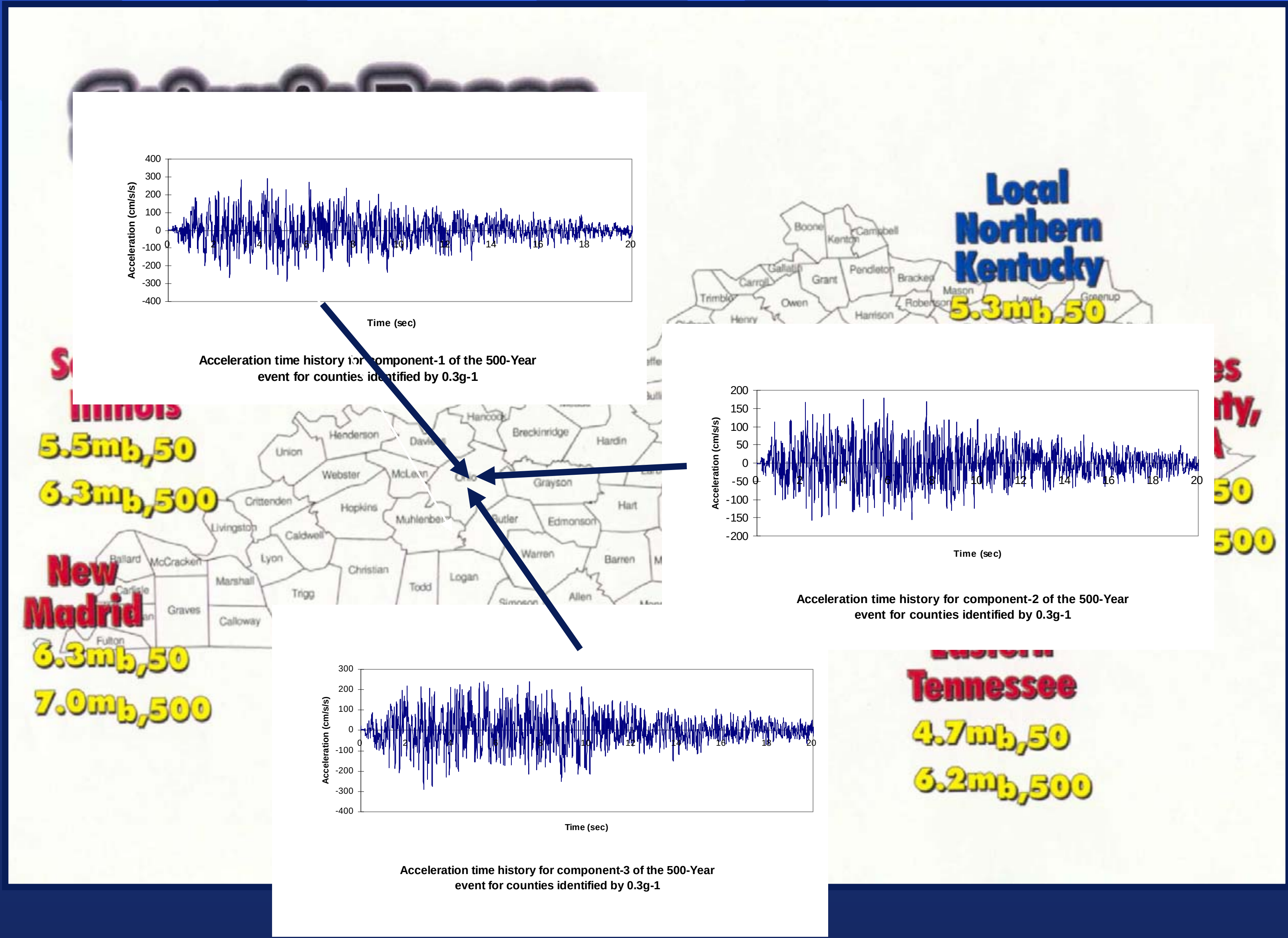
New Madrid Zone




Highest hazard
64 +
48-64
32-48
%g
16-32
8-16
4-8
0-4
Lowest hazard

Activities in Kentucky

Seismic Zones

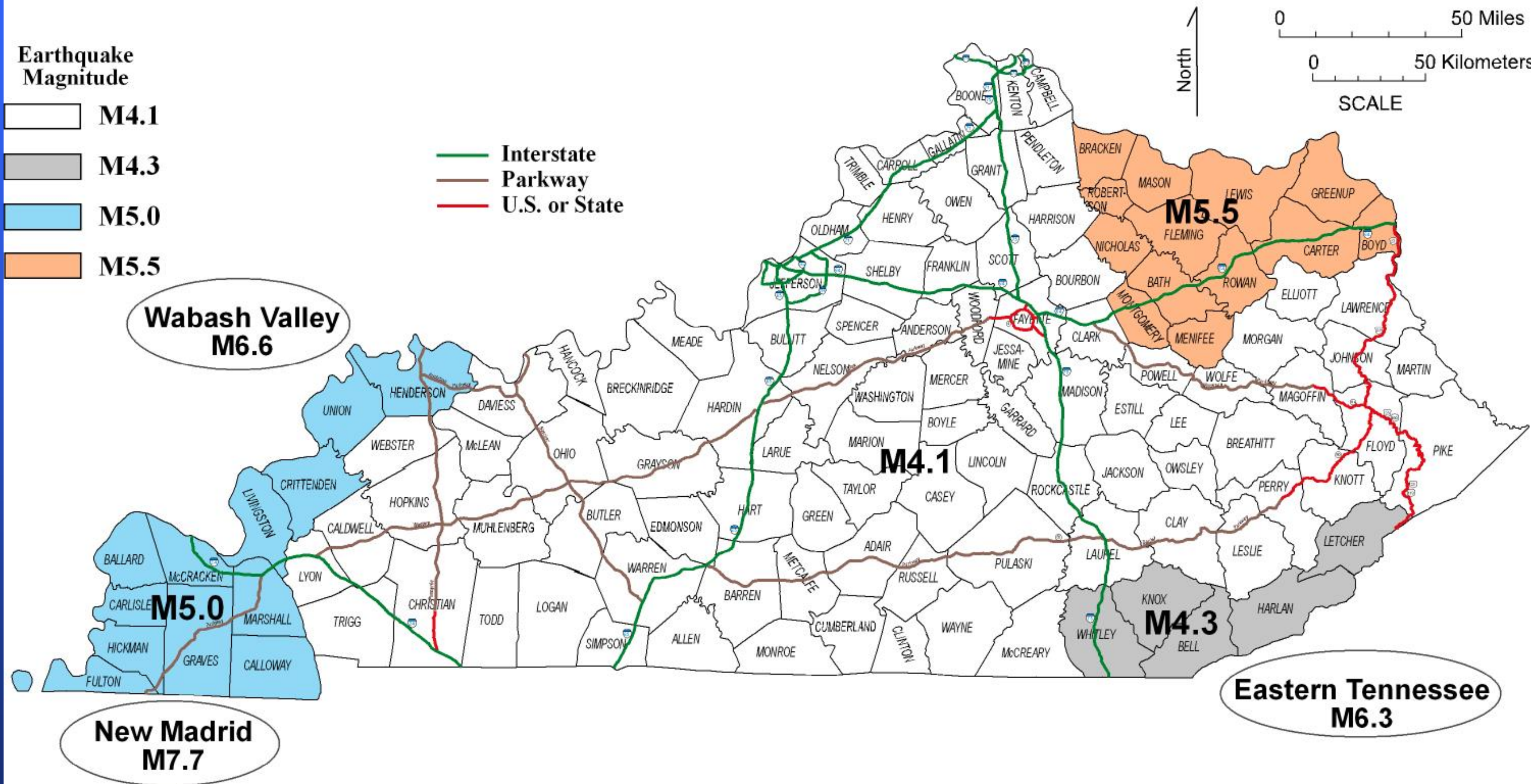


Acceleration time history for component-1 of the 500-Year event for counties identified by 0.3g-1

Acceleration time history for component-2 of the 500-Year event for counties identified by 0.3g-1

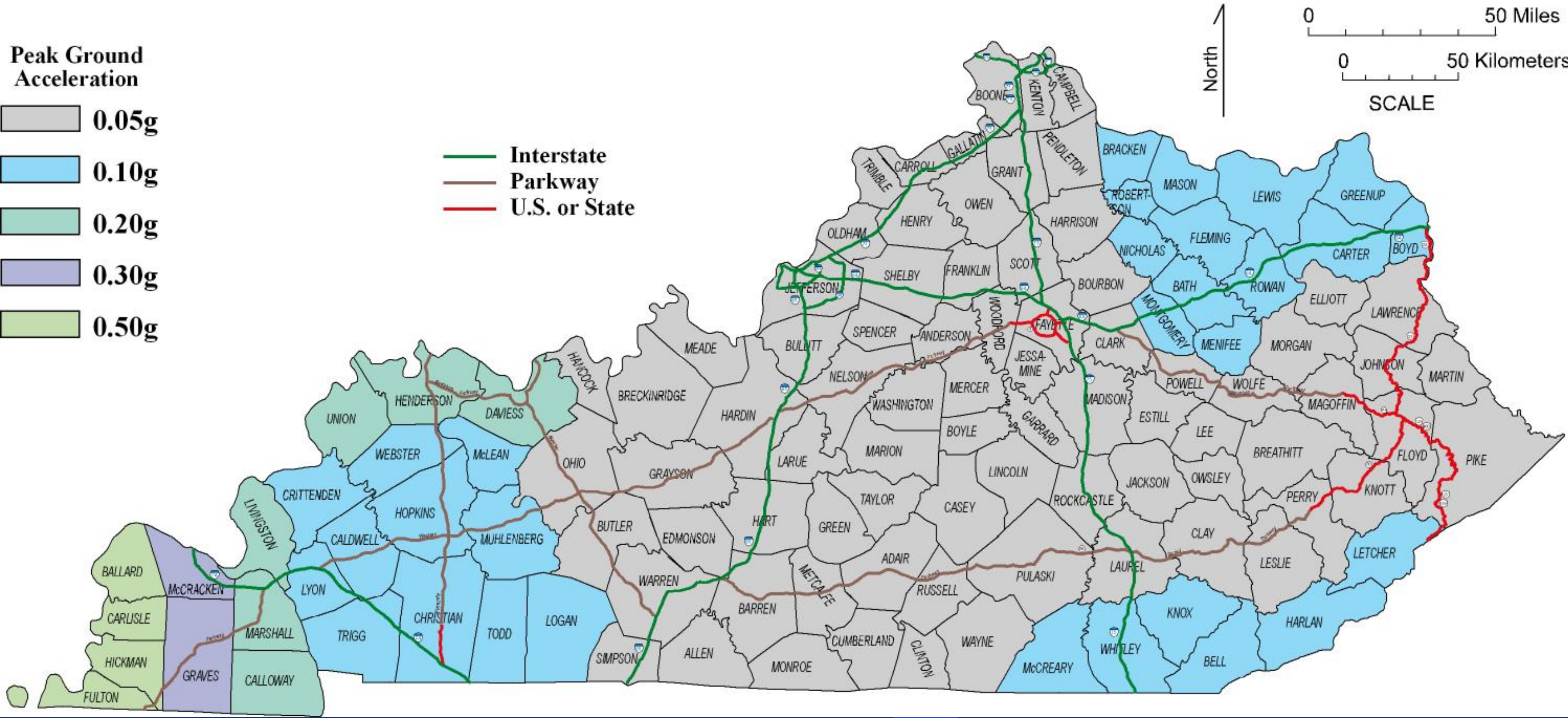
Acceleration time history for component-3 of the 500-Year event for counties identified by 0.3g-1

Maximum Credible Earthquake (MCE)

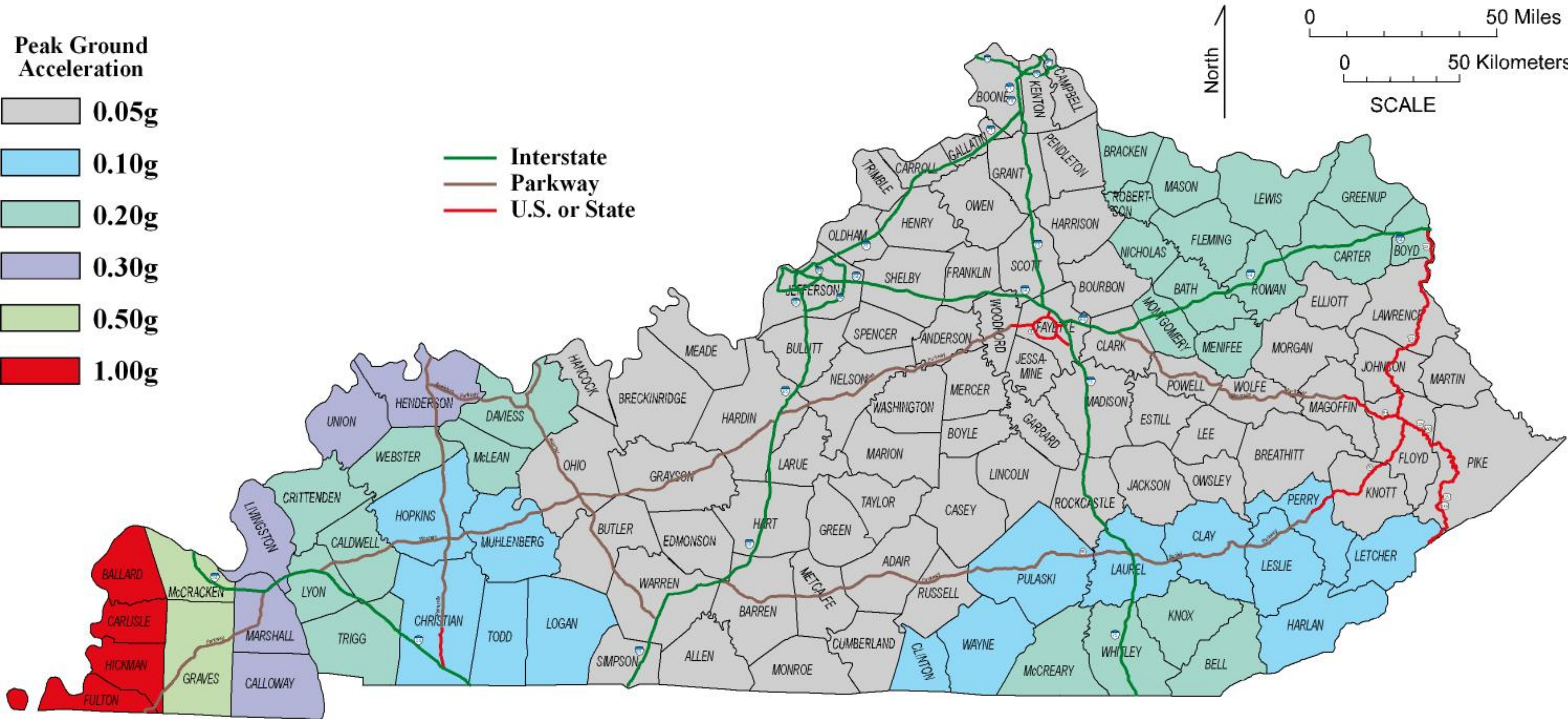


Maximum Credible Earthquake (MCE)

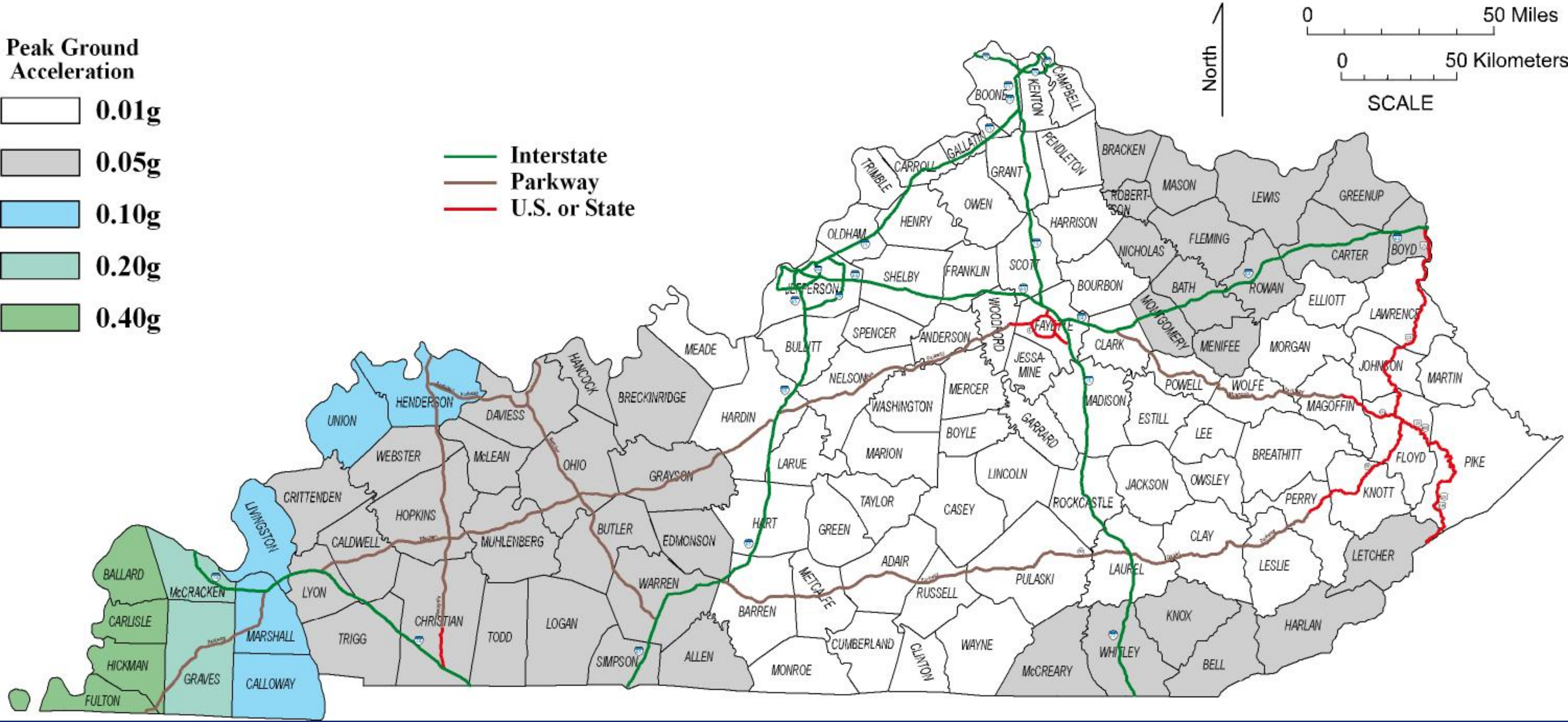
Peak Ground Acceleration for the Maximum Credible Earthquake (MCE)

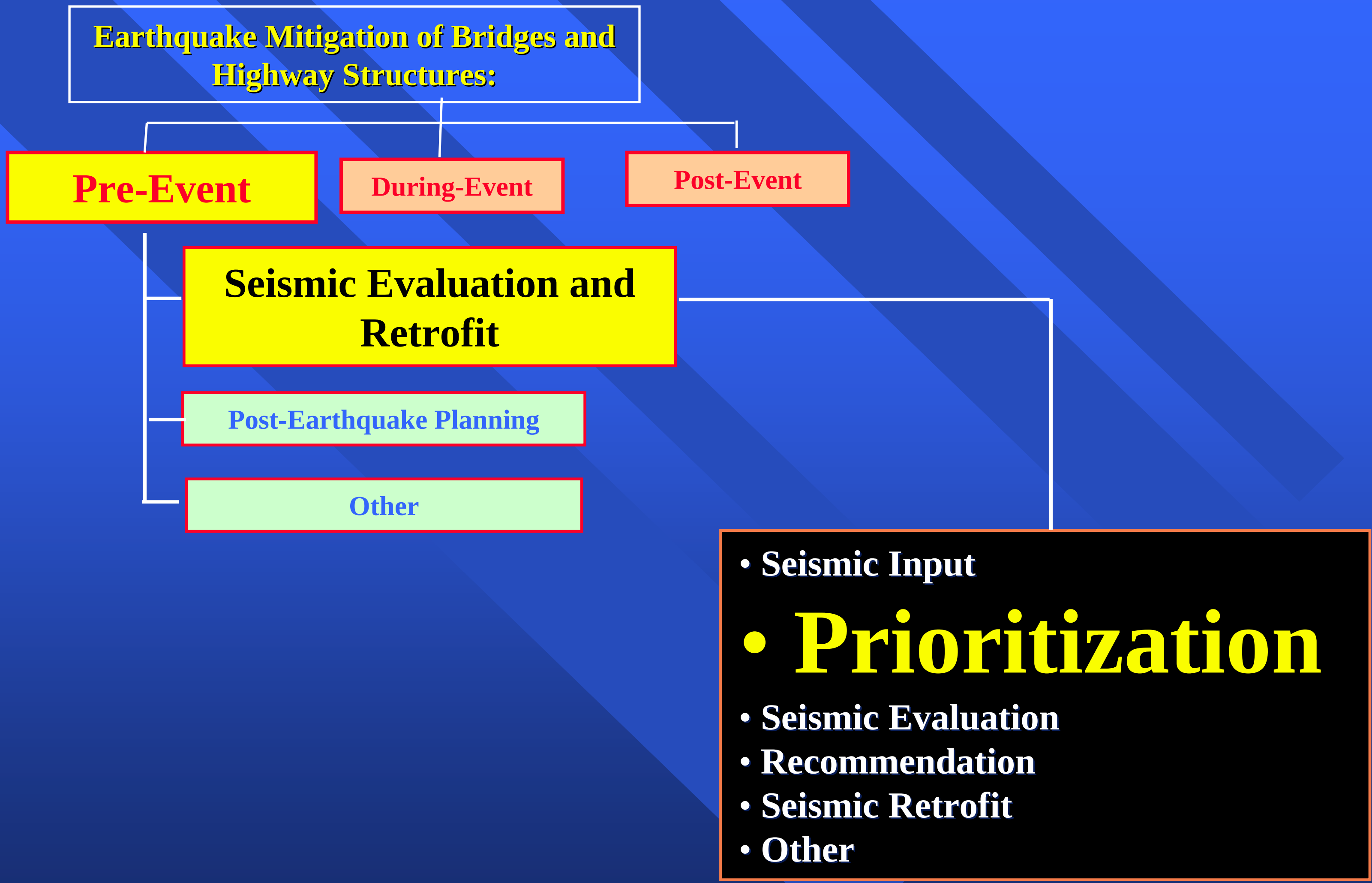


Maximum Credible Earthquake (MCE) Ground Motion: 0.2 Sec Spectral Response Acceleration (5% of Critical Damping), Site Class A (Hard Rock)



Maximum Credible Earthquake (MCE) Ground Motion: 1.0 Sec Spectral Response Acceleration (5% of Critical Damping), Site Class A (Hard Rock)




Earthquake Mitigation of Bridges and Highway Structures:
Pre-Event
During-Event
Post-Event
Seismic Evaluation and Retrofit
Post-Earthquake Planning
Other
• Seismic Input
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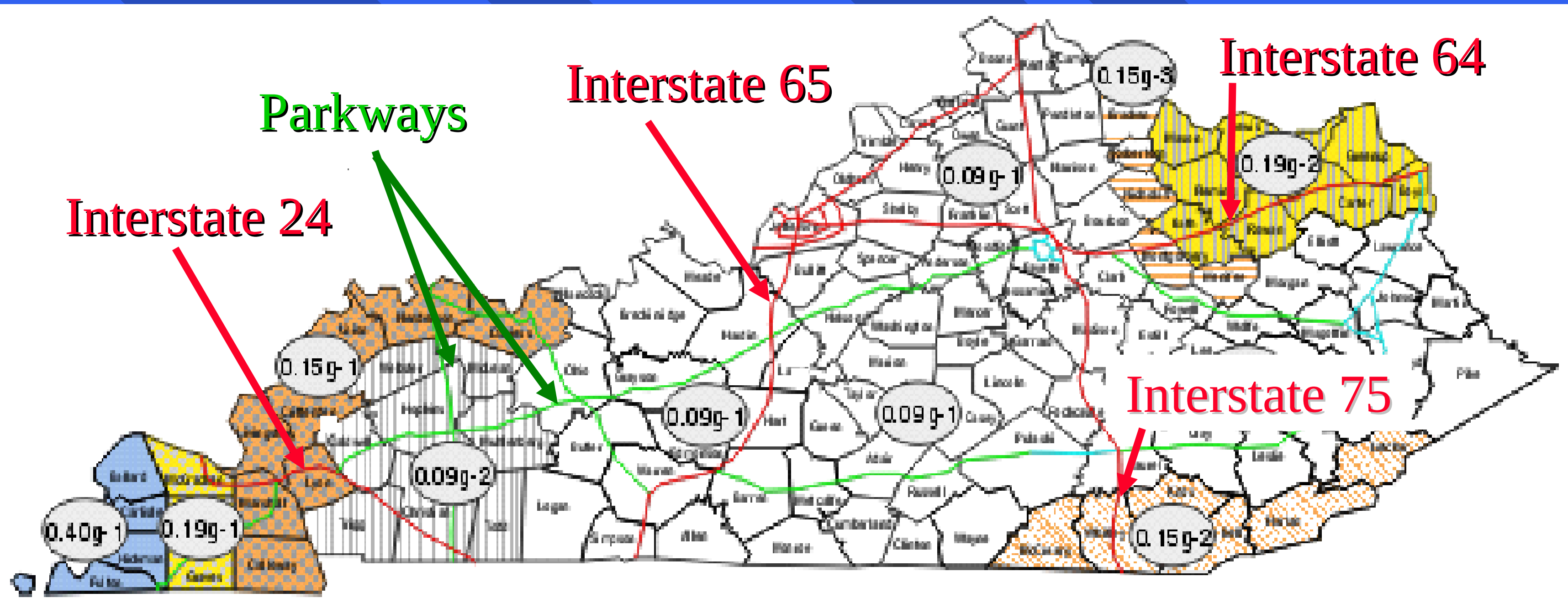
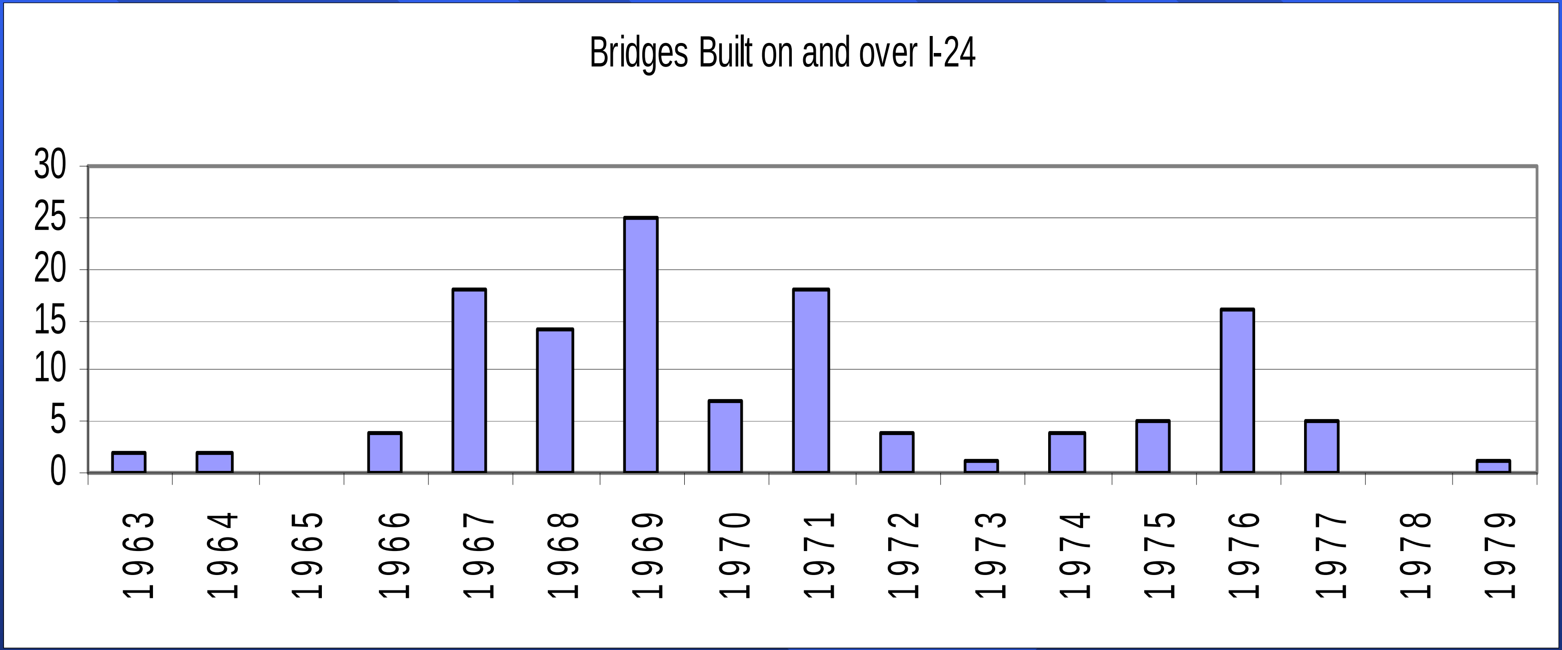
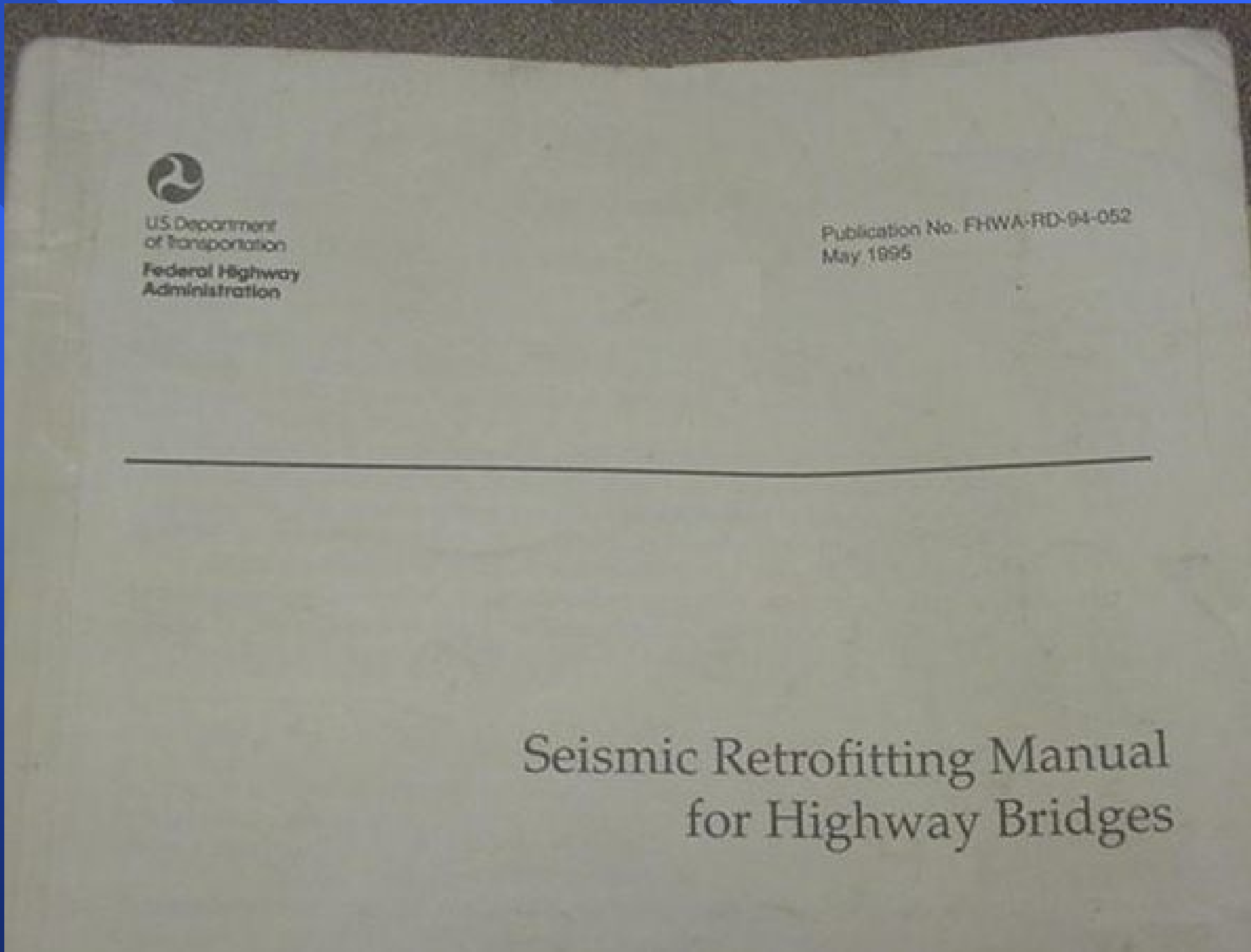
• Seismic Retrofit
• Other

I-24 and Parkways


Interstate 65
Interstate 64
Parkways
Interstate 24
Interstate 75
0.15g-3
0.09g-1
0.19g-2
0.15g-1
0.09g-1
0.09g-1
0.09g-2
0.40g-1
0.19g-1
0.15g-2

Bridge Timeline





U.S. Department of Transportation
Federal Highway Administration

Publication No. FHWA-RD-94-052
May 1995

Seismic Retrofitting Manual for Highway Bridges

Preliminary Screening

StartUp : Form

Seismic Inventory of Bridges

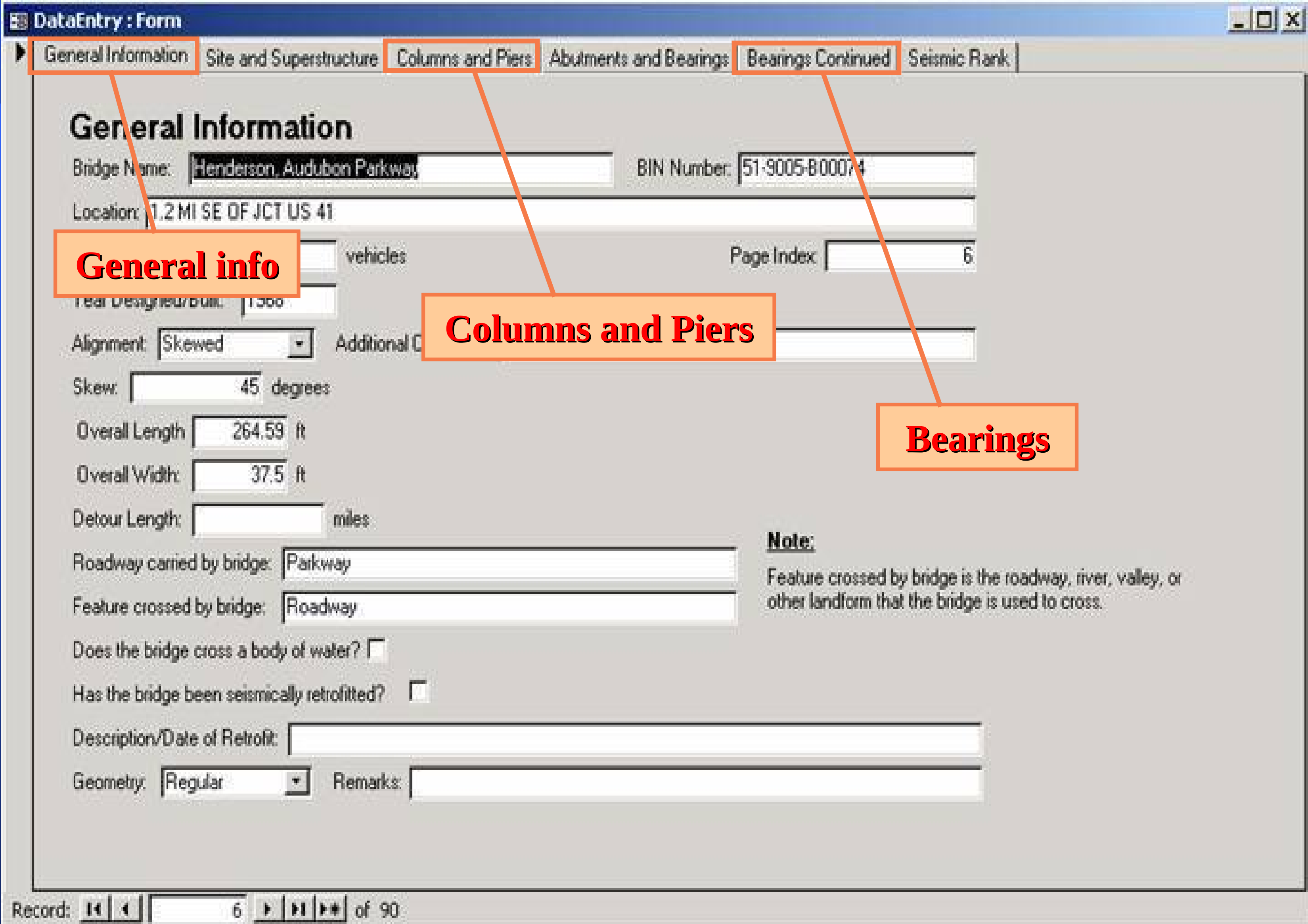
This program is designed to aid the user in a preliminary siesmic inventory of bridges in a particular region. The program will also allow the user to export an Excel spreadsheet or generate a report detailing the information.

Please make your selection below.

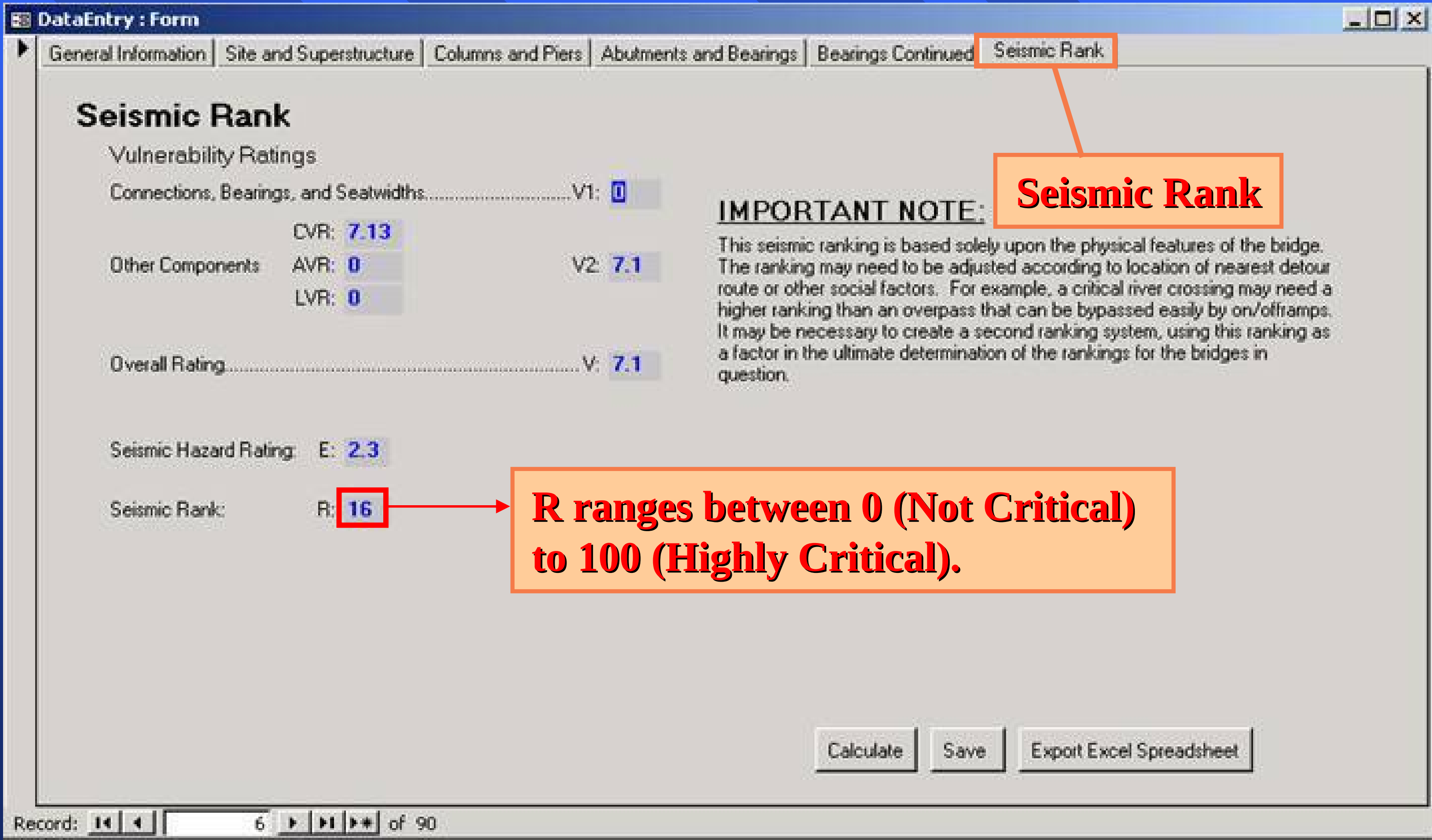
Enter or Modify Data | Preview Siesmic Report

Export Excel Spreadsheet | Print Seismic Report

Close | Exit


DataEntry : Form
General Information
Site and Superstructure
Columns and Piers
Abutments and Bearings
Bearings Continued
Seismic Rank
General Information
Bridge Name:
Henderson, Audubon Parkway
BIN Number:
51-9005-B00074
Location:
1.2 MI SE OF JCT US 41
General info
vehicles
Page Index
6
Columns and Piers
Alignment:
Skewed
Skew:
45
degrees
Bearings
Overall Length
264.59
ft
Overall Width:
37.5
ft
Detour Length:
miles
Note:
Feature crossed by bridge is the roadway, river, valley, or other landform that the bridge is used to cross.
Roadway carried by bridge:
Parkway
Feature crossed by bridge:
Roadway
Does the bridge cross a body of water?
Has the bridge been seismically retrofitted?
Description/Date of Retrofit:
Geometry:
Regular
Remarks:
Record:
6
of 90

PRIORITIZATION (Preliminary Screening):



Earthquake Mitigation of Bridges and Highway Structures:

- **Pre-Event**
  - **Seismic Evaluation and Retrofit**
  - Post-Earthquake Planning
  - Other
- During-Event
- Post-Event

Seismic Evaluation and Retrofit:

- Seismic Input
- Prioritization
- **Seismic Evaluation**
- Recommendation
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- Other

Steel Beam with RC Slab


Steel Beam with RC Slab


Pre-stressed Concrete I-Girder
with RC Slab


Pre-stressed Concrete I-Girder
with RC Slab

Single Span Bridges

Two-span Bridges

Multi-span Bridges

Evaluation Process For Critical Bridges

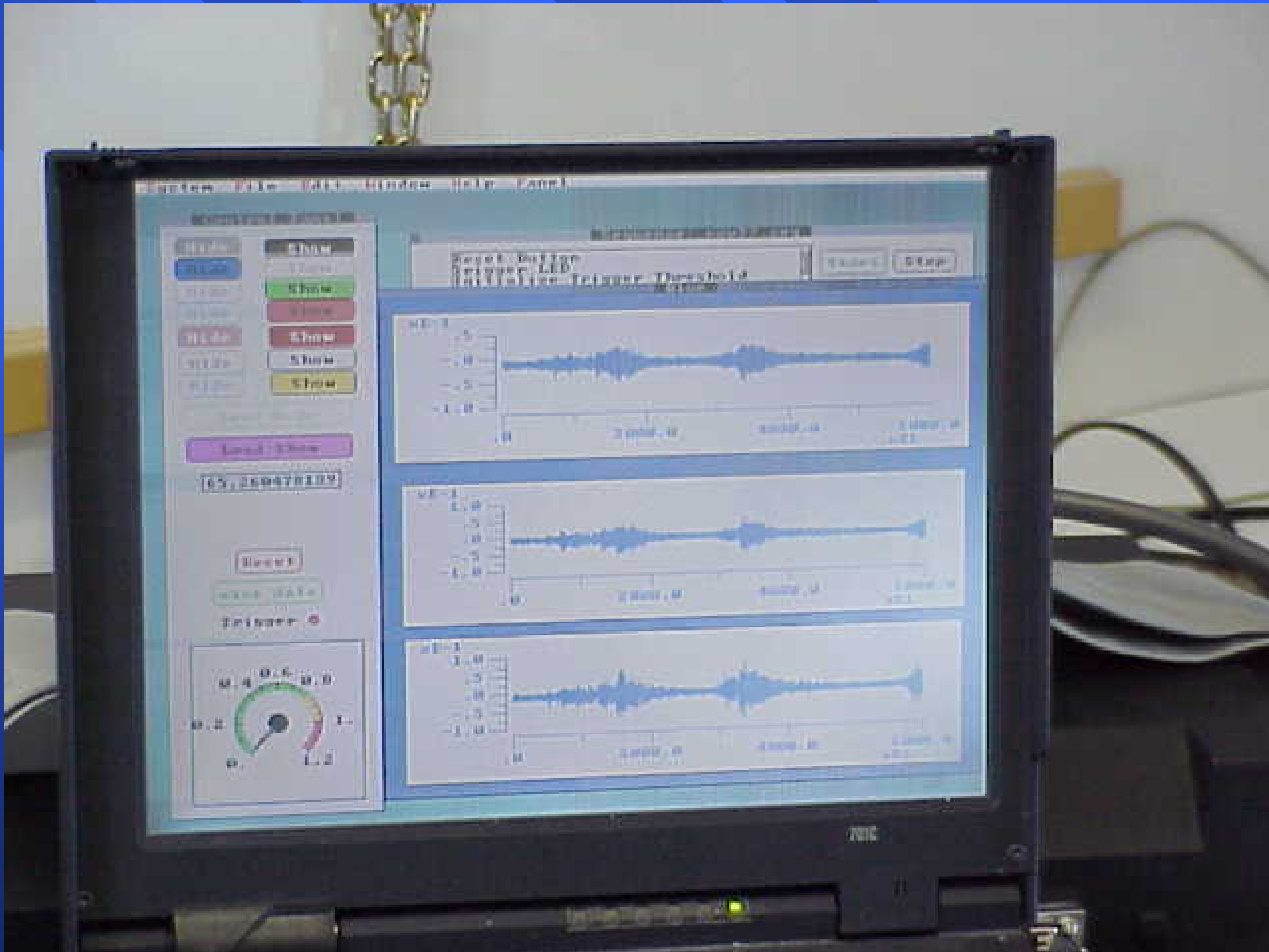
- Field Testing
- FE Model Calibration
- Seismic Evaluation


Roebling Bridge over Ohio River

The Maysville Bridge

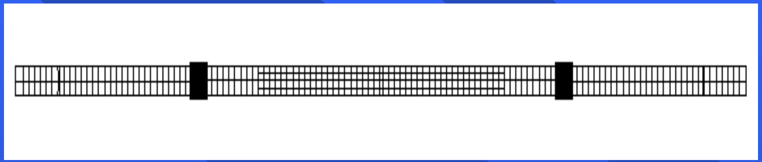

The Maysville Bridge


Block
03

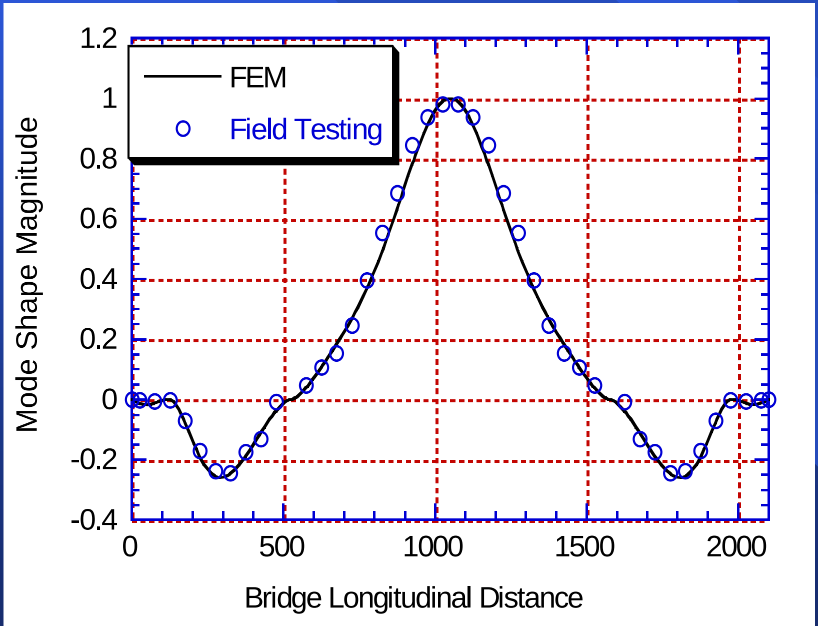


Reset Buffer
Trigger LED
Stop
Show
Reset
Trigger

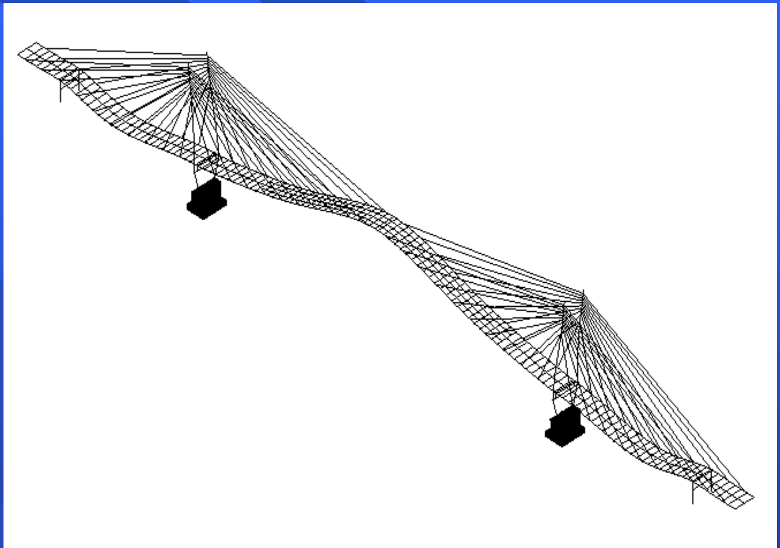
Task 3: FE Modeling ….. Maysville Bridge



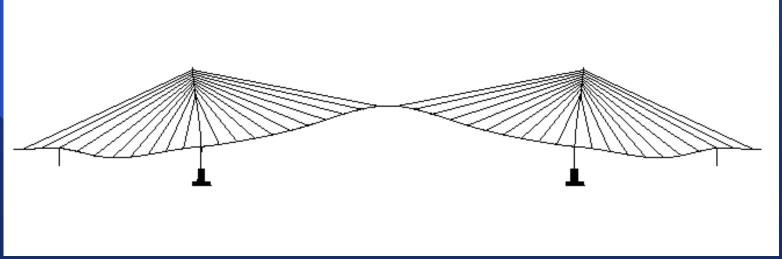
Plan



1st Vertical Mode

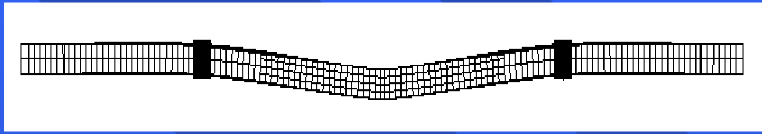


3-D View

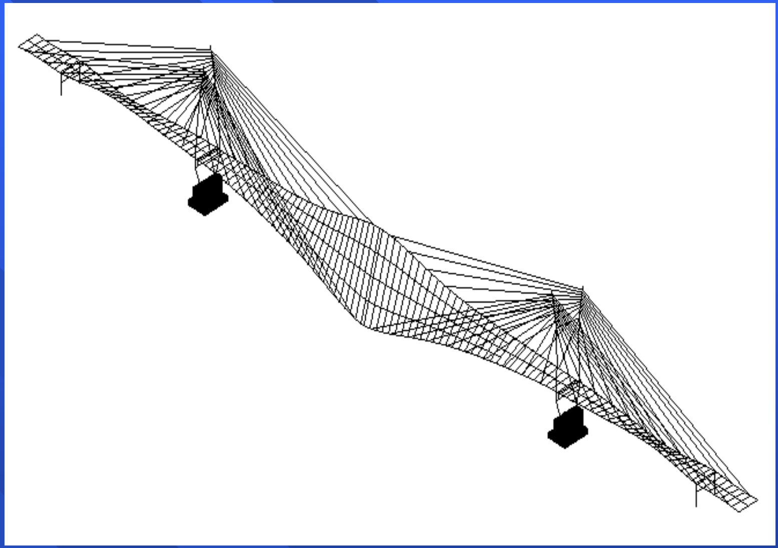


Elevation

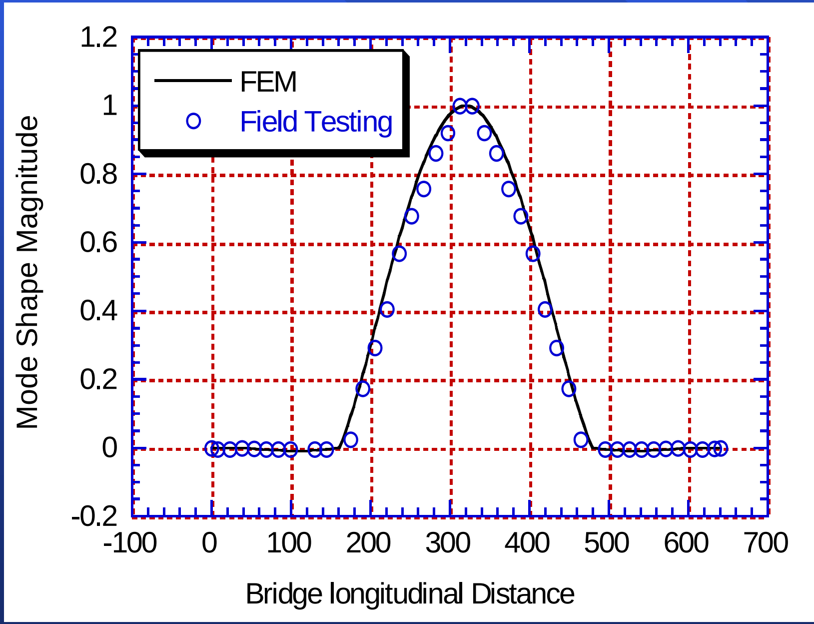
Task 3: FE Modeling ….. Maysville Bridge



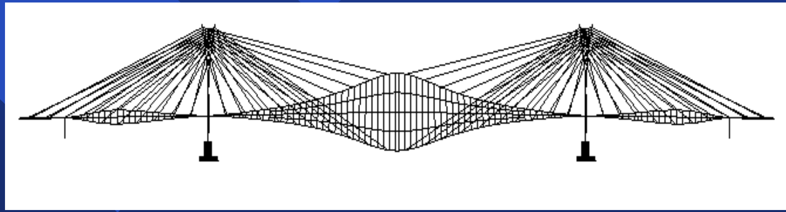
Plan



3-D View



1st Transverse Mode (+Torsion)



Elevation

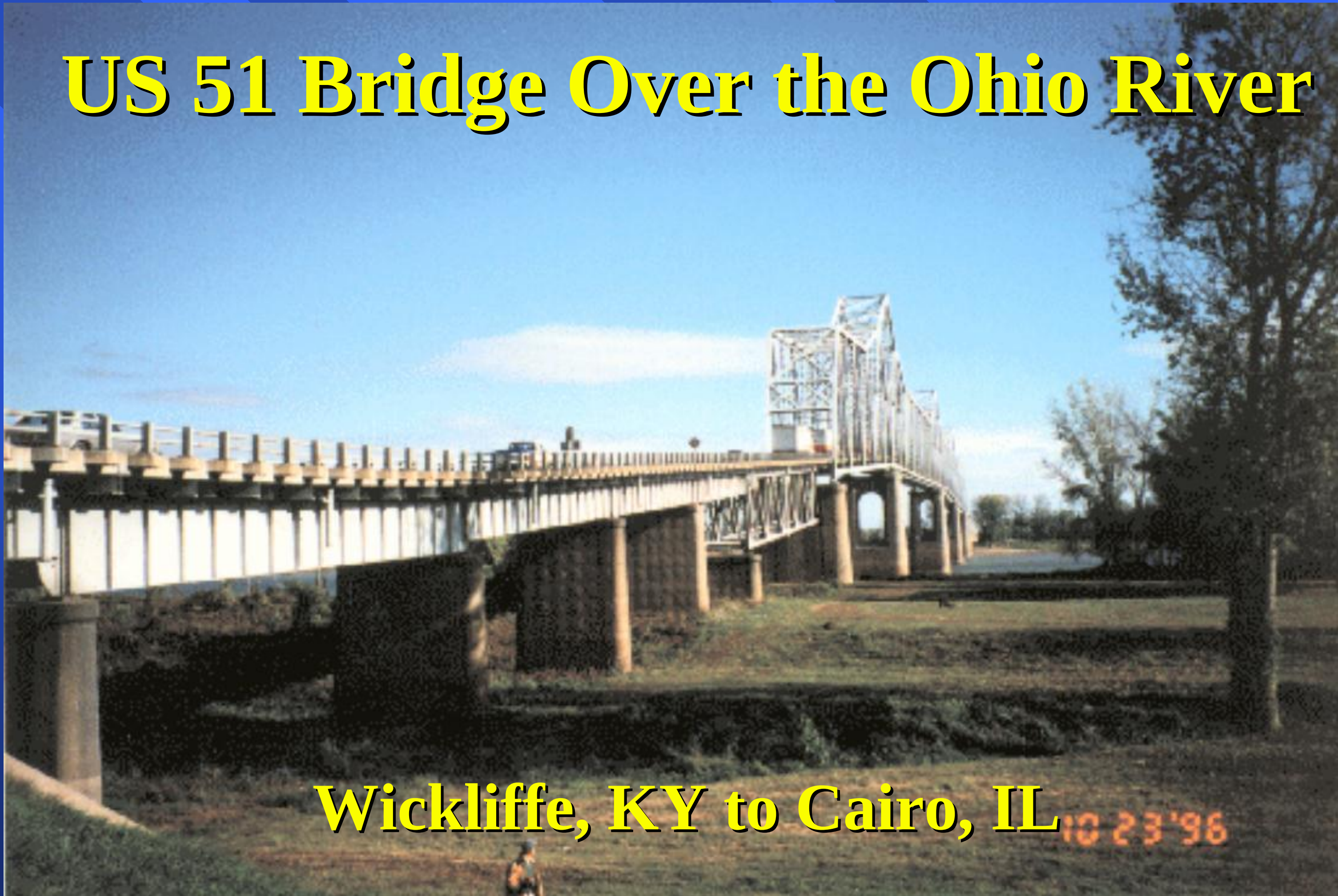
The Owensboro Bridge

Owensboro Bridge

The Brent-Spence Bridge


I 64 over the Ohio River
(Sherman-Minton Bridge)
Between Louisville, KY and New Albany, IN

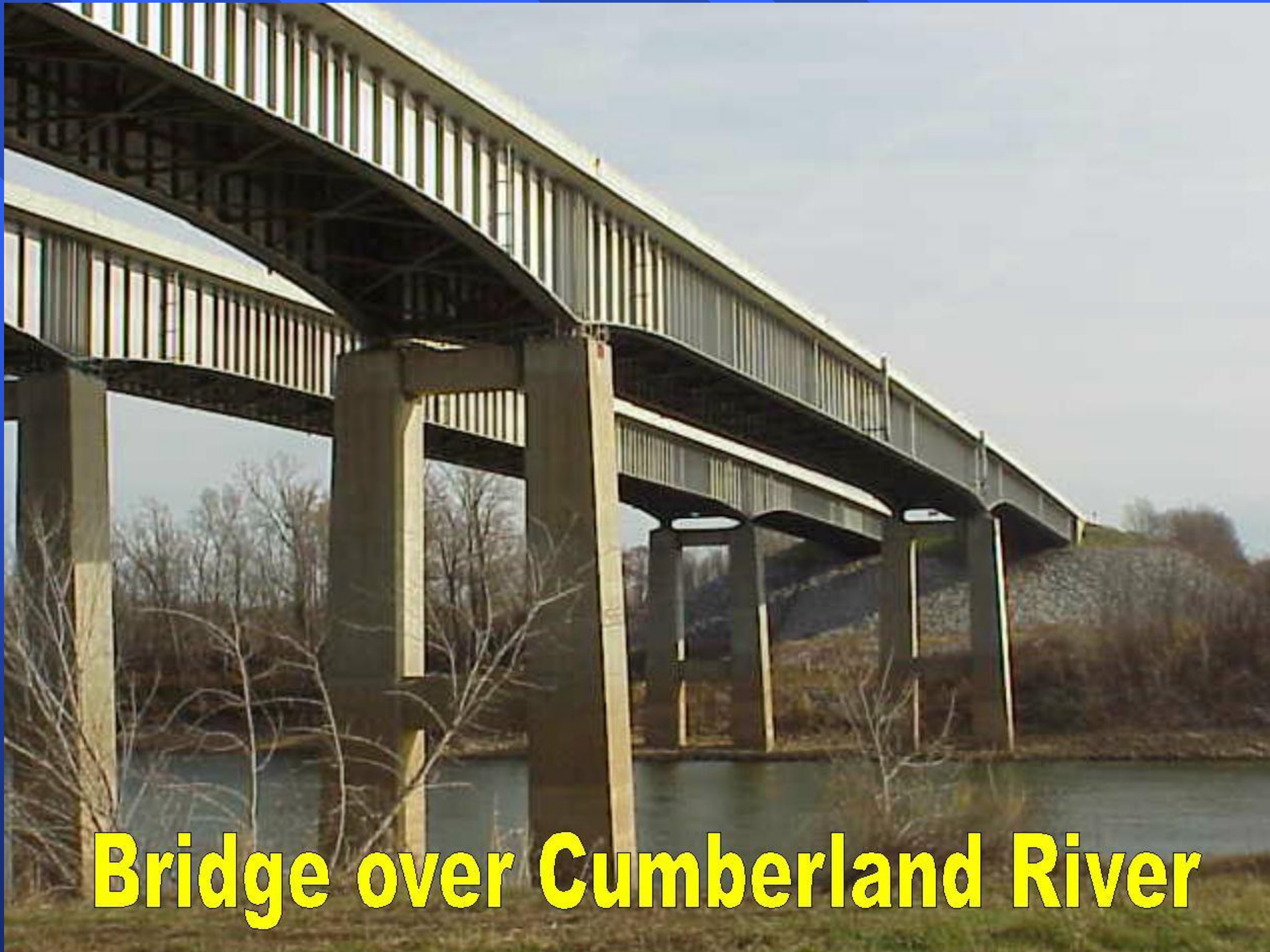
US 51 Bridge Over the Ohio River

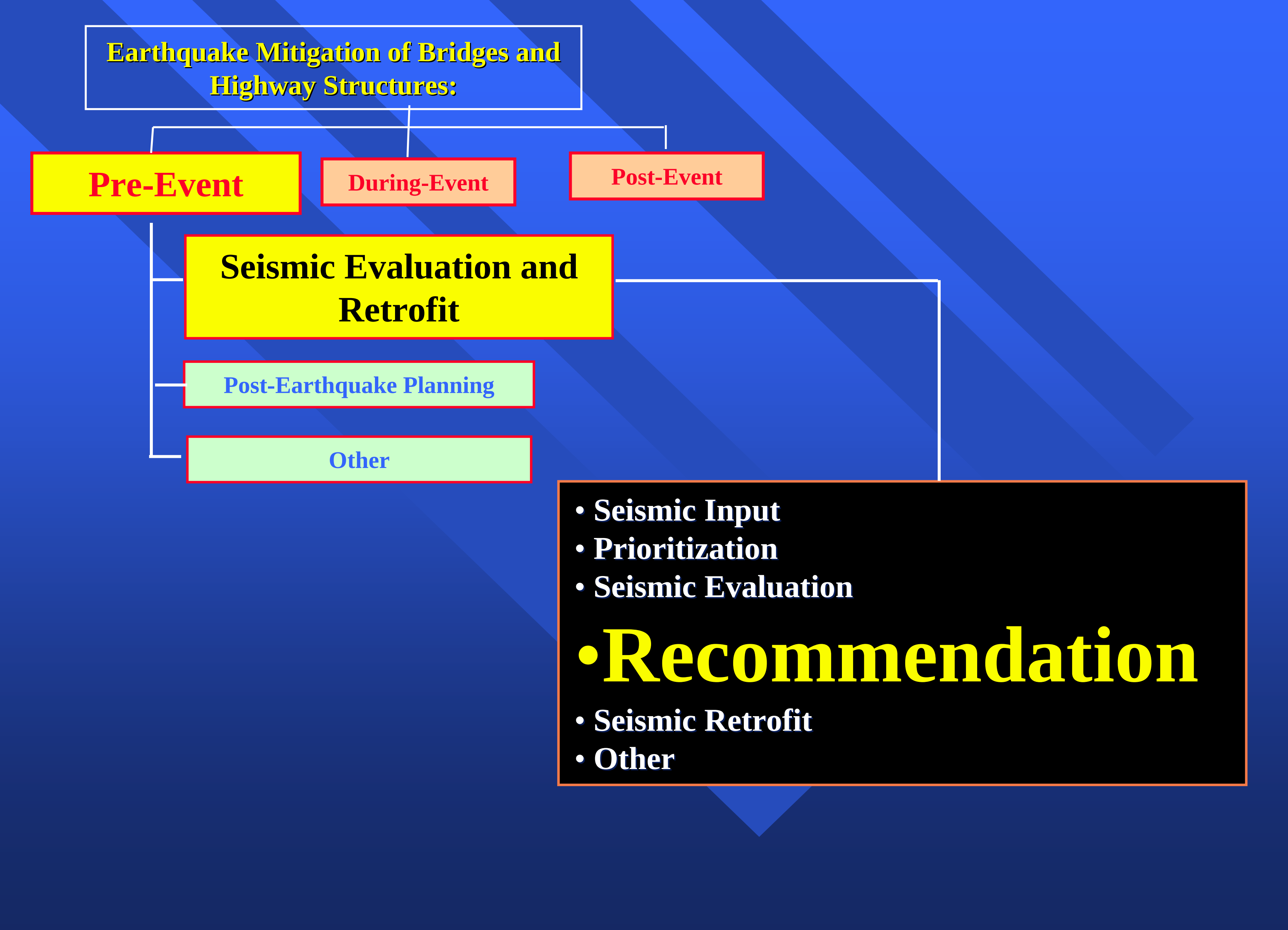


Wickliffe, KY to Cairo, IL


Henderson, KY to Evansville, IN
Bridge on US-41
10 23 '96


Bridge over Tennessee River


Bridge over Cumberland River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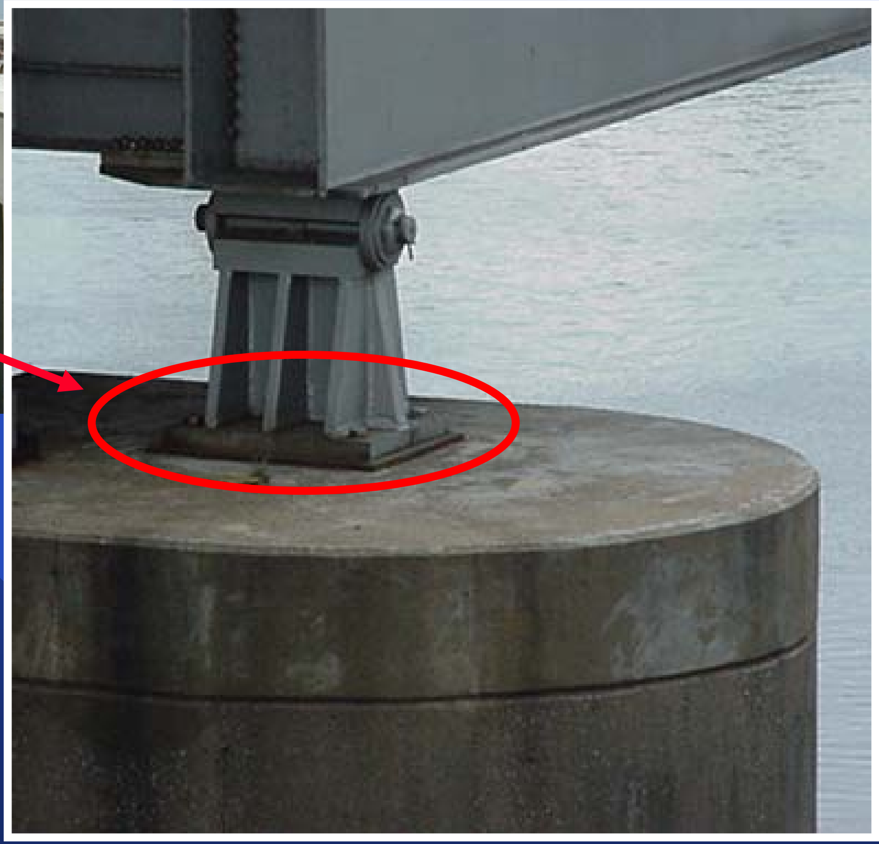
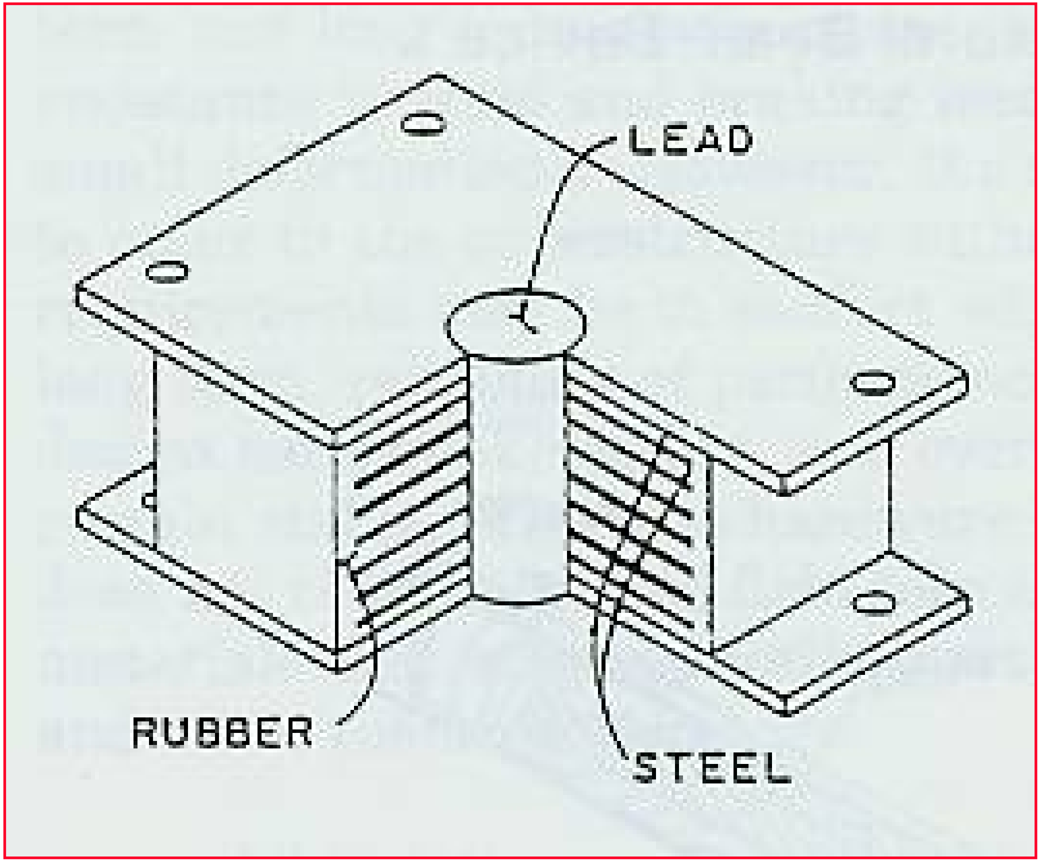


Provide additional shear bolts or replace bearing

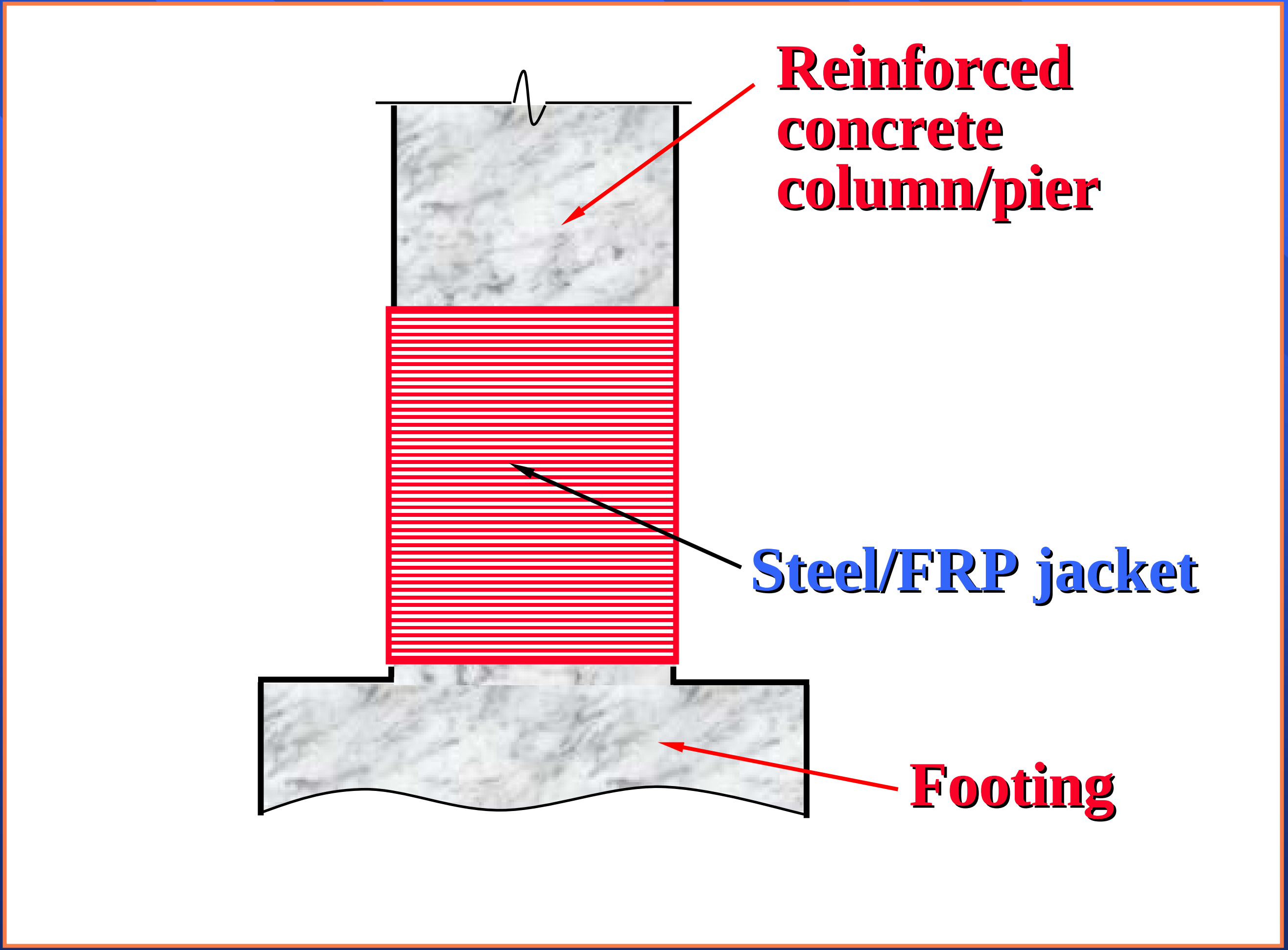
Earthquake Mitigation of Bridges and Highway Structures:

- **Pre-Event**
  - **Seismic Evaluation and Retrofit**
    - Seismic Input
    - Prioritization
    - Seismic Evaluation
    - Recommendation
    - **Seismic Retrofit**
    - Other
  - Post-Earthquake Planning
  - Other
- **During-Event**
- **Post-Event**



Lead-filled Elastomeric Isolation Bearing

Retrofit measure: Example



Earthquake Mitigation of Bridges and Highway Structures:

Pre-Event | During-Event | Post-Event

- Seismic Evaluation & Retrofit
- **Post-Earthquake Planning**
  - Develop Contingency Plan
  - Provide Training
  - Instrumentation & Monitoring
  - Other
- Other

Earthquake Mitigation of Bridges and Highway Structures:

- **Pre-Event**
  - Seismic Evaluation & Retrofit
  - **Post-Earthquake Planning**
    - Develop Contingency Plan
    - Provide Training
    - **Instrumentation & Monitoring**
    - Other
  - Other
- During-Event
- Post-Event

Activities in Kentucky


Bridge over Tennessee River


Henderson, KY to Evansville, IN
Bridge on US-41
10 23 '96

Earthquake Mitigation of Bridges and Highway Structures

Pre-Event

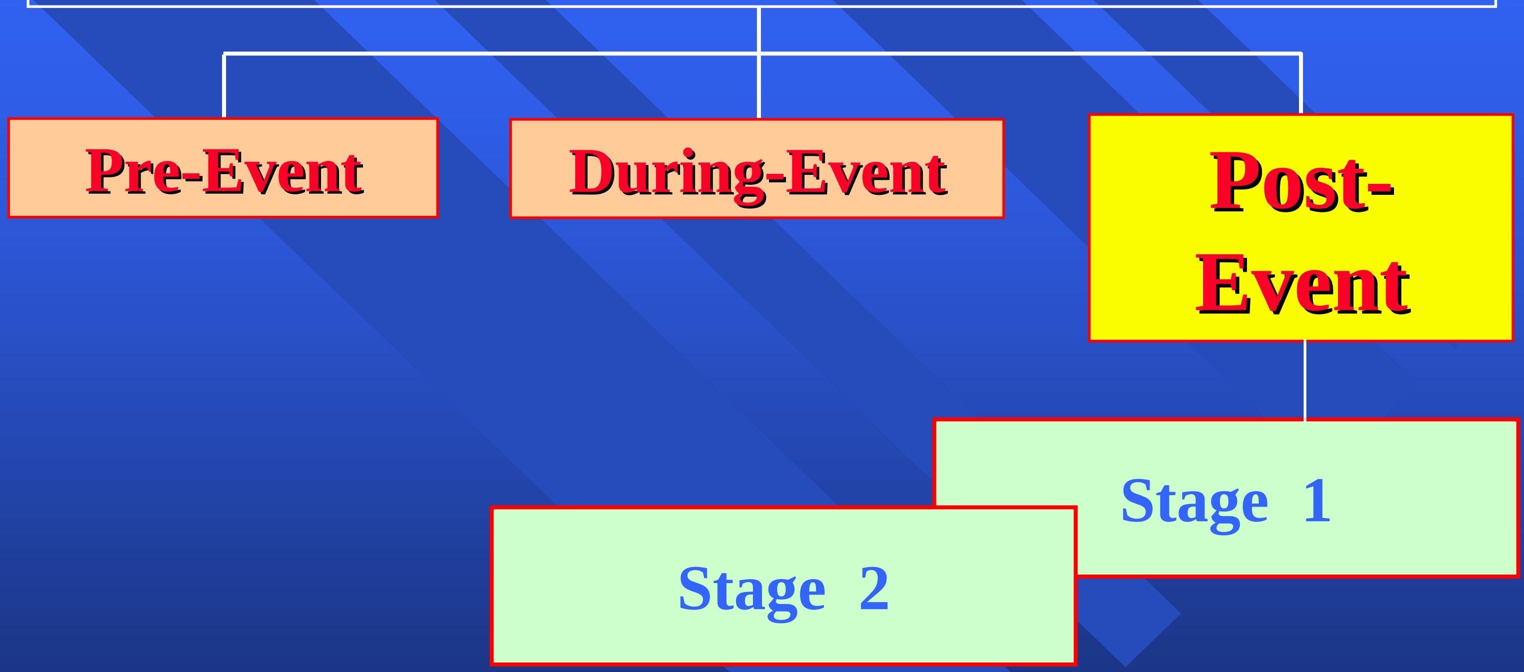
During-Event

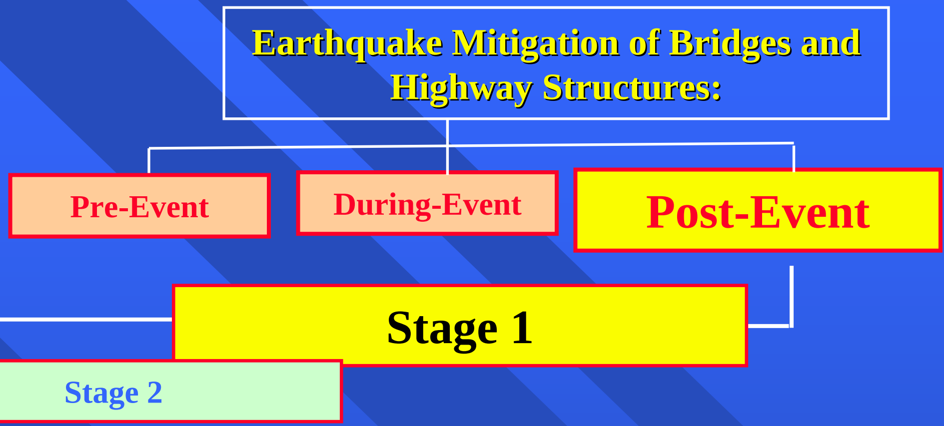
Post-Event

- An earthquake lasts for few seconds.

- Action during the event is not possible.

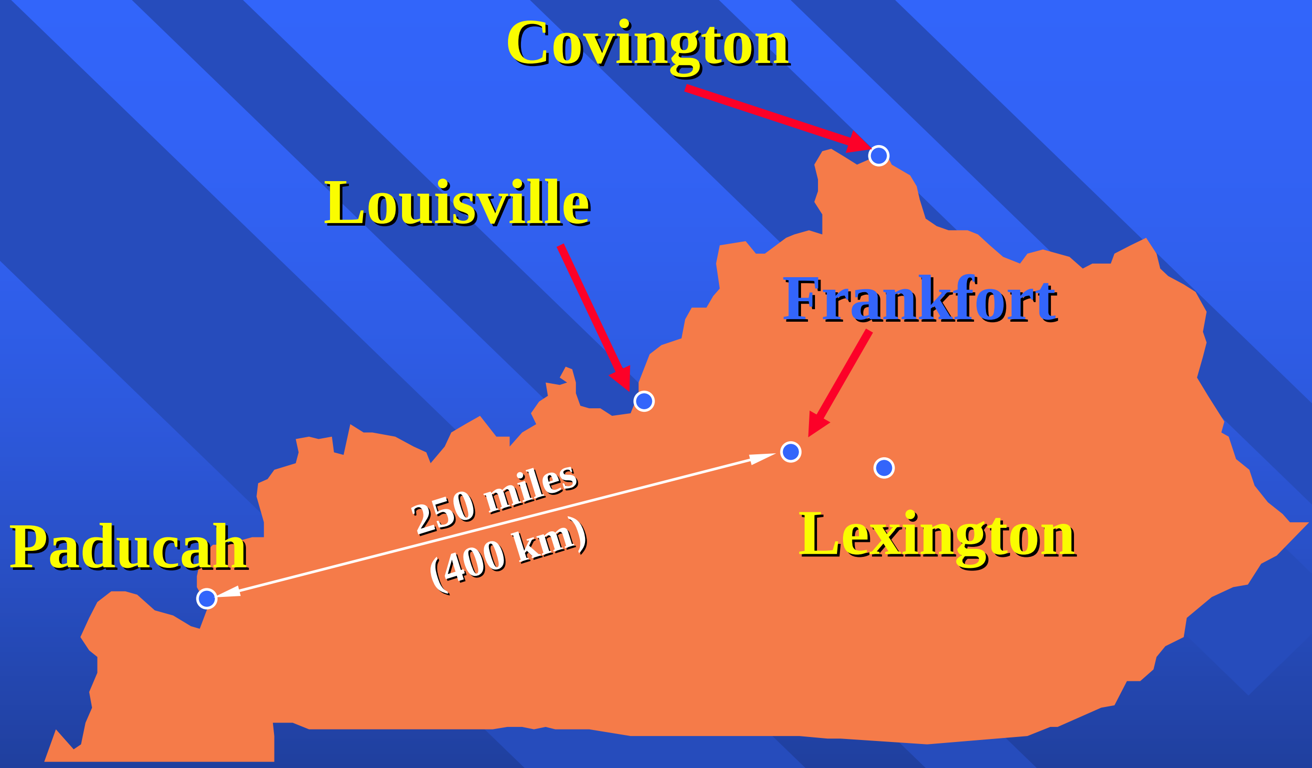
Earthquake Mitigation of Bridges and Highway Structures





- Preliminary Assessment
- Prioritization
- Recommendation
- Immediate Action
- Other

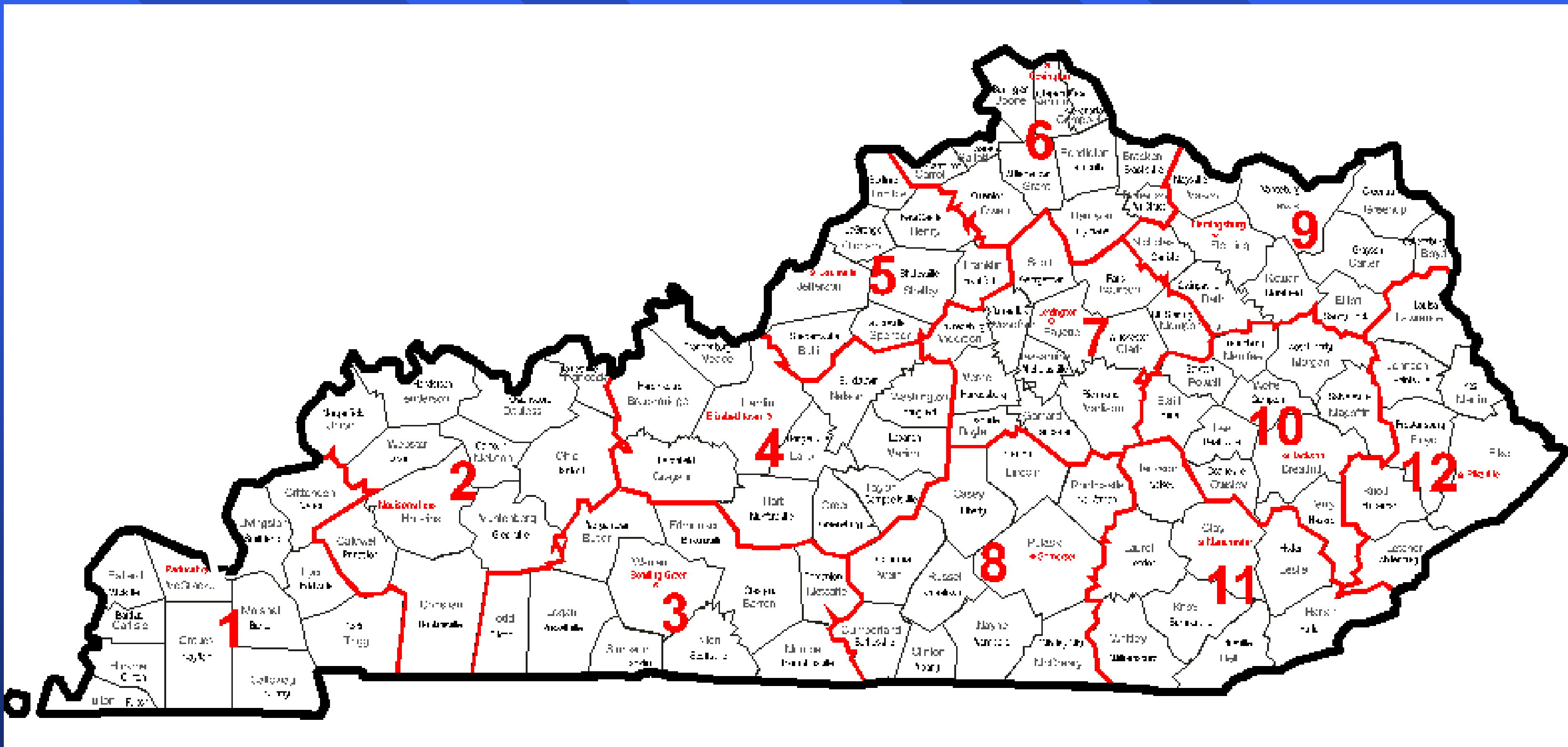
Activities in Kentucky

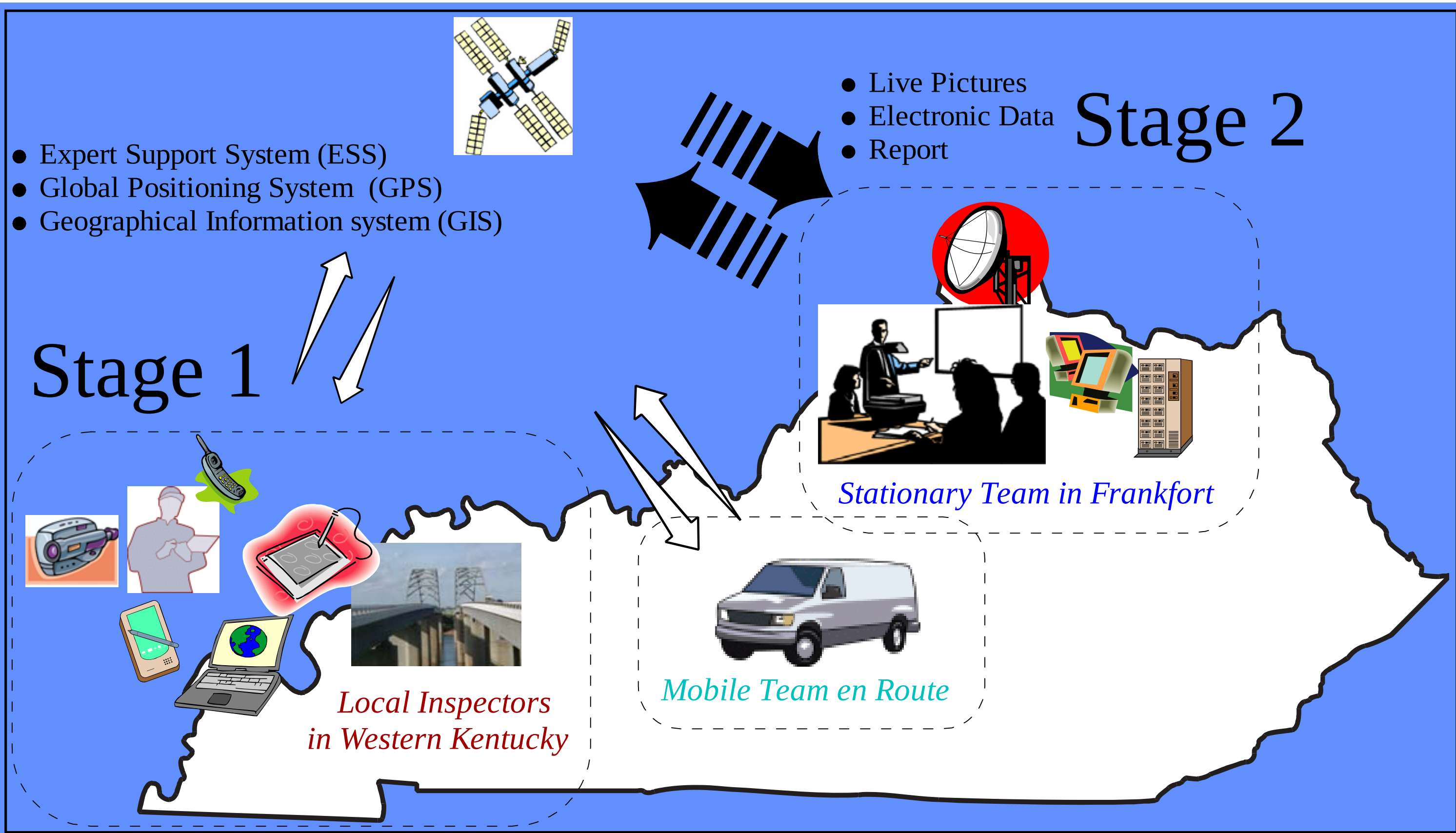


- Response Team $\geq$ 2 hours
- Driving $\geq$ 4 hours
- Delays = ?? hours
- Other = ?? hours

At Least 6 hours

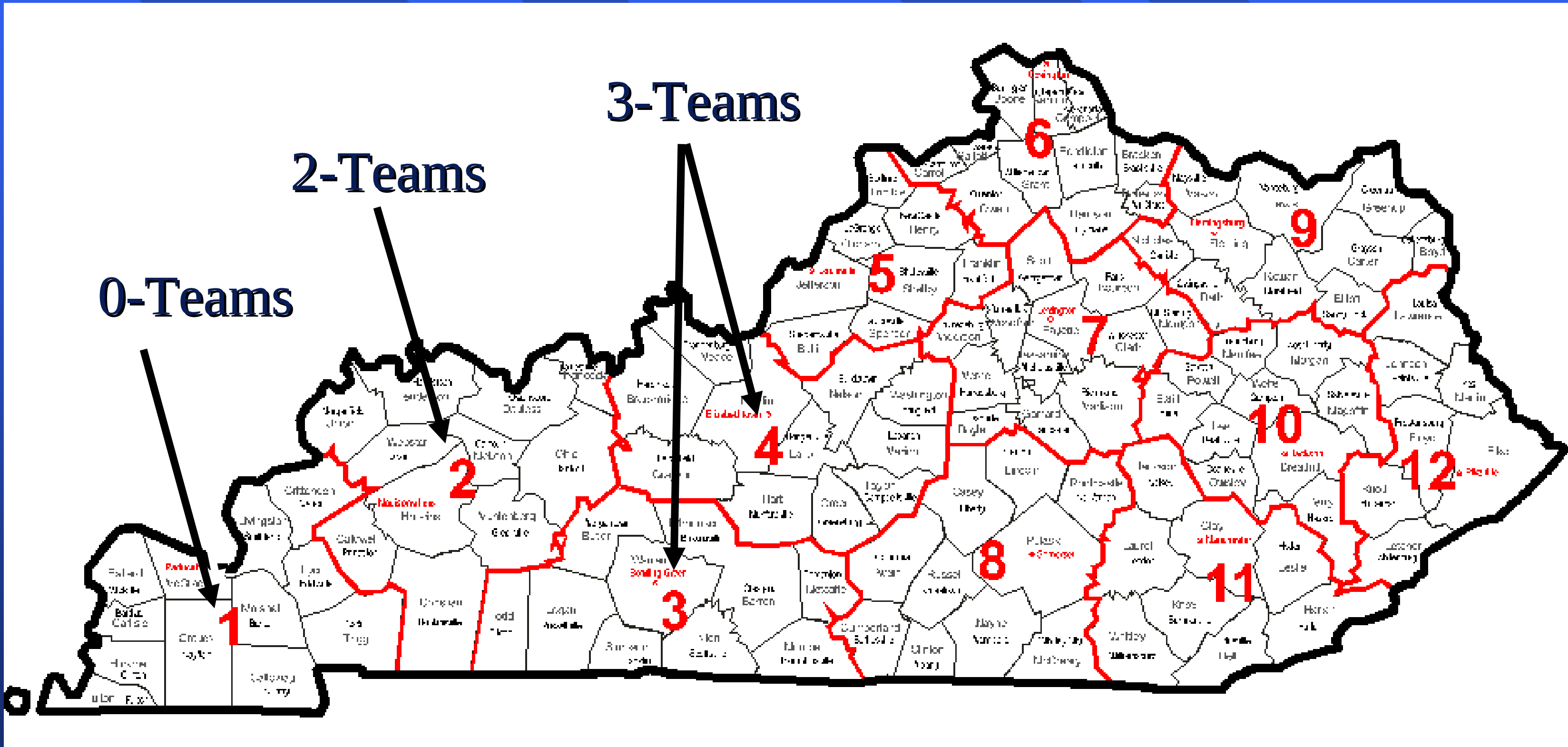
Kentucky Highway Districts





Live Pictures
Electronic Data
Report
Stage 2
Expert Support System (ESS)
Global Positioning System (GPS)
Geographical Information system (GIS)
Stage 1
Stationary Team in Frankfort
Mobile Team en Route
Local Inspectors
in Western Kentucky

Teams in Stage 1



Objective of Stage 1

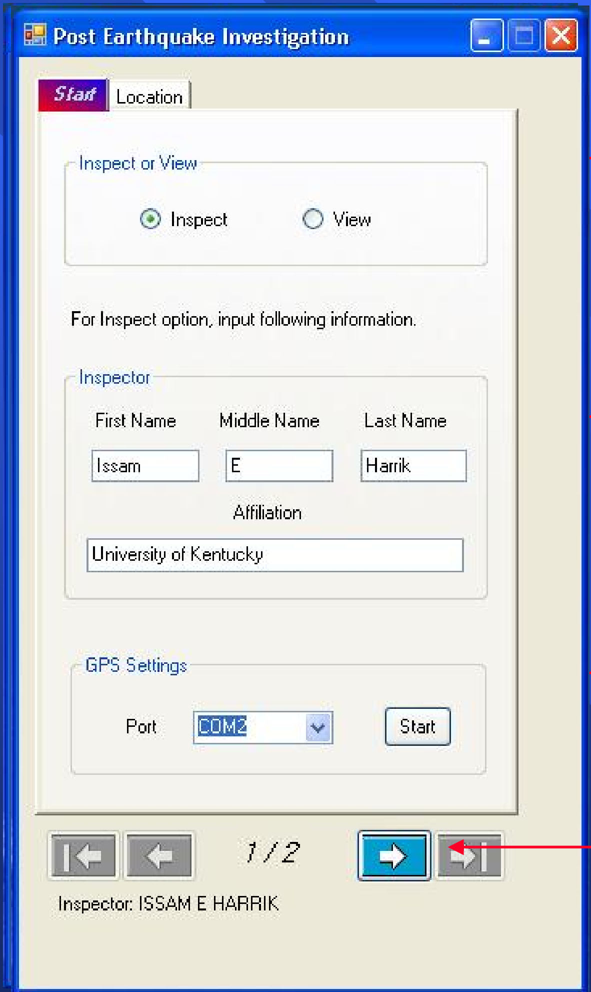
Triage

In Cooperation with the

Kentucky National Guard


Gateway
NAVMAN

Kentucky Post-Earthquake Investigation Software (KyPEIS)



Select Inspect or View

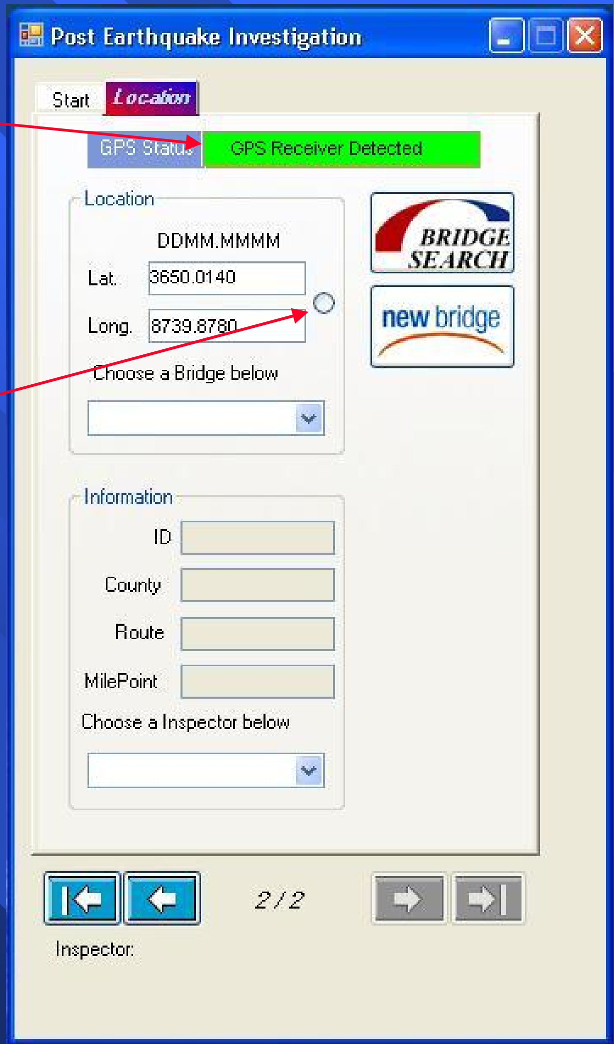
Enter Name and Affiliation

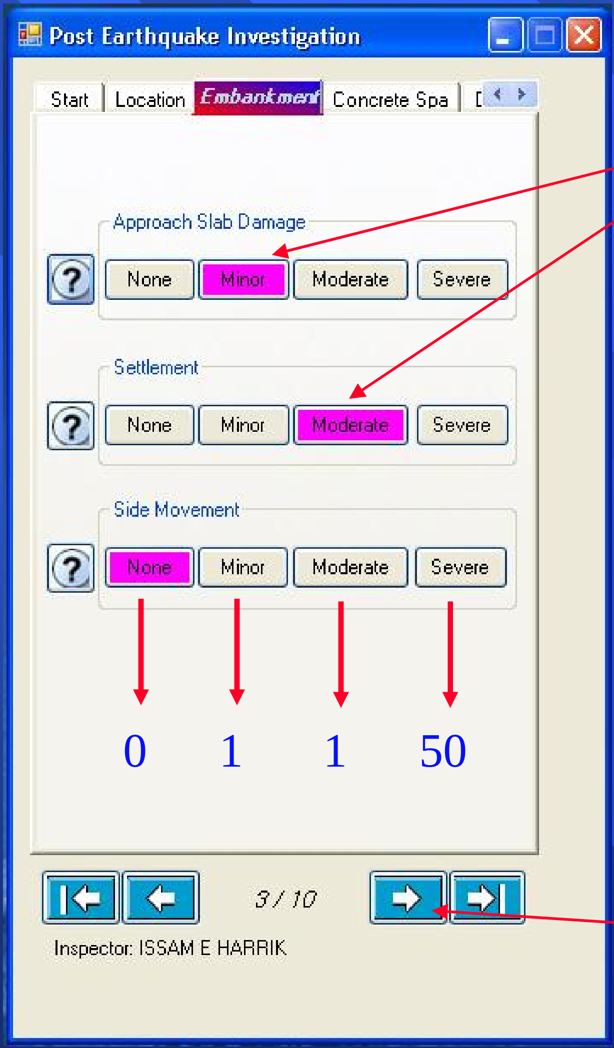
Press start if connected to GPS receiver and require data

Next to continue

GPS receiver detection message

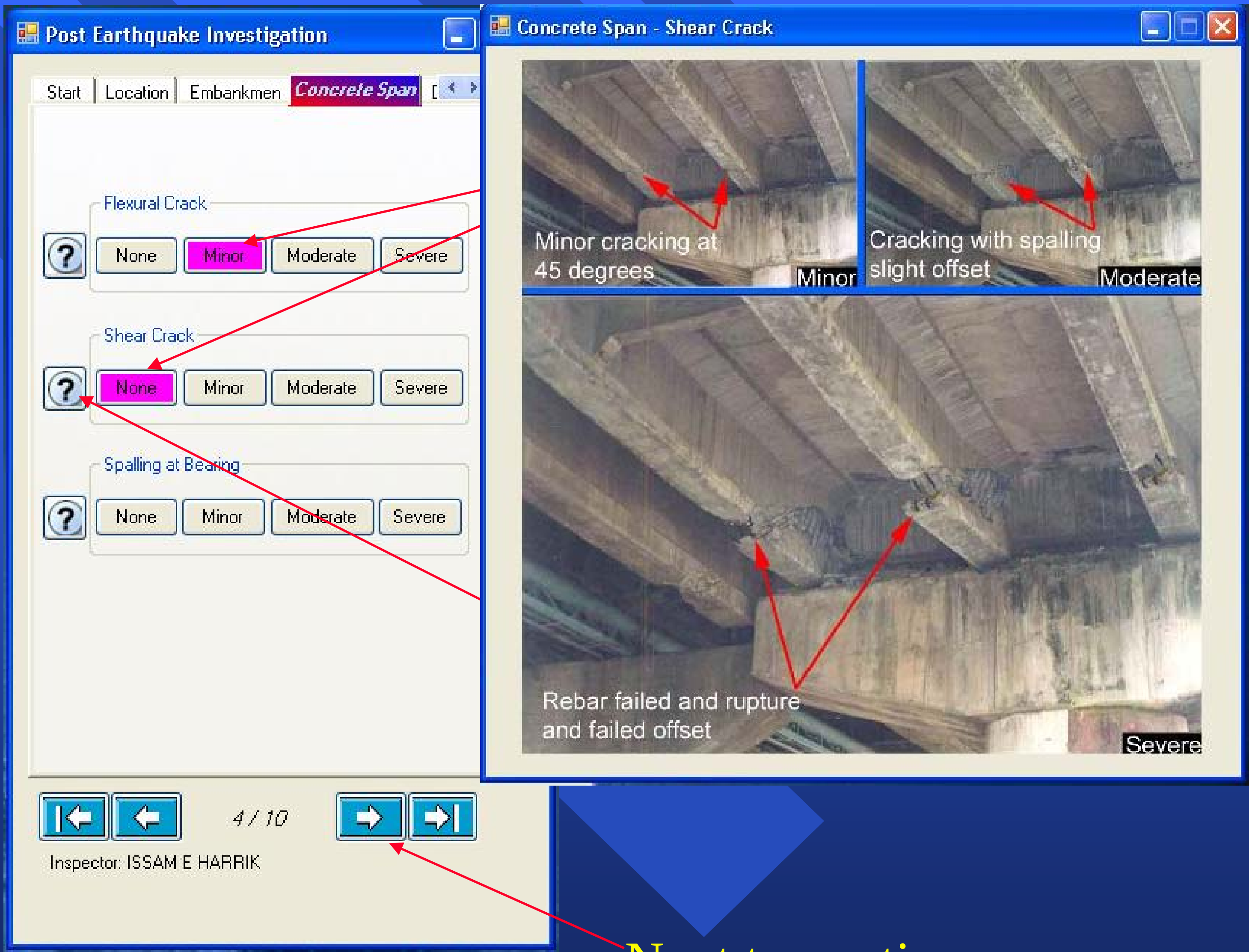
Check here to use GPS data to select bridge



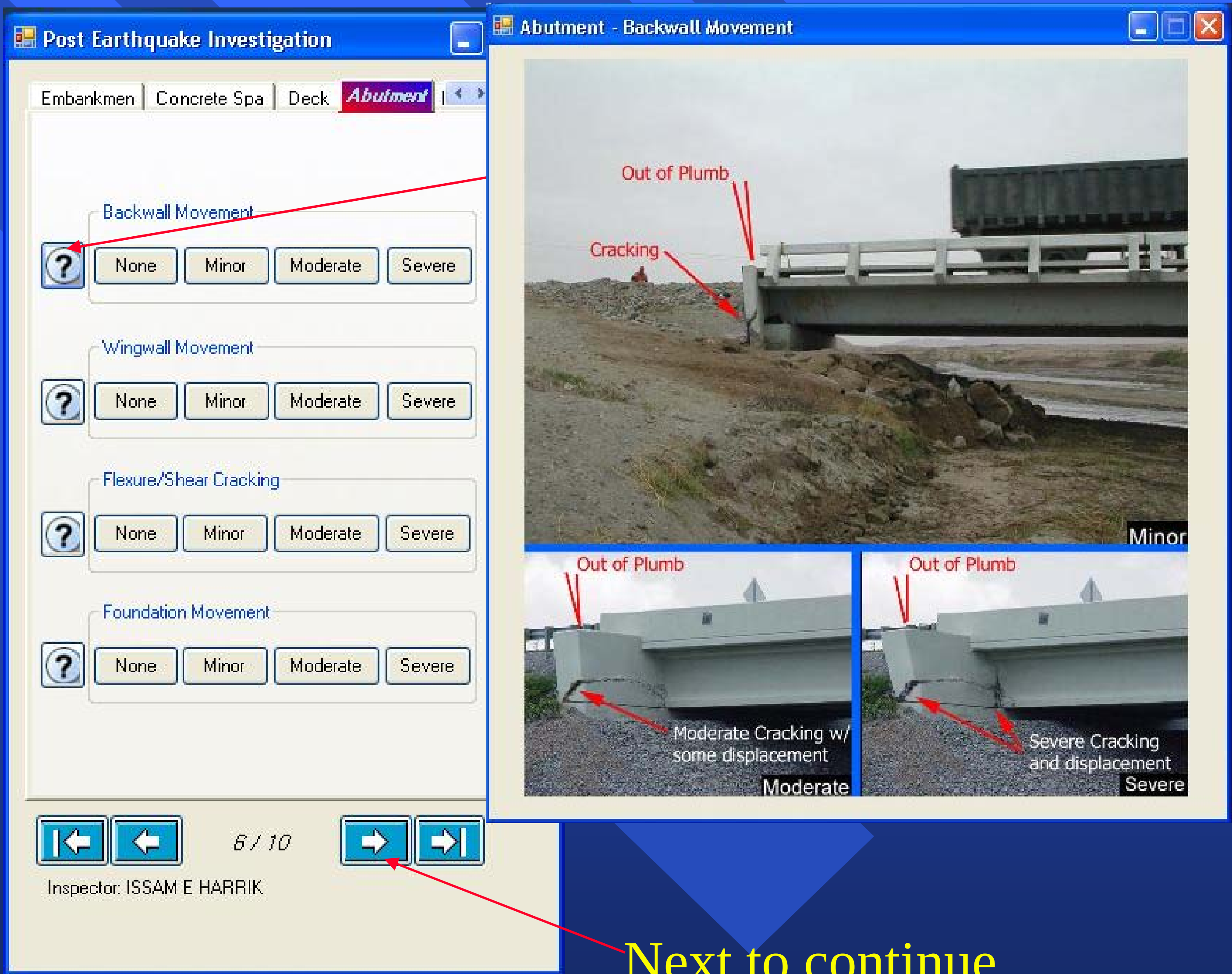


Enter damage level

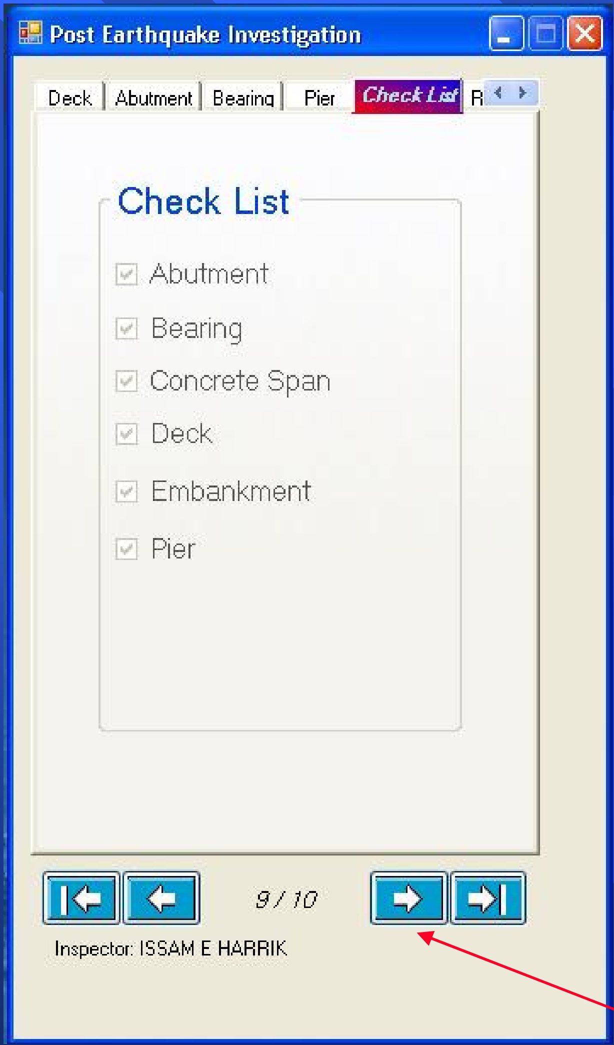
Next to continue



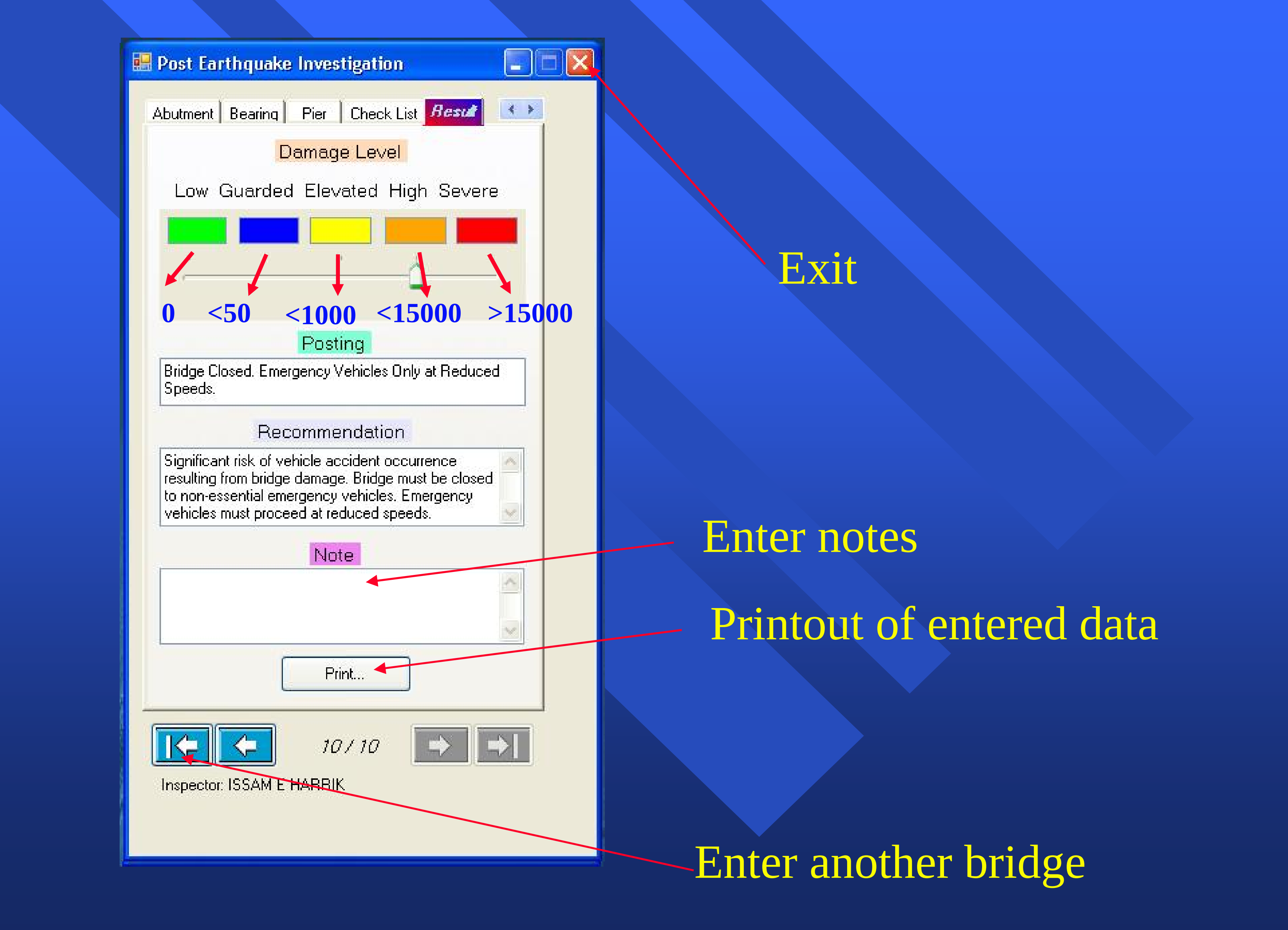
Next to continue



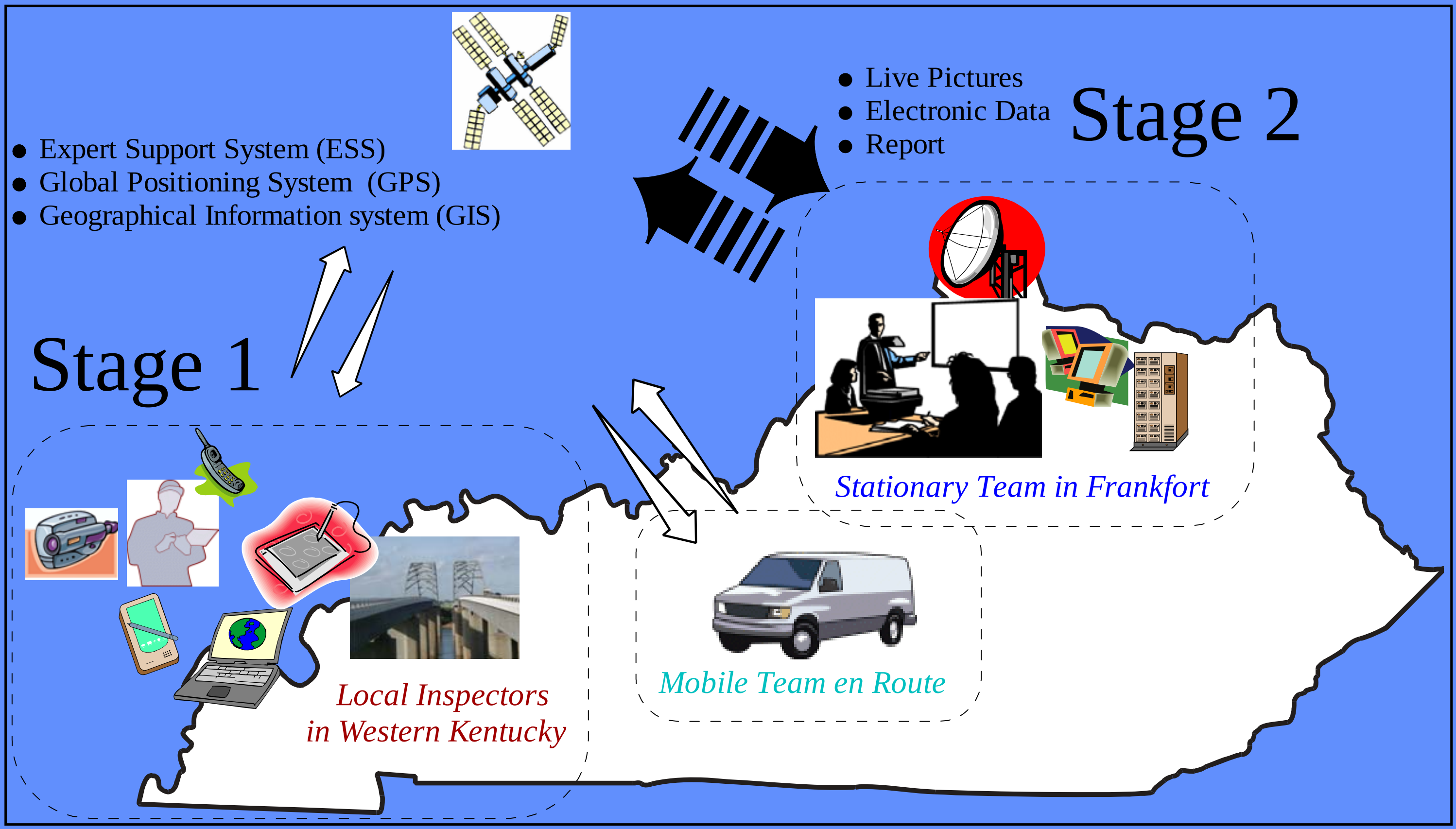
Next to continue



Next to continue


Post Earthquake Investigation
Abutment
Bearing
Pier
Check List
Result
Damage Level
Low Guarded Elevated High Severe
0
<50
<1000
<15000
>15000
Posting
Bridge Closed. Emergency Vehicles Only at Reduced Speeds.
Recommendation
Significant risk of vehicle accident occurrence resulting from bridge damage. Bridge must be closed to non-essential emergency vehicles. Emergency vehicles must proceed at reduced speeds.
Note
Print...
10 / 10
Inspector: ISSAM E HARRIK
Exit
Enter notes
Printout of entered data
Enter another bridge

Teams in Stage 2



Outline

- Introduction
- Hazard Mitigation

- **Conclusions**

Conclusions

- **We Can no Longer Accept the High Cost of Life or Ensuing Economic Losses When Natural or Man-Made Disasters Strike**

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Conclusions

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- We Cannot Be "Prevent" nor "Predict" Disasters
- We Now Have the Means to Better "Prepare" for Disasters
- We Now Have the Means to "Respond" Immediately Following a Disaster
- **We Now Have the Means to Quickly and Effectively "Restore" Defective Structures Following a Disaster**

Questions?

Thank You

and

Have a Nice Day