# Lecture #5
# Introduction to
# Network for Earthquake Engineering Simulation Laboratory @ UB

S. Thevanayagam
Associate Professor
**Department of Civil, Structural and Environmental Engineering**
**State University of New York, Buffalo, NY, USA**
**Workshop, Australia, Dec.14, 2007**

# NSF NEES

- **Slide To be Added**

# UB-NEES Laboratory History

- **Founded in 1975 as the "Structural Engineering Laboratory" Enhanced with a strong floor in new building in 1981.**
- **Upgraded to Earthquake Engineering capabilities in 1983 by adding a 5-DOF shake table.**
- **Served as the flagship lab for the (National) Multidisciplinary Center for Earthquake Engineering Research - (N)MCEER since 1986**
- **Upgraded to current size in 2000-2004 by adding the Network for Earthquake Engineering Simulation capabilities**
- **Currently provides services to:**
  - **CSEE - instructional**
  - **MCEER / NSF-NYS – research**
  - **NEES / NSF – research**
  - **INDUSTRIES – qualification and development related testing**

# UB - NEES Vision

## Develop a *Versatile* National Large-Scale Earthquake Engineering Facility

**Combine *State of the Art Experimental Equipment*, *On-Line Experimental Control Methods* and *a Diverse Staff of Expert Researchers* for:**

- **The development of the physical infrastructure and capabilities to test full size or large sub-scale structures and components**
- **The development of new experimental techniques and approaches to earthquake engineering**
- **The development of new earthquake resistant design concepts and systems**
- **The development of new analytical and computational methods (supported by experimental data)**
- **The development of network-based collaborative research activities and data sharing**

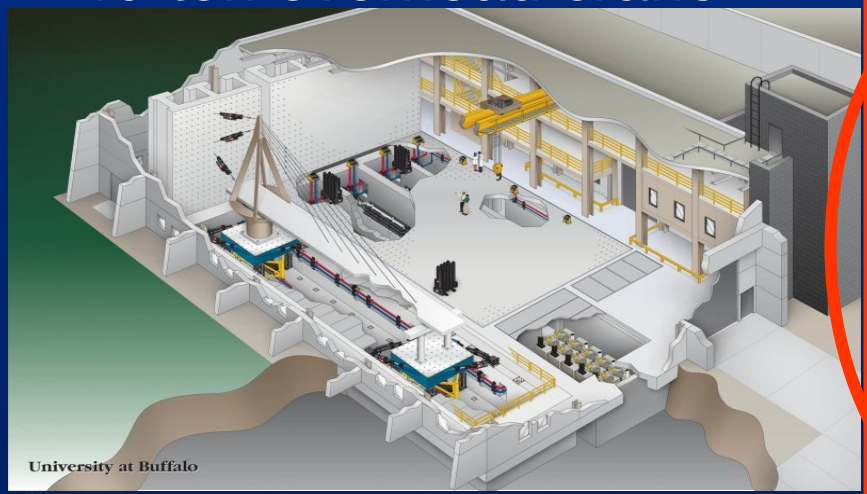
# Ketter Hall Expansion

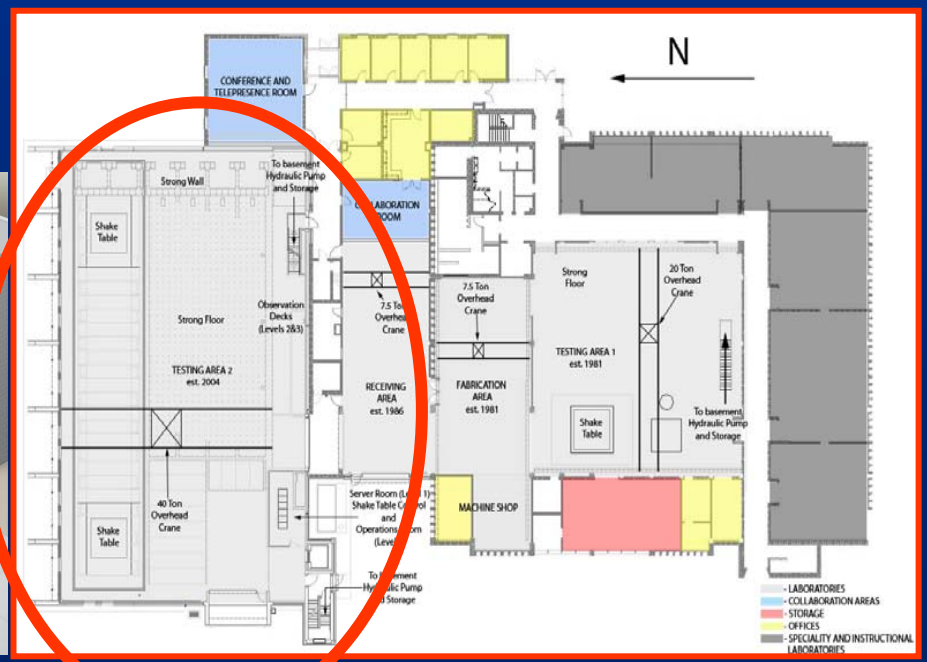
- 13,000sq,ft.

  -600 sq.ft. for control and server rooms

  -800 sq. ft. of elevated observation space

  -1,500 sq. ft. of renovated space
- 3,400 sq.ft. strong floor
- 1,800 sq. ft. reaction wall
- 115 ft. long shake table trench
- 40-ton overhead crane




nees@buffalo

SEESL

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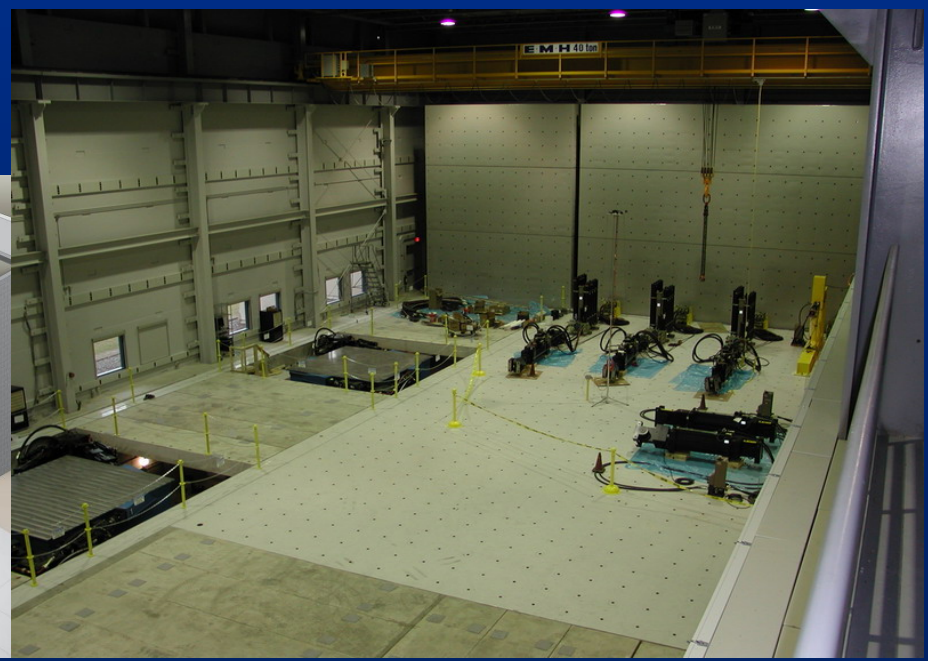
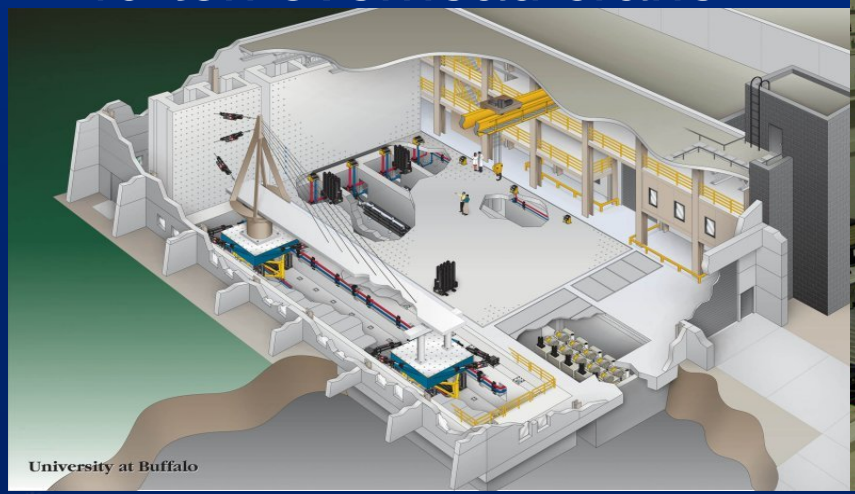
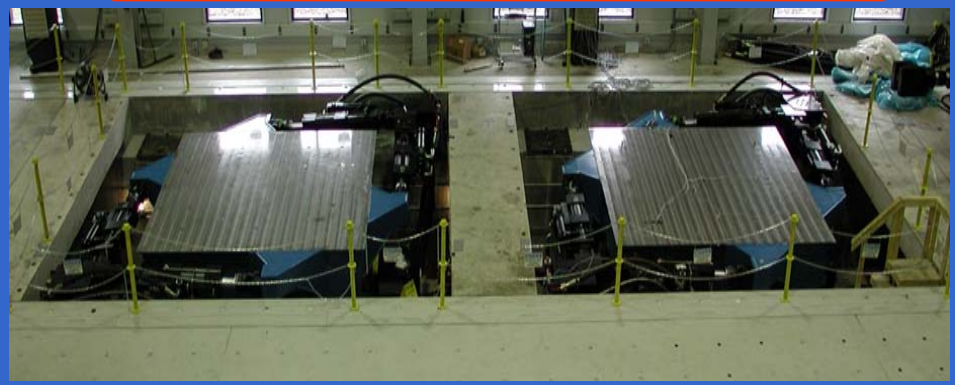
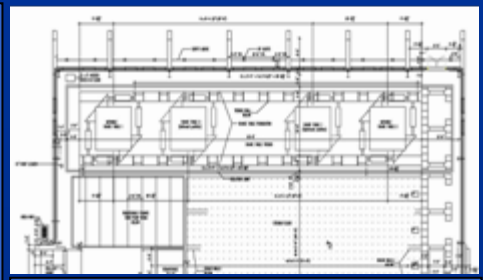


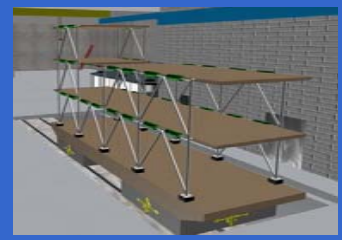



# Relocatable Shake Tables

- **Two 6-DOF Shake Tables (3.6x3.6m)**



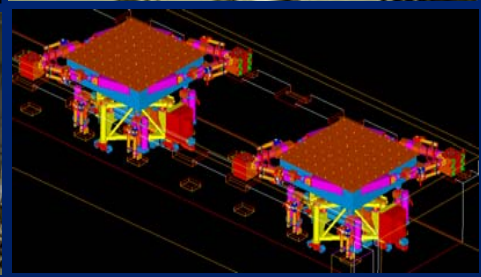




- **Controllers**

  **-Conventional Control Techniques**

  **-MTS Adaptive Control Techniques**



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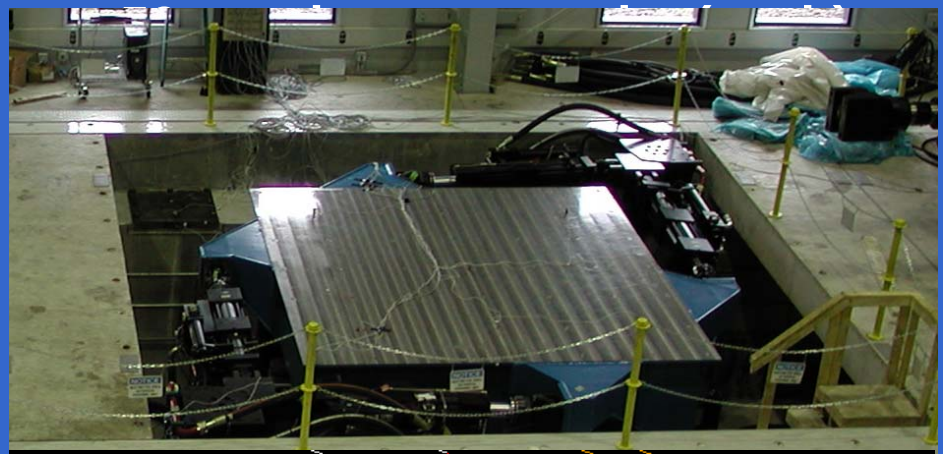

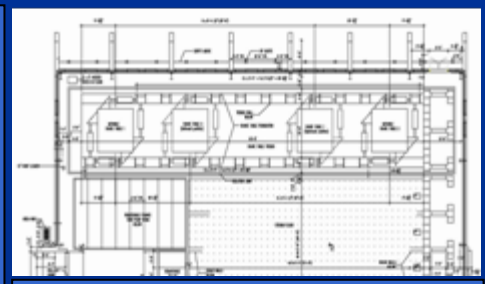

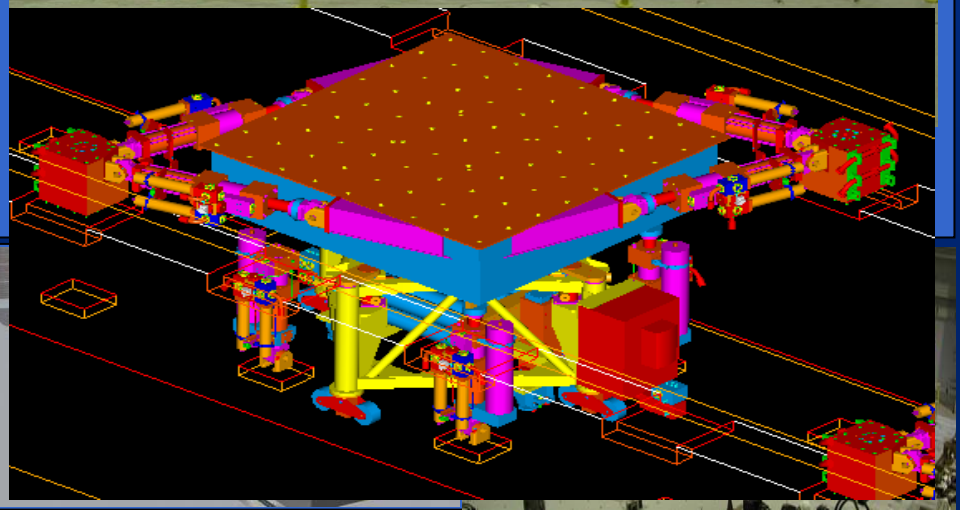

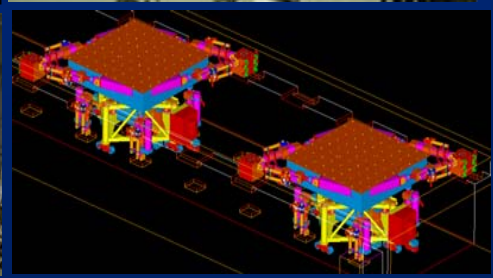

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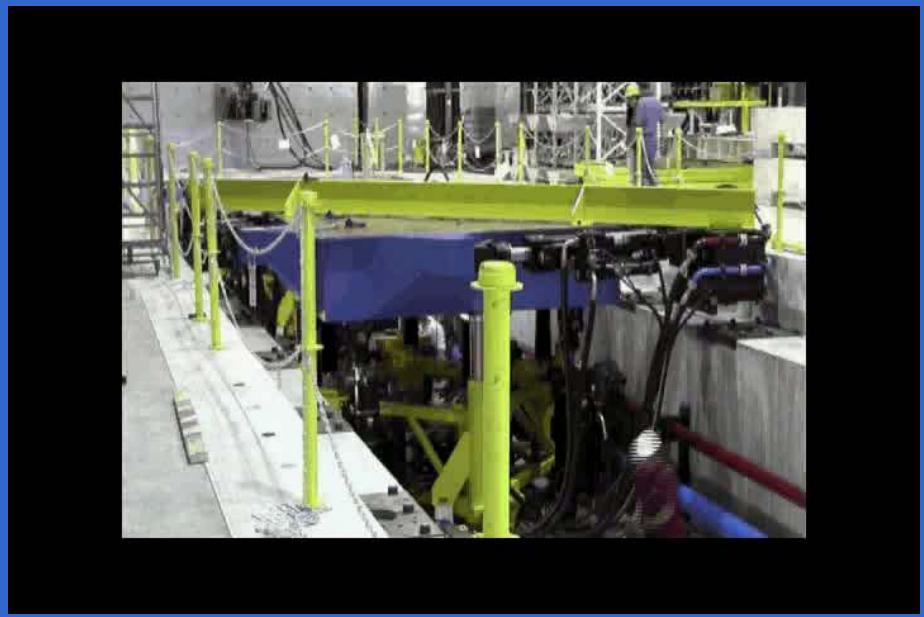
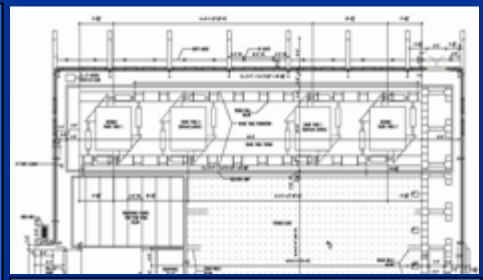
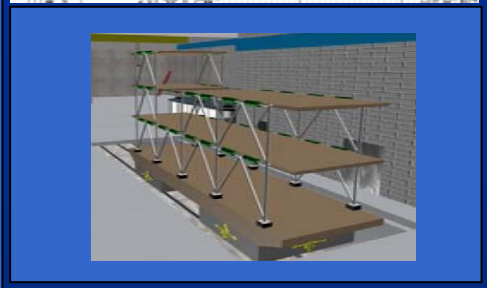
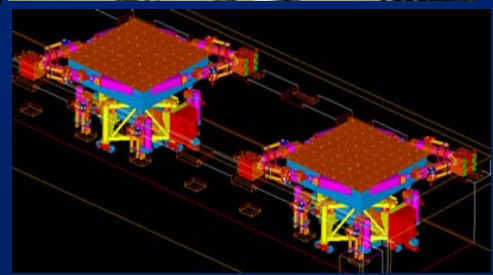


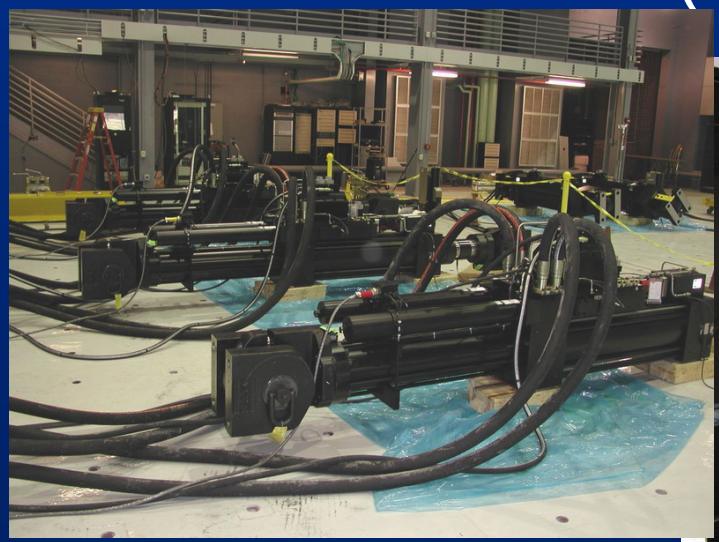


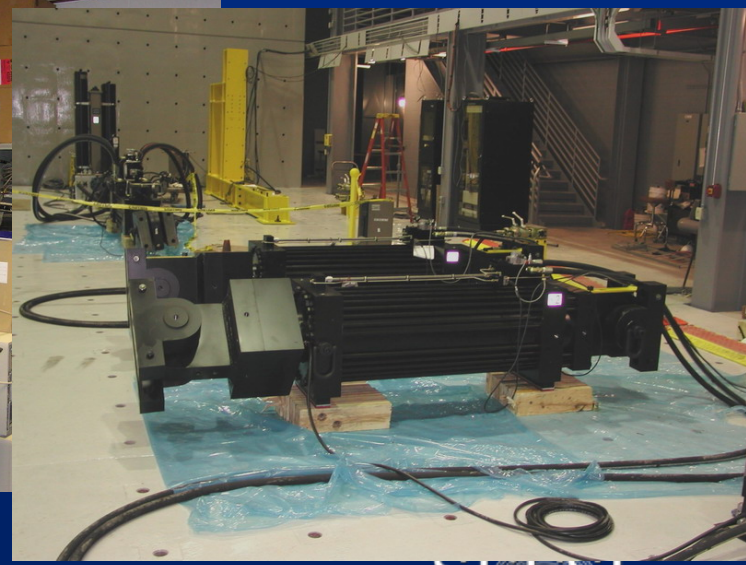




# Large Dynamic and Static Actuators and Controllers

- 3 x 100 tons Dynamic Actuators (0-100Hz)
- 2 x 200 tons Static Actuators
- Flex-Test Controllers and Software
- STS Controller (MTS469) – Custom Made



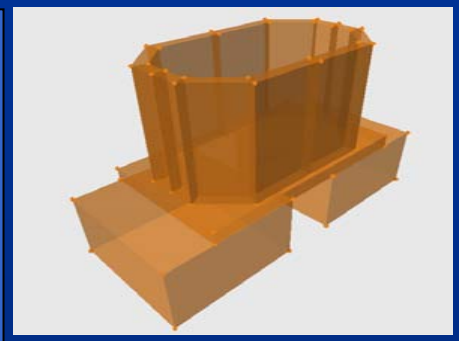


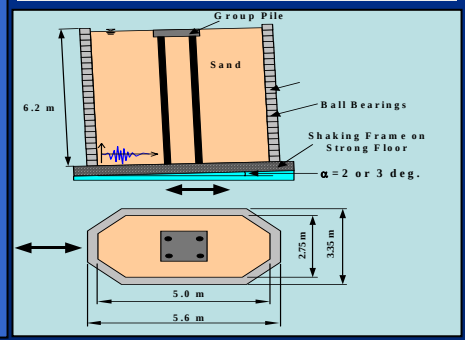
# Hydraulic Supply and Distribution System

- 4 x 900HP Hydraulic Pumps Operating at 3000psi
  (Space for a 5th Pump)
- Integrated Accumulators and Distribution System
- 1600 gpm System Flow Capacity

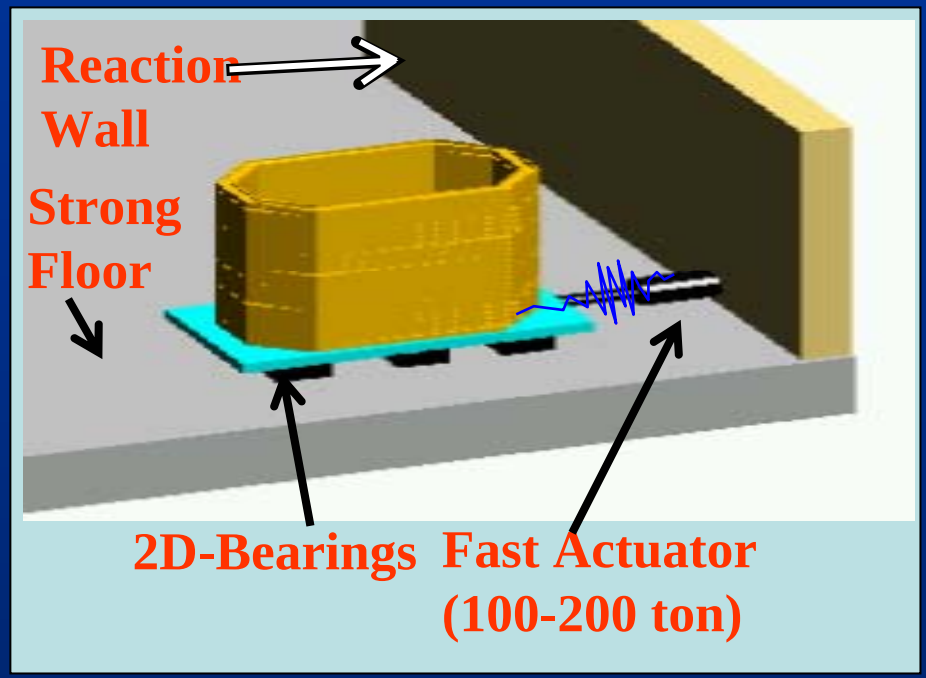
# 2-D Large Scale Geotechnical Laminar Box

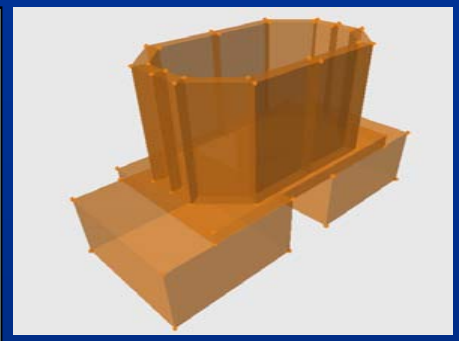
- Modular Multilayer-Laminate-Bearing Design; 5.0x2.75x6.2m (85 cubic meter maximum capacity)
- Simulate 2-D Ground Response for Soil-Foundation-Structure Interaction Studies at or Near Full Scale
- 1-g Geotechnical Studies (Compliment Centrifuge)

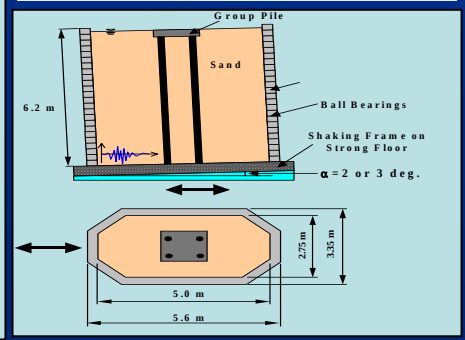





# 2-D Large Scale Geotechnical Laminar Box






# Other Complementary Facilities
# Centrifuge at RPI & UC Davis

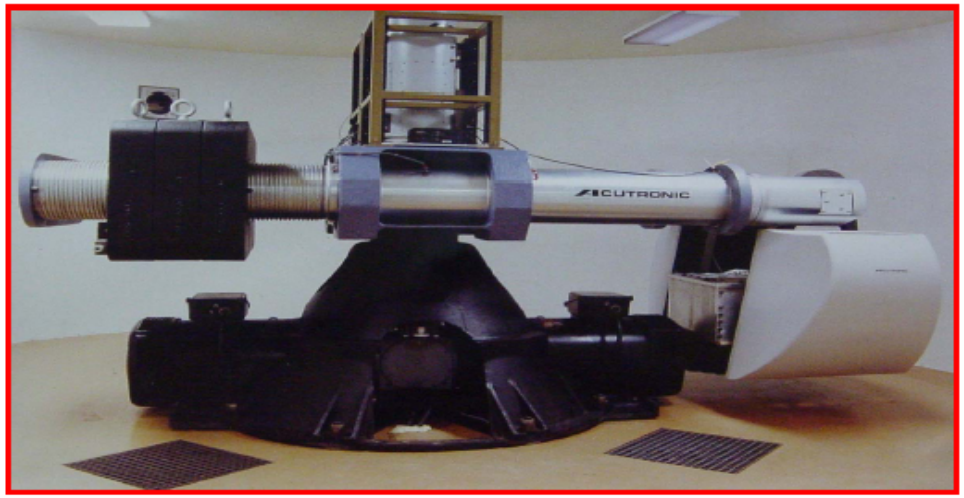



**Fig. I-4.** RPI-NEES: RPI 150g-ton geotechnical centrifuge

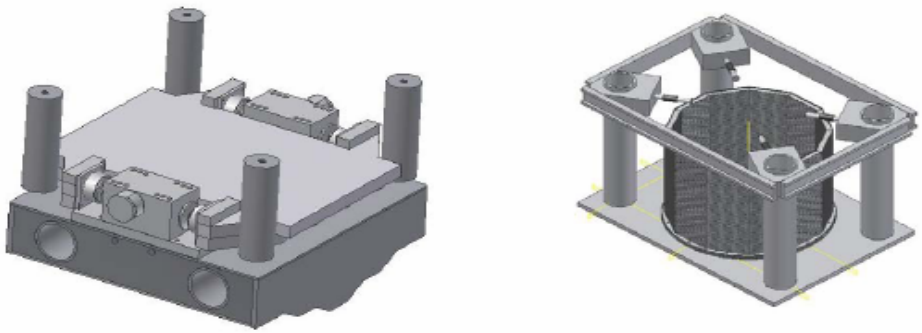


**Fig. I-5:** Two-dimensional in flight servohydraulic shaker (two prototype horizontal directions) and two-dimensional laminar container

# GEOTECHNICAL RESEARCH

Some New Possibilities are

- Verify and develop design approaches
- Investigate lateral spreading effects on piles
- Investigate lateral spreading effects on pile group
- Validate applicability of centrifuge test results
- Understand the mechanisms and involved physics
- Develop correct scaling laws
- Explore superstructure effects
- Validate remediation techniques
- Investigate effects of Quay-wall/Abutment movement on pile foundations

# Soil-Structure Interaction

- Determine the influence of bi-axial, soil-structure interaction on bridge response using one, or more, large laminar soil boxes on a very large shake table at full scale and on a set of tables at near-full-scale.
- Superstructure inertia effects could be modeled either by a full-scale bridge superstructure spanning two or more boxes.
- Superstructure inertia effects could be modeled by using hybrid testing techniques and actuators applied to the column cap to simulate superstructure inertia loads.
- Use one or more centrifuges for component validation work. Both piled-foundation and abutment back-wall interaction studies should be undertaken. This work should also be supplemented by soil-pile interaction studies on single piles and pile groups in both stiff and soft soils using a full-scale soil pit and biaxial actuators at the pile cap.

# Liquefaction

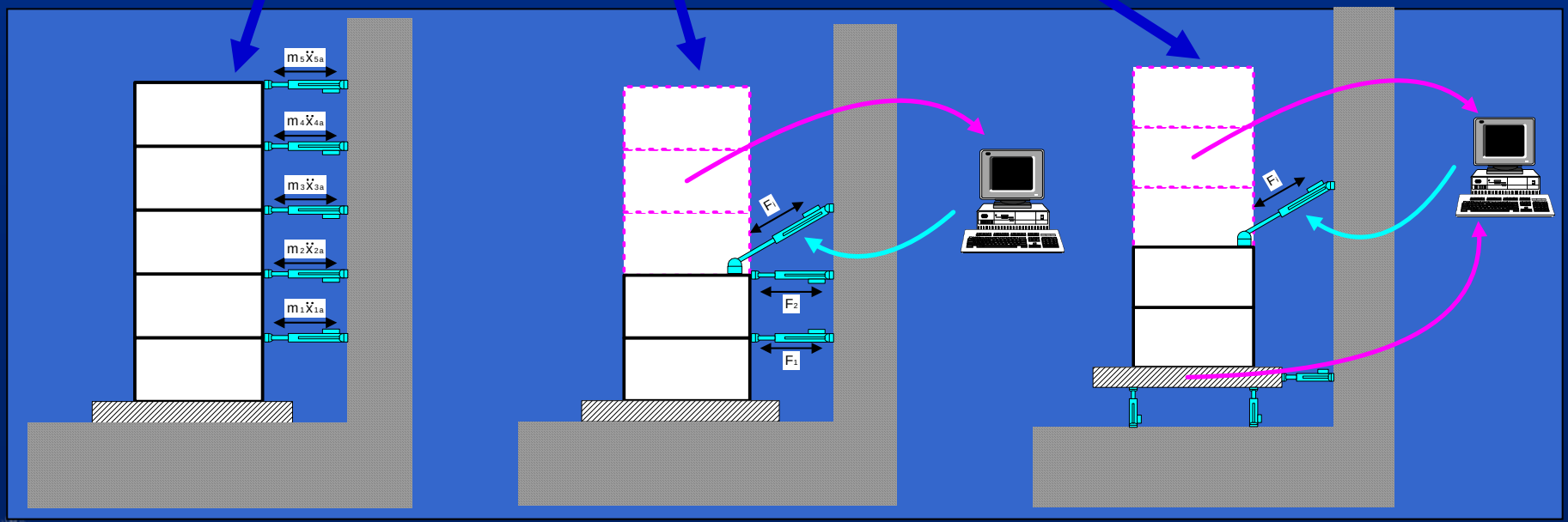
- Determination of the magnitude and effect of liquefaction-induced forces and displacements on piled foundations at full-, or near full-, scale using a large laminar soil box.
- Verify Experimental Results using near-full scale using laminar boxes
- Study Scale effects by conducting parallel experiments using one or more centrifuges.
- Understand the mechanism and physics of lateral spreads, and scale effects. Develop correct scaling laws.
- Once calibrated, a range of foundation configurations could be studied using multiple centrifuge experiments

# Validate Ground Remediation

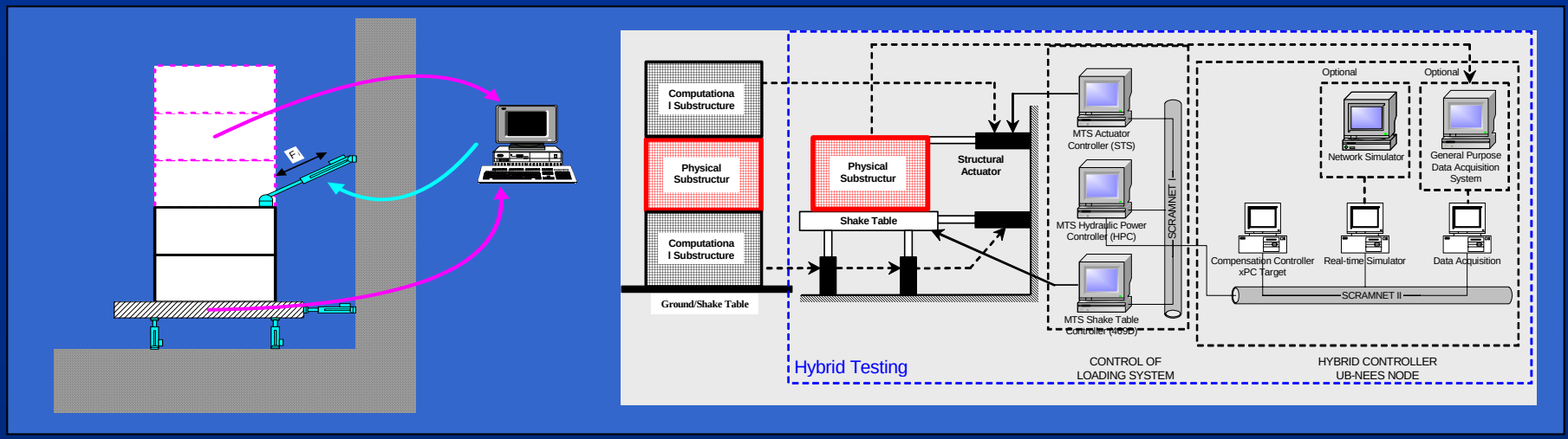
- Payload projects on the above experiments by introducing ground improvement – Study before-and-after response of the system in the respective experiments.

# New testing capabilities

- Effective Force Method
- Pseudo-dynamic testing
- Real Time Dynamic Hybrid Testing (new developement)



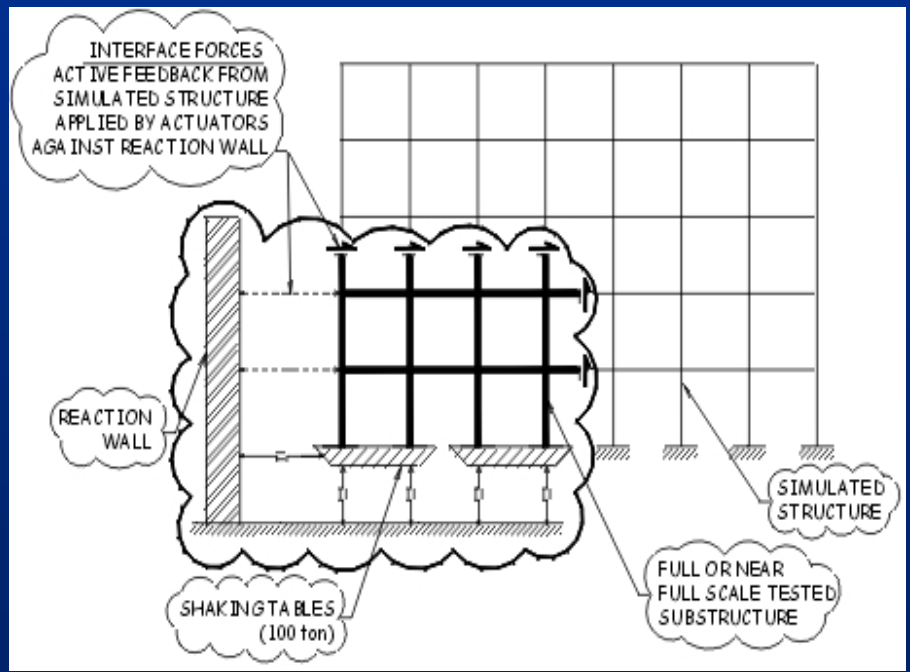
# Real-Time Dynamic Hybrid Testing (RTDHT)

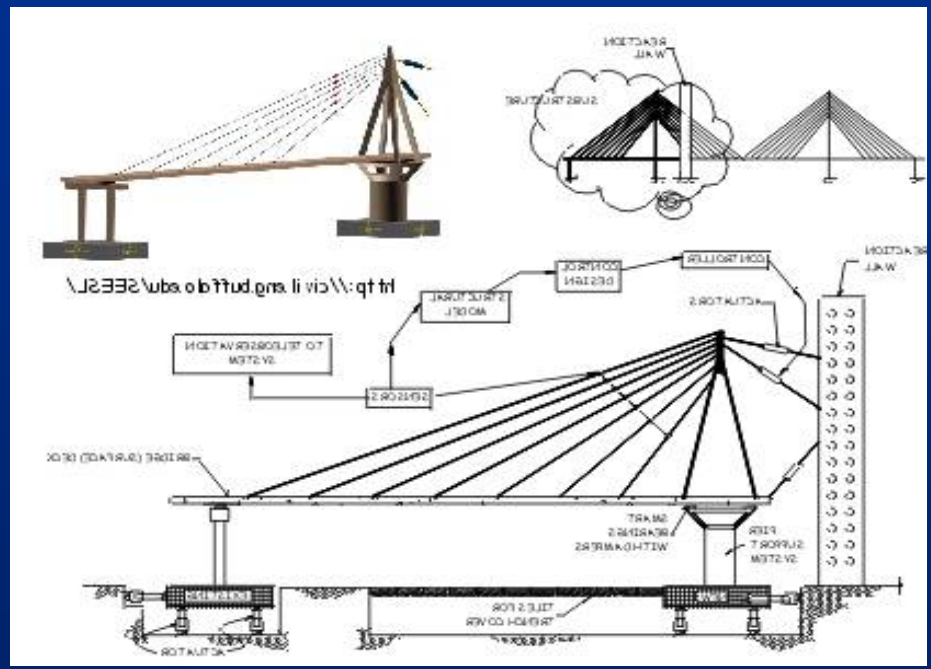



- **Integrated Use of Shake Tables, Actuators, Reaction Wall, Strong Floor and Computational Resources (Unique to UB)**
- **Inertia Effects in the Physical Model-Different from Real-Time Pseudo Dynamic Testing**
- **Force-Based Substructure and Actuators in Force Control Necessitated by the Above**
- **Parallel computer built for this type of testing technique**

# Typical Applications of RTDHT

- **Building and Cable Stayed Bridge Segments With RTDHT Using Two Shake Tables, the Reaction Wall and Large Actuators**



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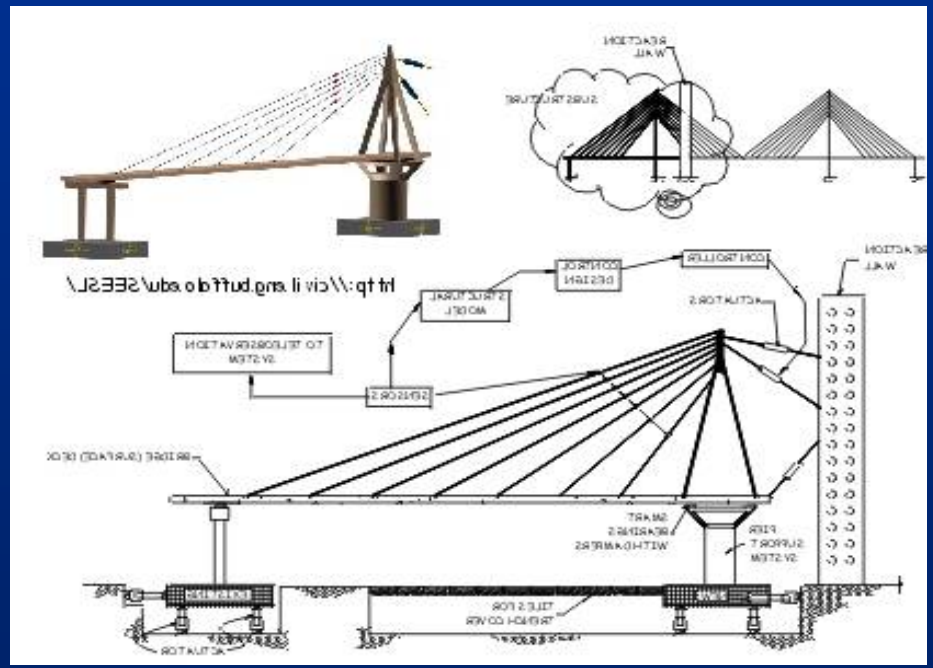
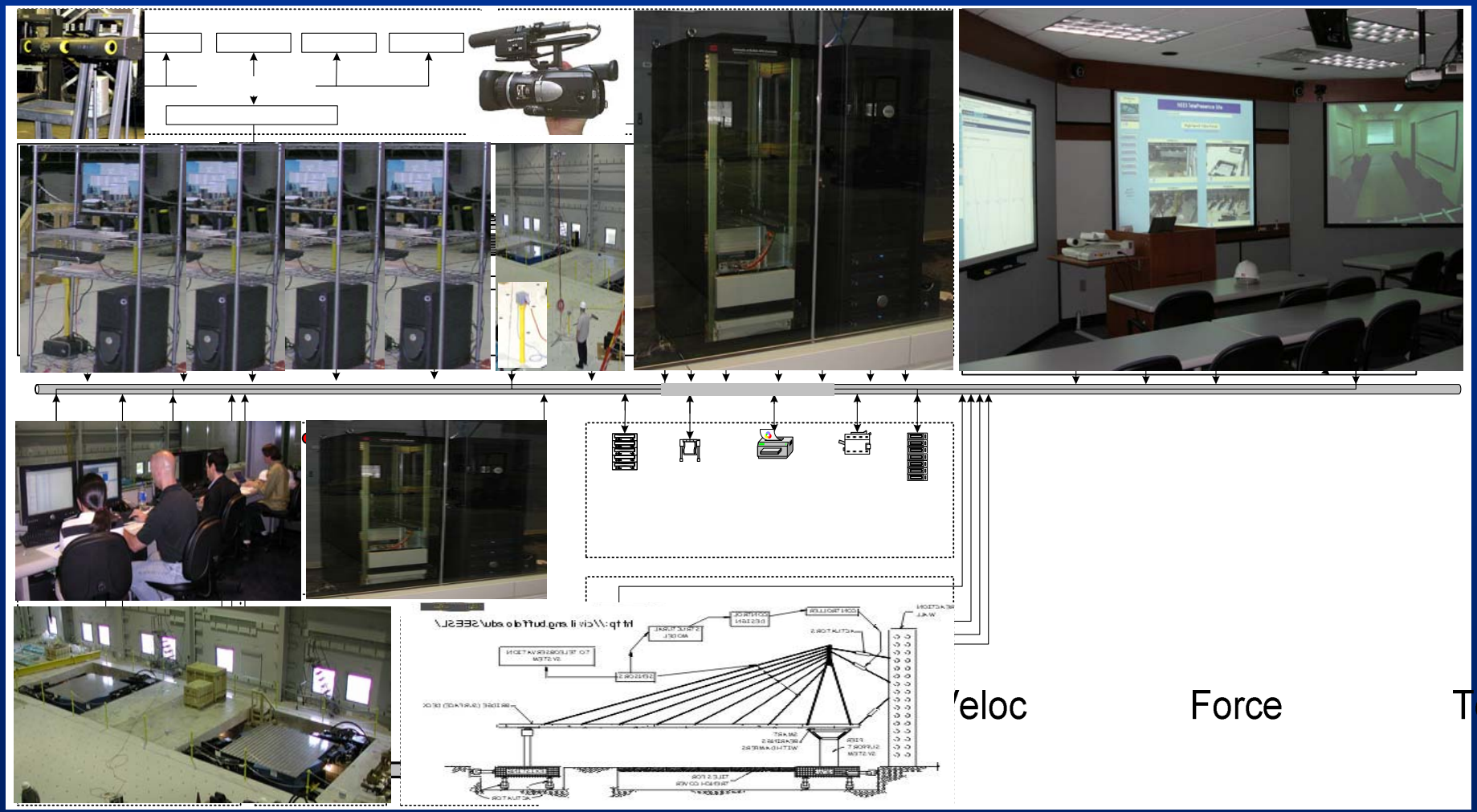


# Telepresence and Collaboration Rooms

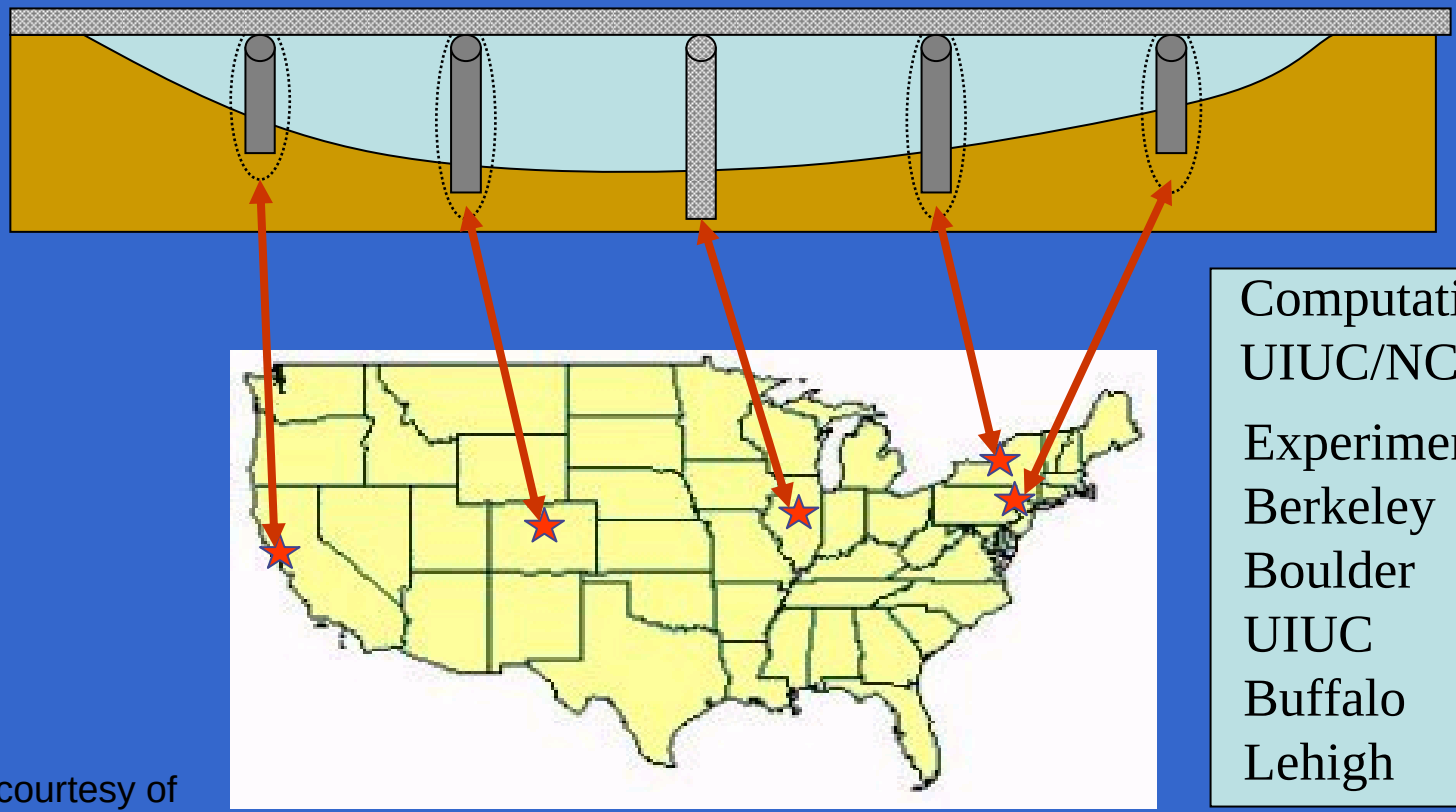
- Ketter 140 and 133A have undergone renovation establishing new telepresence and collaboration rooms
- The telepresence room was completed January 2004 and provides for:
  - *Video Conferencing*
  - *Audio and Video Streaming*
  - *Data Streaming*
  - *Data Visualization*
- Collaboration Room for Visiting Researchers

# UB-IT Infrastructure for Networking, Data Acquisition and Telepresence



# Collaboration Projects

- 6-span bridge model
  - Span and one column are numerical models
  - Other 4 columns are experimental models



Computational Sites:
UIUC/NCSA

Experimental Sites:
Berkeley
Boulder
UIUC
Buffalo
Lehigh

Slide courtesy of
Gilberto Mosqueda

# Funding for the Development of the New UB-NEES Facility

- The Development of the New UB-NEES Facility Was Supported Through Collaborative Sources of Funding

  - **The National Science Foundation Under Awards:**
    - **CMS-0086611 ($4.6M)**
    - **CMS-0086612 including the LAN Supplement ($6.6M)**
  - **The State University of Construction Fund ($6.0M)**
  - **The UB-School of Engineering ($3.2M)**
  - **The Department CSEE (>$0.8M)**

- Total Investment: **~$21.2M**

# Opening Ceremonies September 26, 2004


Click Here to Play Video

# “Night Life at UB”

Questions?