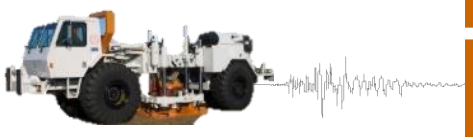
Shared-Use of NHERI@UTexas Mobile Shakers for Geophysical and Seismological Research

Thursday, December 3, 2020

- 4:00 pm – Welcome
- 4:05 pm – Introduction of NHERI@UTexas (presented by Prof. Kenneth Stokoe, University of Texas at Austin, and Prof. Brady Cox, Utah State University)
- 4:30 pm – Use of Thumper as a source for Full waveform inversion (presented by Prof. Khiem Tran, University of Florida)
- 4:45 pm – Integration of T-Rex Vibrator and PASSCAL Texan Recorders for Seismic Profiling of Shallow and Deep Crustal Targets (presented by Prof. Derek Lerch, Feather River College)
- 5:00 pm – Q&A, (participant self-introduction)



LARGE MOBILE SHAKERS

NHERI@UTexas

NHERI@UTexas
Large Mobile Shakers
NSF Shared-use Experimental Facility

Presented by

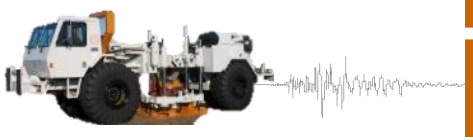
Dr. Kenneth H. Stokoe, P.E., NAE

Professor, UT Austin, Dept. of Civil, Architectural, and Environmental Engineering

Dr. Brady R. Cox, P.E.

Professor, Utah State University, Dept. of Civil and Environmental Engineering

December 3rd, 2020

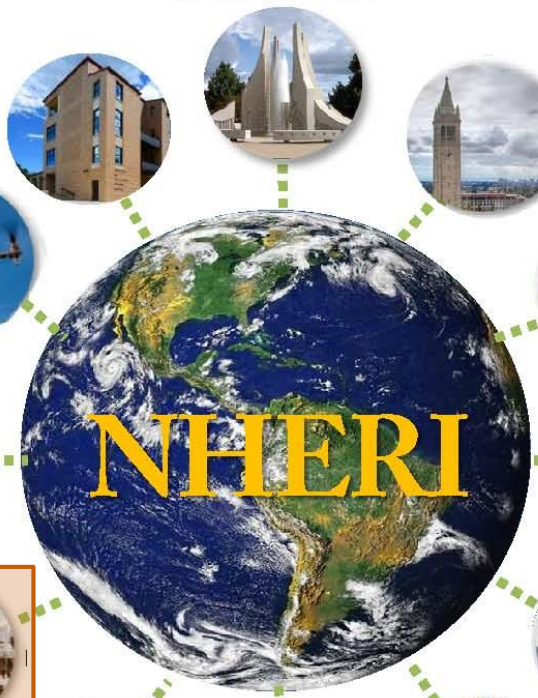


LARGE MOBILE SHAKERS

NHERI@UTexas

Natural Hazards Engineering Research Infrastructure

7 Experimental Facilities with Large-Scale Equipment
1 Cyberinfrastructure Facility for Archiving and Sharing Data
1 Computational Modeling/Simulation Center
1 Post-disaster Rapid Response Facility
1 Network Coordination Office



PURDUE UNIVERSITY
Network Coordination Office
NSF Award #1612144

UNIVERSITY OF COLORADO BOULDER
Extreme Event Reconnaissance Coordination
NSF Award #1841338

UC BERKELEY
Computational Simulation
NSF Award #1612843

UNIVERSITY OF WASHINGTON
Natural Hazards Reconnaissance Equipment
NSF Award # 1611820

UNIVERSITY OF TEXAS, AUSTIN
Community Cyberinfrastructure
NSF Award #1520817

OREGON STATE UNIVERSITY
Wave Basin and Flume
NSF Award # 1519679

FLORIDA INTERNATIONAL UNIVERSITY
Wind Simulation
NSF Award #1520853

UNIVERSITY OF TEXAS, AUSTIN
Mobile Field Shakers
NSF Award #1520808

UNIVERSITY OF FLORIDA
Wind Simulation
NSF Award #1520843

UC DAVIS
Geotechnical Centrifuges
NSF Award #1520581

LEHIGH UNIVERSITY
Hybrid Simulation
NSF Award #1520765

UC SAN DIEGO
Large Outdoor Shake Table
NSF Award #1520904

Engineering for Civil Infrastructure (ECI)

CONTACTS

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Joy M. Pauschke	ECI@nsf.gov	(703) 292-7024	

Principal Investigators are encouraged to leverage NSF's investments in the Natural Hazards Engineering Research Infrastructure (NHERI) experimental, computational modeling and simulation, and data resources (https://www.designsafe-ci.org/) in their research to accelerate advances needed for reducing the impacts of natural hazards..

- NHERI equipment can be used with funding from any NSF program
- NHERI equipment can be used at higher rates for non-NSF funding (including industry)

Project Team

Director/PI
Kenneth Stokoe
Professor, UT Austin

Co-PI
Brady Cox
Professor, Utah State Univ.

Co-PI
Patricia Clayton
Asst. Professor, UT Austin

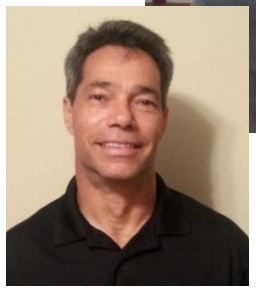
Co-PI
Robert Gilbert
Chair & Prof., UT Austin

IT/Cybersecurity
Robert Kent
UT Austin

Mobile Shaker Specialist
Cecil Hoffpauir
UT Austin

Operations Manager
Farnyuh Menq
UT Austin

Hydraulics Technician
Andrew Valentine
UT Austin



NHERI@UTexas Equipment Overview

- Five (5) large, servo-hydraulic, mobile shaker trucks
- Various support vehicles and trailers
- A wide array of instrumentation for recording vibration, force, and pore water pressure

T-Rex (Tri-axial Shaker)
- Off-road buggy;
- 32 ft long, 8 ft wide, weight = 64,000 lbs
- Three vibrational orientations
- Push-button transformation of shaking orientation
- Shear mode Peak Force = 30,000 lbs
- Vertical mode Peak Force = 60,000 lbs

Liquidator (Low Frequency Shaker)
- Off-road buggy;
- 32 ft long, 8 ft wide, weight = 72,000 lbs
- Two vibrational orientations
- One day shop transformation of shaking orientation
- Shear mode Peak Force = 20,000 lbs
- Vertical mode Peak Force = 20,000 lbs

Thumper (Urban Shaker)
- Built on a International 4300 truck;
- 27 ft long, 8.5 ft wide, weight = 24,800 lbs
- Three vibrational orientations
- Four hours field transformation of shaking orientation
- Shear mode Peak Force = 6,000 lbs
- Vertical mode Peak Force = 6,000 lbs

Raptor (Mid-Size Shaker)
- Highway legal truck
- 32 ft long, 8 ft wide, weight = 41,200 lbs
- Vertical mode Peak Force = 27,000 lbs

Rattler (Horizontal Shaker)
- Off-road truck;
- 29 ft long, 8.5 ft wide, weight = 54,500 lbs
- Shear mode Peak Force = 30,000 lbs

Big-Rig
- 26 wheeler tractor-trailer rig for shipping T-Rex, Liquidator, and Rattler
- Overweight permit required

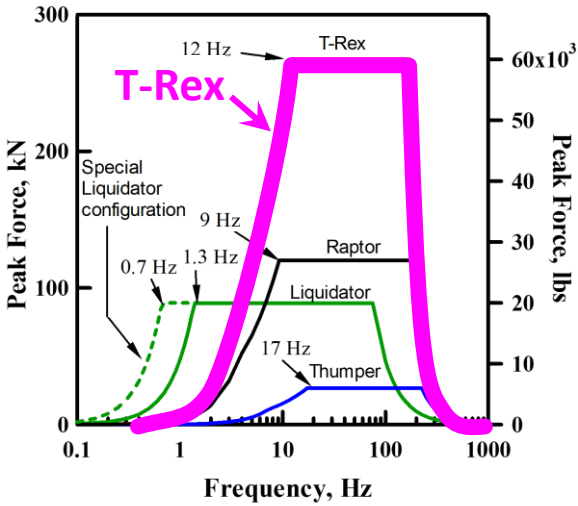
Fuel-Supply Truck
- Carries diesel fuel for T-Rex, Liquidator, and Rattler in the field
- provides a working platform for maintenance and CPT tests

Instrumentation Van & Trailer
- A customized Chevrolet cargo van provides an air-conditioned workspace
- A 8 ft by 16 ft cargo trailer provides additional working and storage space

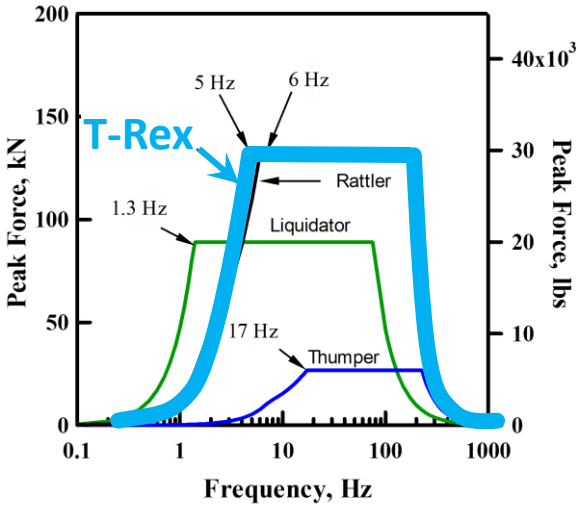
Hydraulic Cylinder with Adjustable Platform
- Mounted at the rear of T-Rex
- Platform for installing and retrieving liquefaction, CPT, and seismic CPT sensors

T-Rex

- Tri-axial shaker
- Push-button transformation of shaking orientation
- 32 ft long, 8 ft wide, Wt. = 64,000 lbs
- Only operating tri-axial vibroseis we are aware of in the world



Vertical force output

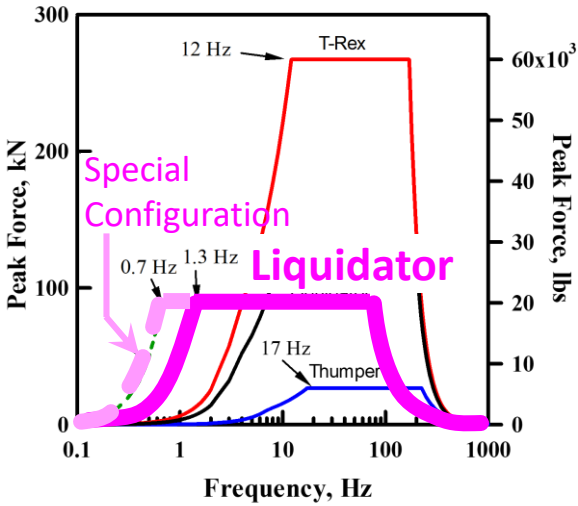


Horizontal force output

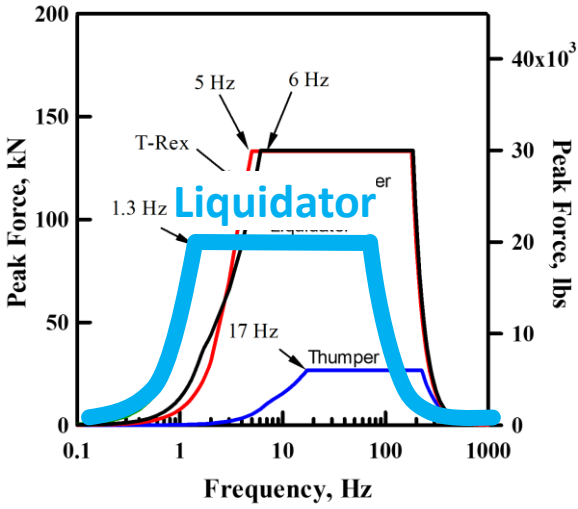
T-Rex – Horizontal Shaking

Liquidator

- Custom-built, one-of-a-kind, low frequency shaker
- Two-shaking orientations
- One-day shop transformation of shaking orientation
- 32 ft long, 8 ft wide, Wt. = 72,000 lbs



Vertical force output



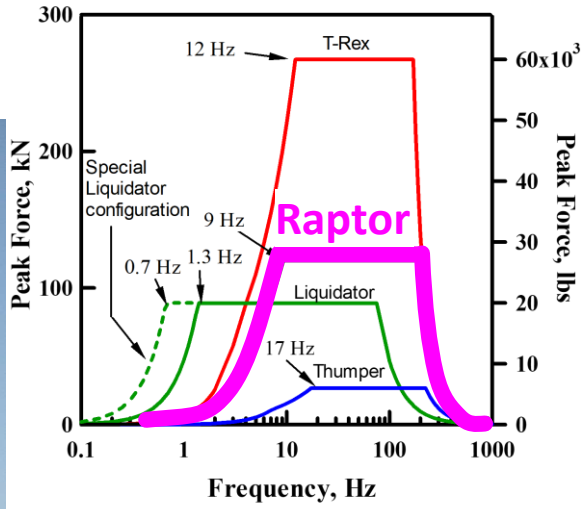
Horizontal force output

Liquidator – Standard Configuration

Liquidator – Special Configuration

Raptor

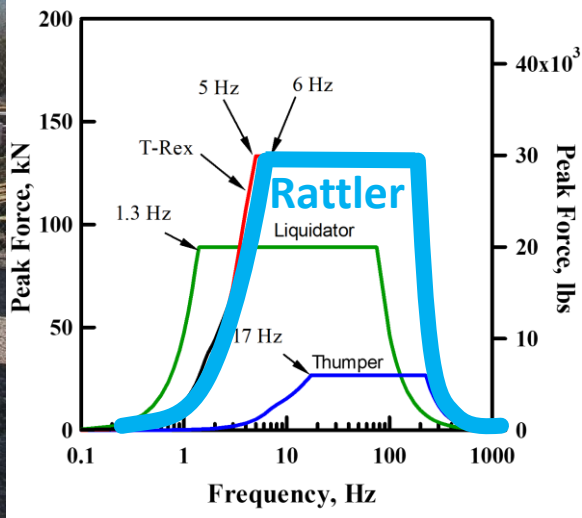
- Standard vibroseis, vertical shaker (P-wave)
- 32 ft long, 8 ft wide, Wt. = 41,200 lbs



Vertical force output

Rattler

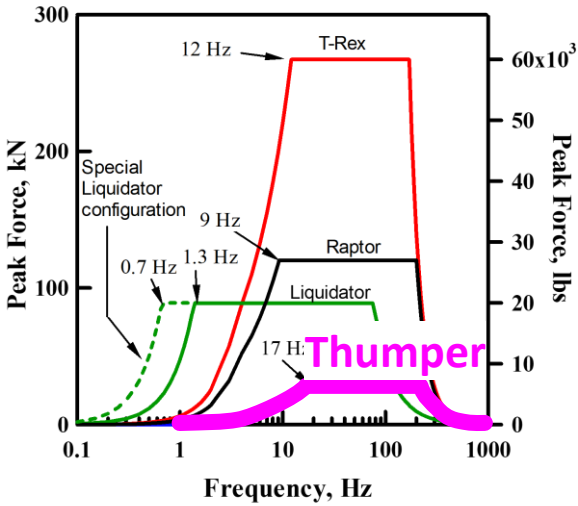
- Standard vibroseis, horizontal shaker (S-wave)
- 29 ft long, 8.5 ft wide, Wt. = 30,000 lbs



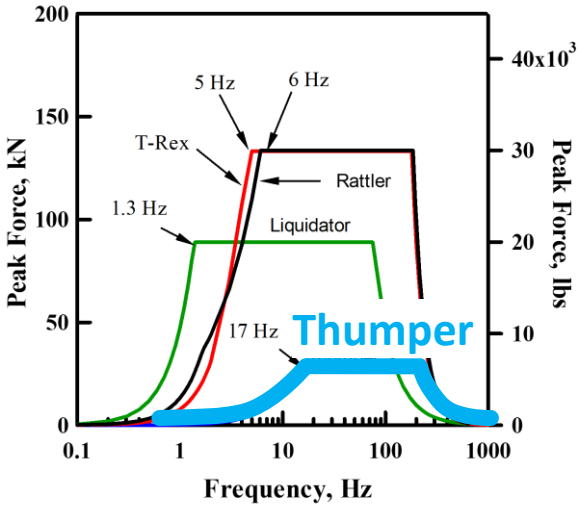
Horizontal force output

Thumper

- Mini-vibroseis/urban shaker
- Three vibrational orientations
- Two-hour field transformation of shaking orientation
- 27 ft long, 8.5 ft wide, Wt. = 28,400 lbs.



Vertical force output

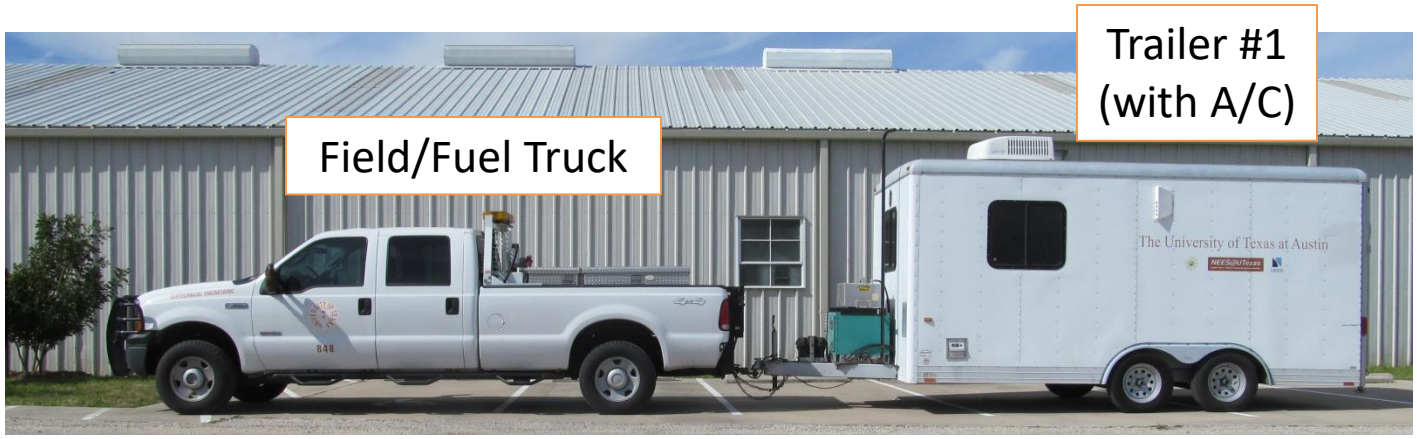


Horizontal force output

Big Rig

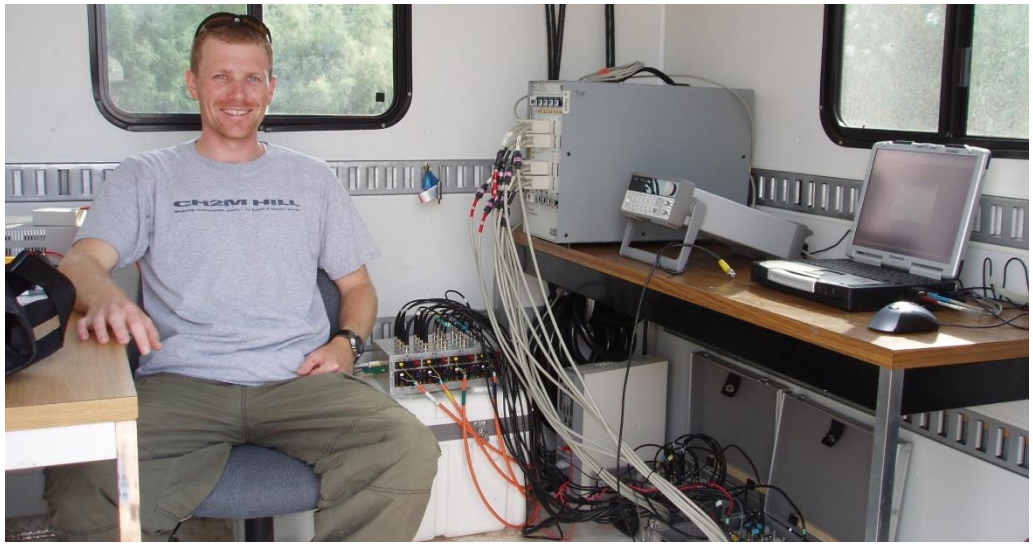
- 26-wheel tractor trailer for shipping T-Rex, Liquidator, and Rattler

Support Vehicles



Provide fuel, storage, and workspace in the field

Instrumentation – Data Acquisition (DAQ)



72-channel VXI DAQ

- 24 bit digitizer
- Up to 50 kHz sampling rate
- Real-time frequency domain capabilities

↓

168 channels of DAQ

↑

96-channel Data Physics DAQ

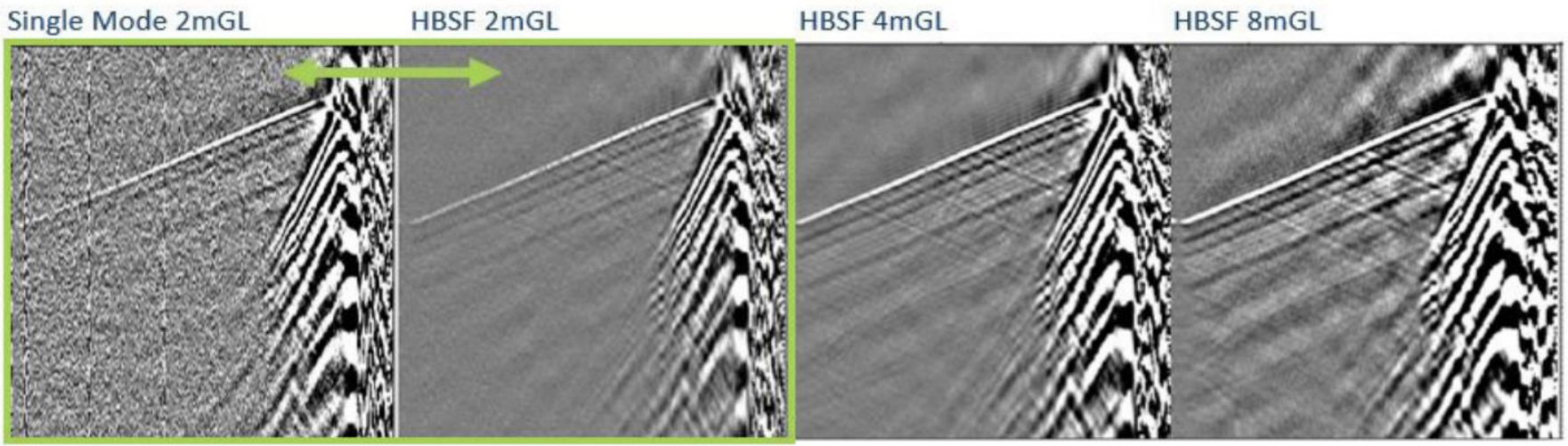
- 24 bit digitizer
- Up to 200 kHz sampling rate
- Real-time frequency domain capabilities

Instrumentation – DAS Interrogator

- **New in 2021**
- OptaSense ODH4 DAS Interrogator
- Distributed Acoustic Sensing (DAS); fiber optic sensing
- Capable of measuring with ANY fiber from ANY vendor (single mode, multi-mode or enhanced high backscatter)
- Sample rate up to 100 kHz

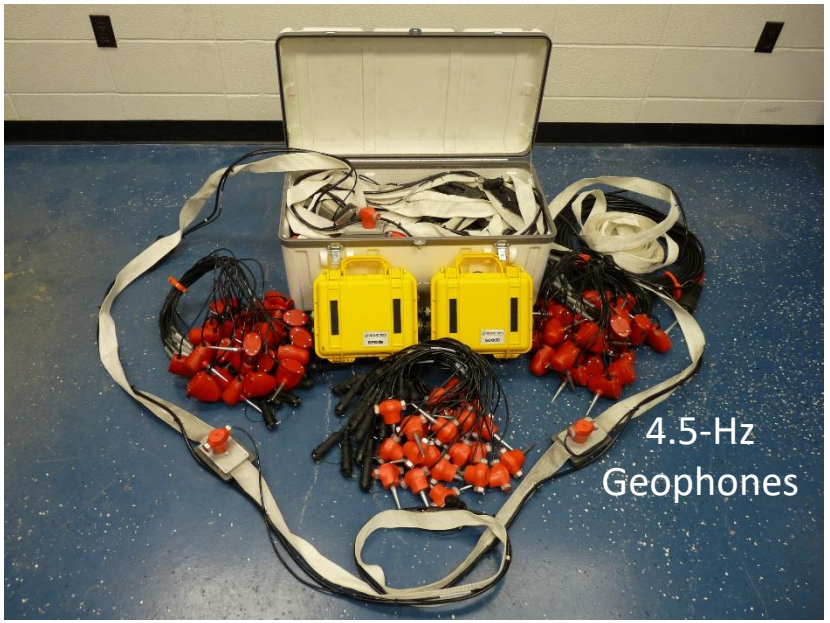
OptaSense®
A QINETIQ company

High Backscatter Single Fiber 2m Gauge Length



Instrumentation – Geophones

- 109, 1-Hz Geophones (85 vertical & 24 horizontal)
- 15,000 ft of twisted, shielded-pair cable

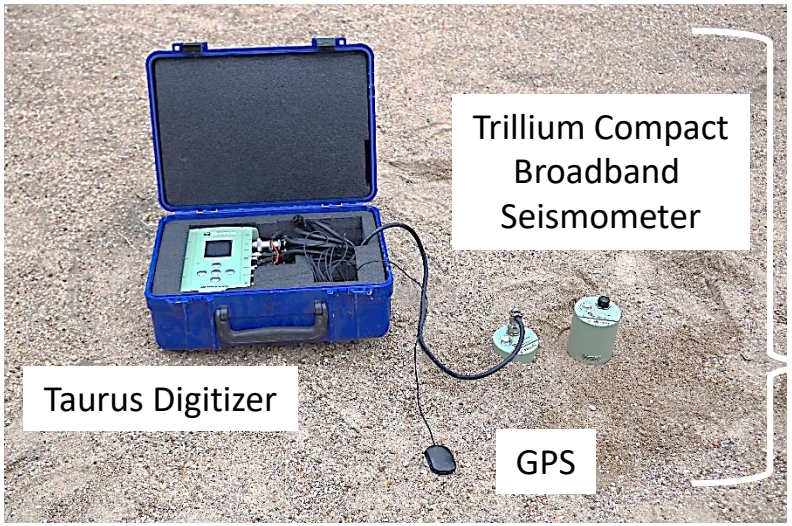


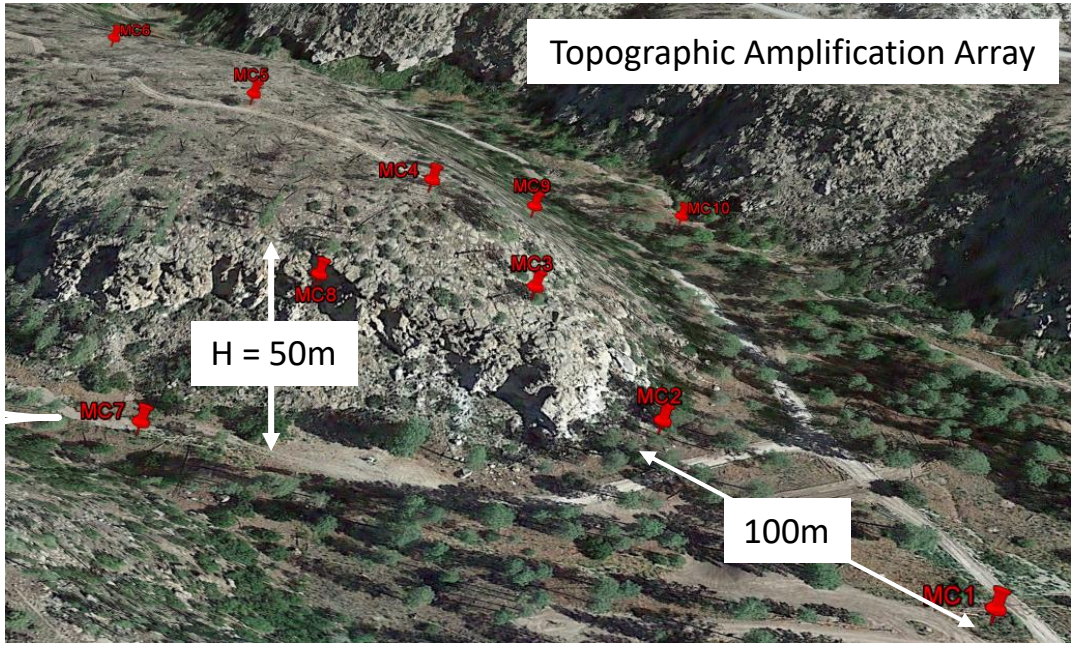
- 196, 4.5-Hz Geophones (98 vertical & 98 horizontal)
- Refraction cables (24-channels, 4 @ 2m & 4 @ 5m)
- Towable landstreamer (24-sleds)
- 2, 24-channel Geode seismographs

Instrumentation – 3C Nodal Geophones

- **New in 2021**
- 100, SmartSolo IGU-16HR 3C nodal stations
- 3-component
- 5-Hz geophones
- 24 bit ADC
- GPS synchronized
- Size: 103mm (L) x 95mm (W) x 150mm (H)
- Weight: 1.7kg

Instrumentation – Broadband Seismometers

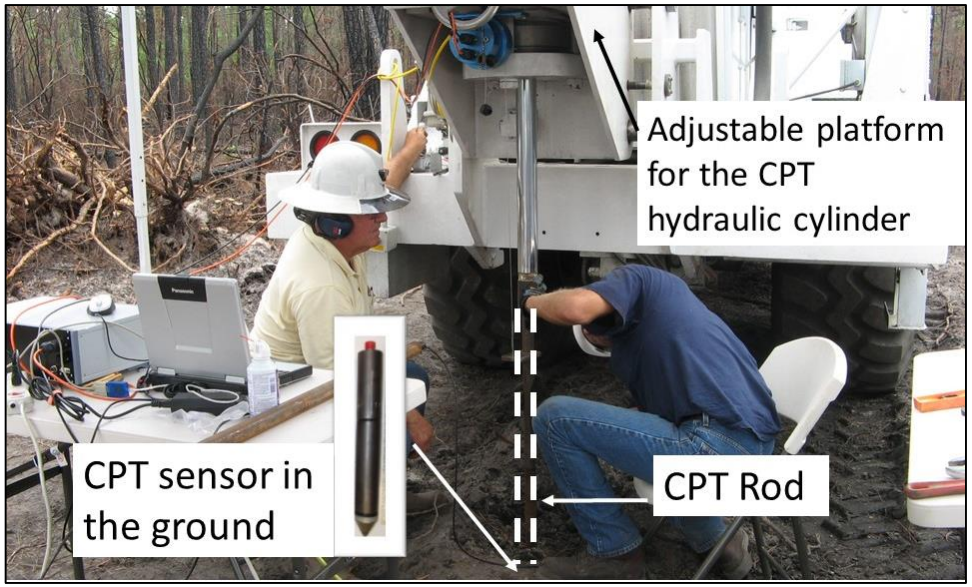




20, Nanometrics Broadband Seismometer Stations

- 3-component
- GPS synchronized
- 10, 120-sec period and 10, 20-sec period Trillium Compact seismometers
- 10, Taurus and 10, Centaur digitizers (3-component, 24 bits)
- Structural and Geotechnical applications (flat response 0.01 to 100 Hz)

Instrumentation – CPT and Liquefaction Sensors



Direct-Push Sensors

Cone Penetrometers

- Standard CPT
- Seismic CPT
- 4 different cones

Liquefaction Sensors

- Custom built
- Tri-axial MEMS accelerometers
- 2D or 3D geophones
- Pore water pressure transducers

Additional Instrumentation Resources
IRIS/PASSCAL

- Broadband
- Intermediate-period
- Short-period
- Accelerometers

IRIS INSTRUMENT CENTER
PASSCAL
Portable Array Seismic Studies of the Continental Lithosphere

Free to NSF-funded projects
*PI pays for shipping & travel expenses

Home | General Information | Instrumentation | Data Archiving | Apply for a PI Account | Experiment Scheduling | Polar | Important Hardware/Softwar

- Home
- General Information
- Instrumentation
  - Dataloggers
  - Power Systems
  - Sensors
    - Sensor Certification
    - Sensor Comparison Chart
    - Accelerometers
    - Broadband Sensors
    - High Frequency Sensors
      - Geophones 4.5Hz HF Sensor
      - L-28 HF Sensor
      - L-40 HF Sensor
      - Y-28 (GS11-3D) HF Sensor
      - Nodes
    - Intermediate Period Sensors
    - Short Period Sensors

Magseis Fairfield ZLand 3C Node - 3-Channel All in One, Sensor and Datalogger

Home ◇ Instrumentation ◇ Sensors ◇ High Frequency Sensors ◇ Nodes

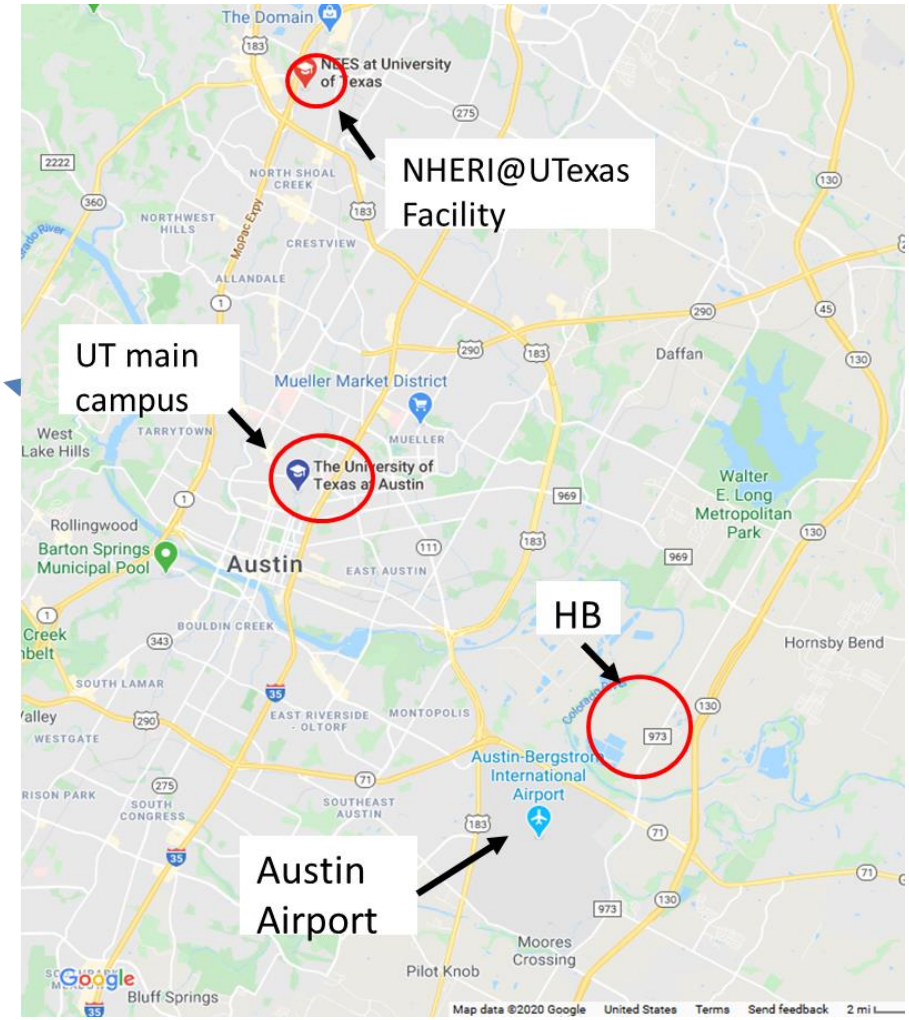
The FairfieldNodal ZLand 3C is a compact all-in-one 3-channel sensor & datalogger with onboard GPS timing, and a self contained power supply. Originally designed for use in large N industry deployments, it has been adopted by the academic community as a useful sensor for both active and short-term passive deployments.

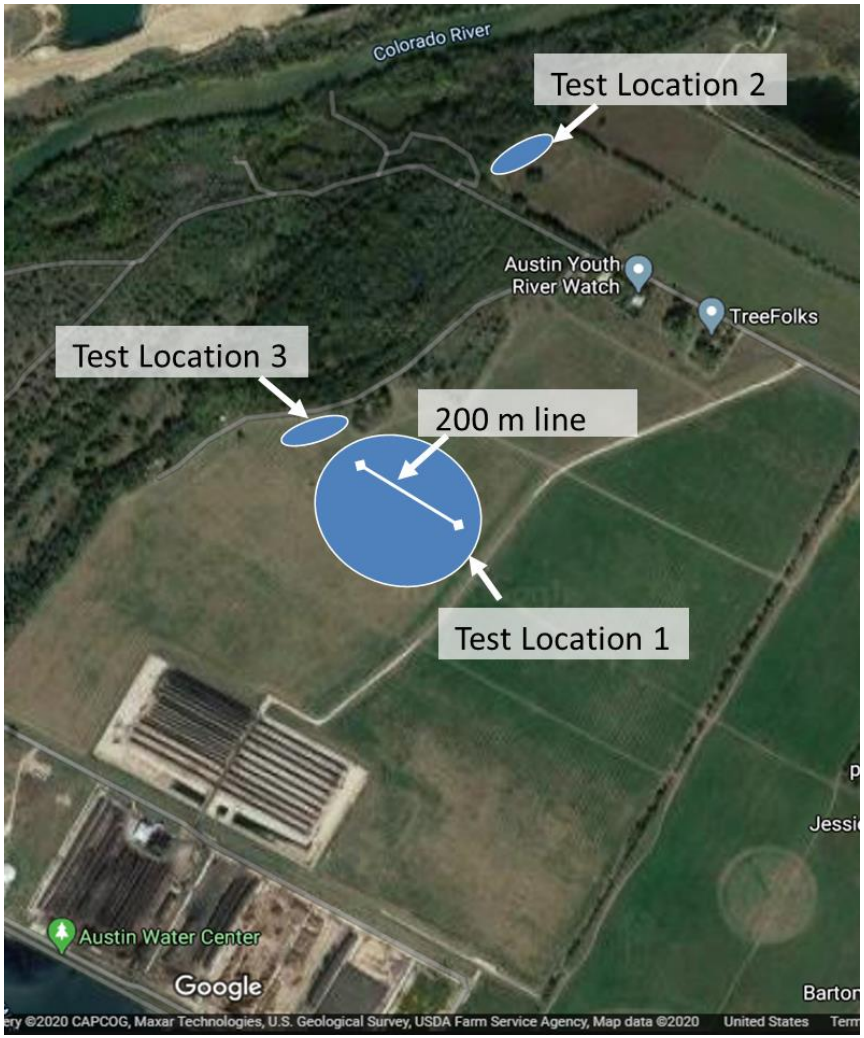
Unlike other sensors & dataloggers at PASSCAL, use of the ZLand 3C requires a deployment plan to be filed in advance with PASSCAL for handheld unit pre-programming. Likewise, the units must be sent back to PASSCAL for data offload.

Specifications:

- This 3-channel all-in-one sensor + datalogger has a frequency of 5Hz and a 24 bit ADC
- Power source: Lithium ion battery with ~35 day lifespan at 500sps continuous recording
- Physical Size: 6.4in x 4.6in with additional 4.6in central spike
- Weight: 6.2lbs

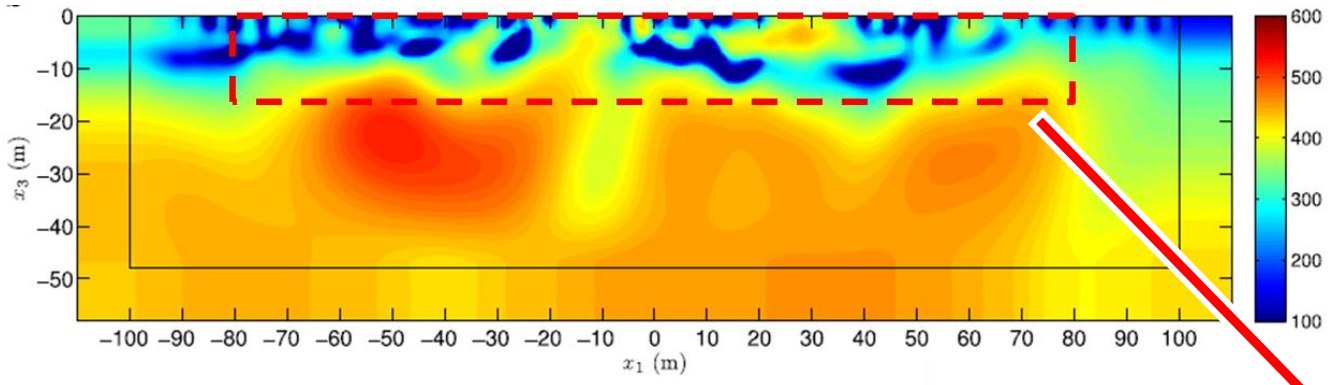
Hornsby Bend (HB) Test Site



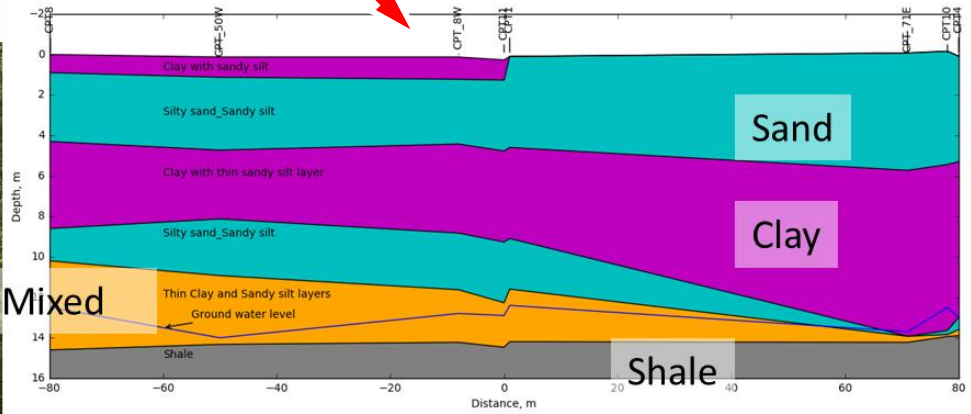


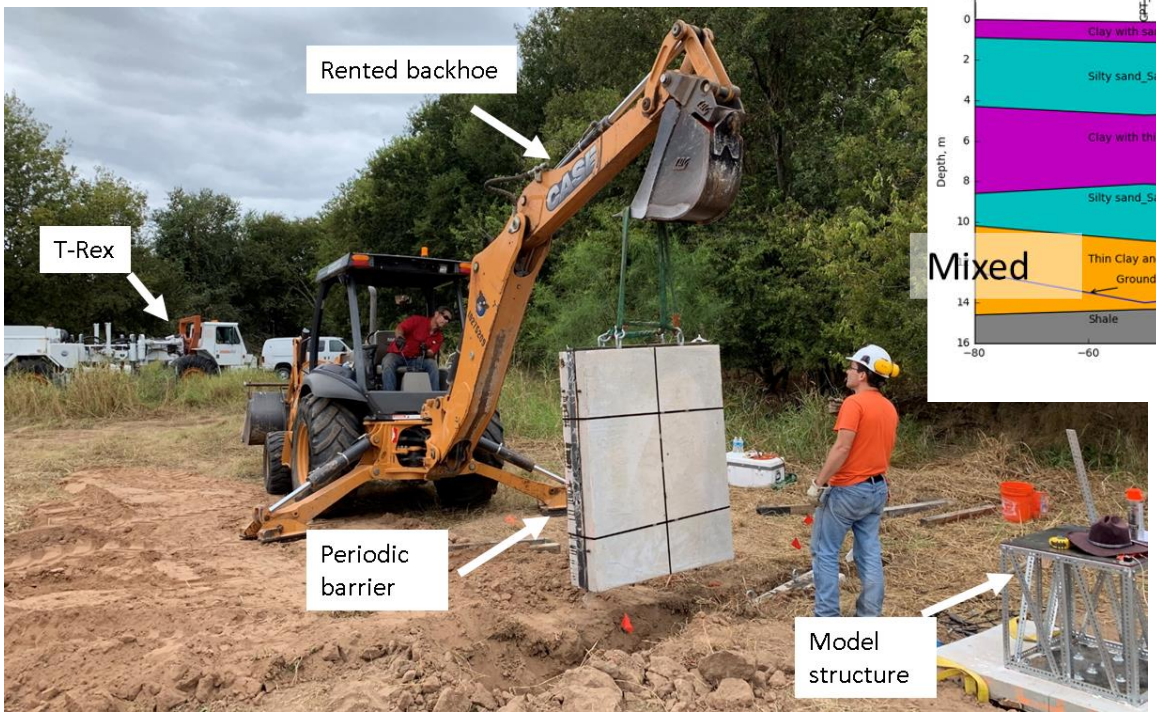
Hornsby Bend (HB) Test Site

Vs using full waveform inversion (Kallivokas et al. 2013)



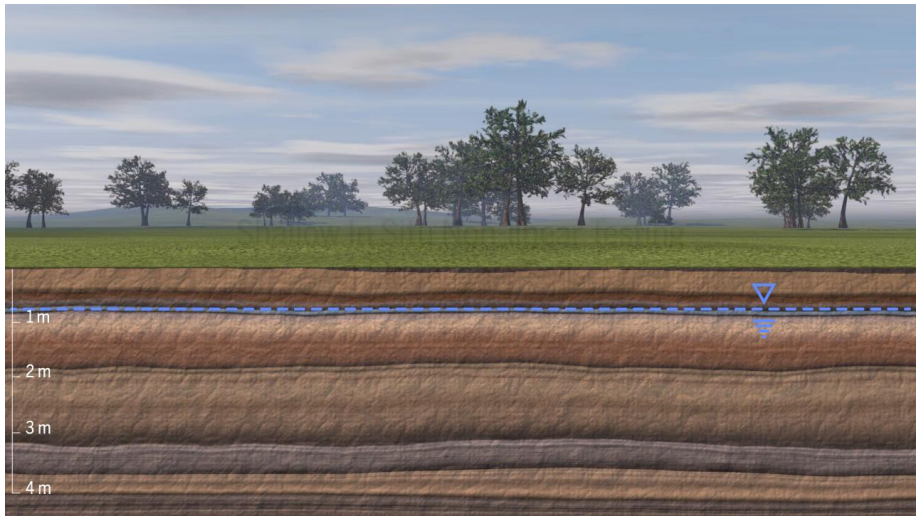
Soil behavior-type classifications from CPT tests





NHERI@UTexas Science Plan

Improved Subsurface Imaging (2D/3D)

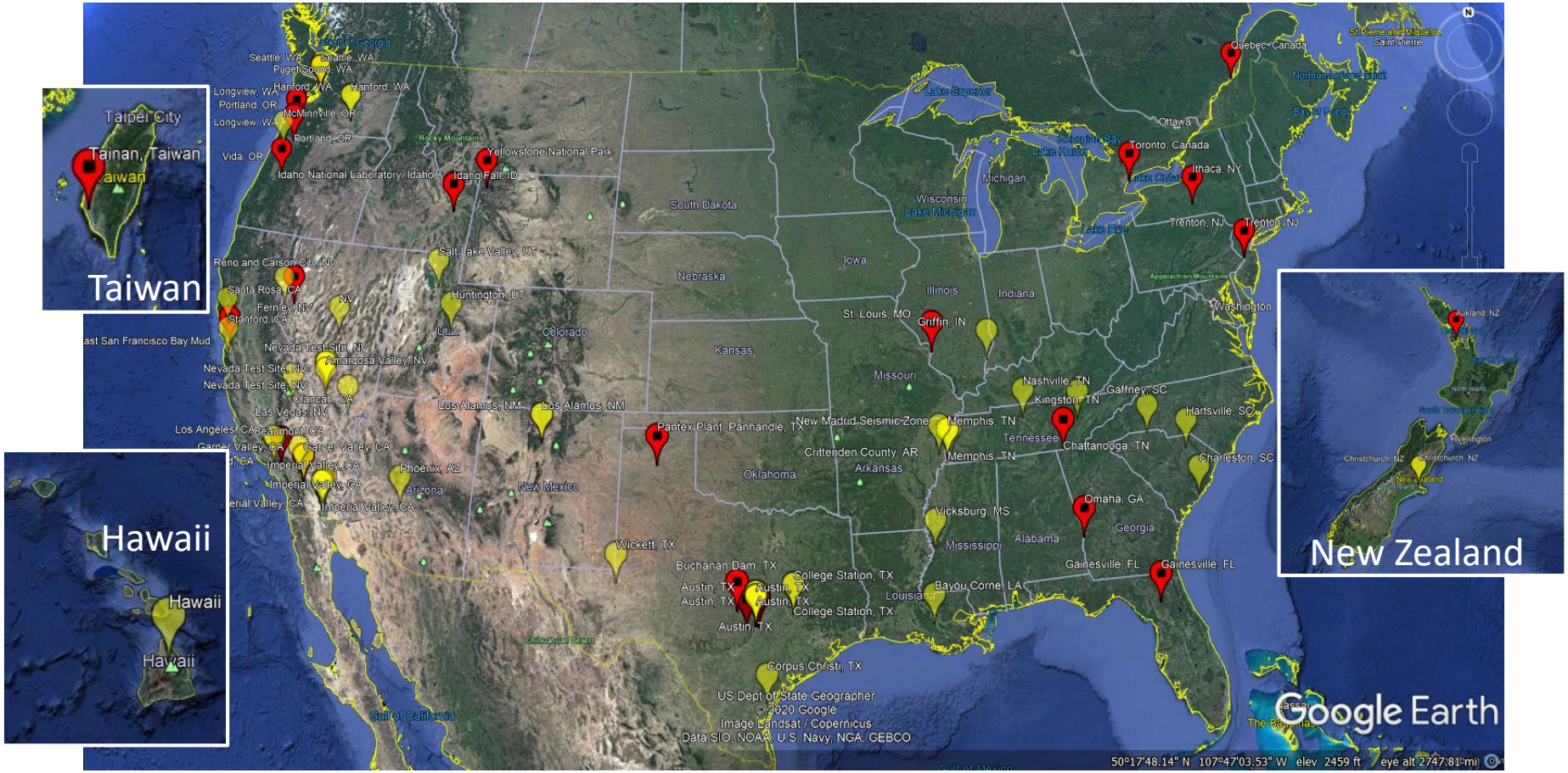


Nonlinear In-Situ Testing

Structural Health Monitoring/Soil-Structure Interaction

“Have shaker trucks, will travel…”

- 55 Projects 2003 - 2014 (NEES, Shared-use, Industry/Gov.)
- 26 Projects 2016 - 2020 (NHERI, Shared-use, Industry/Gov.)



Example: Cost Estimate (Testing at Hornsby Bend Site in Austin)

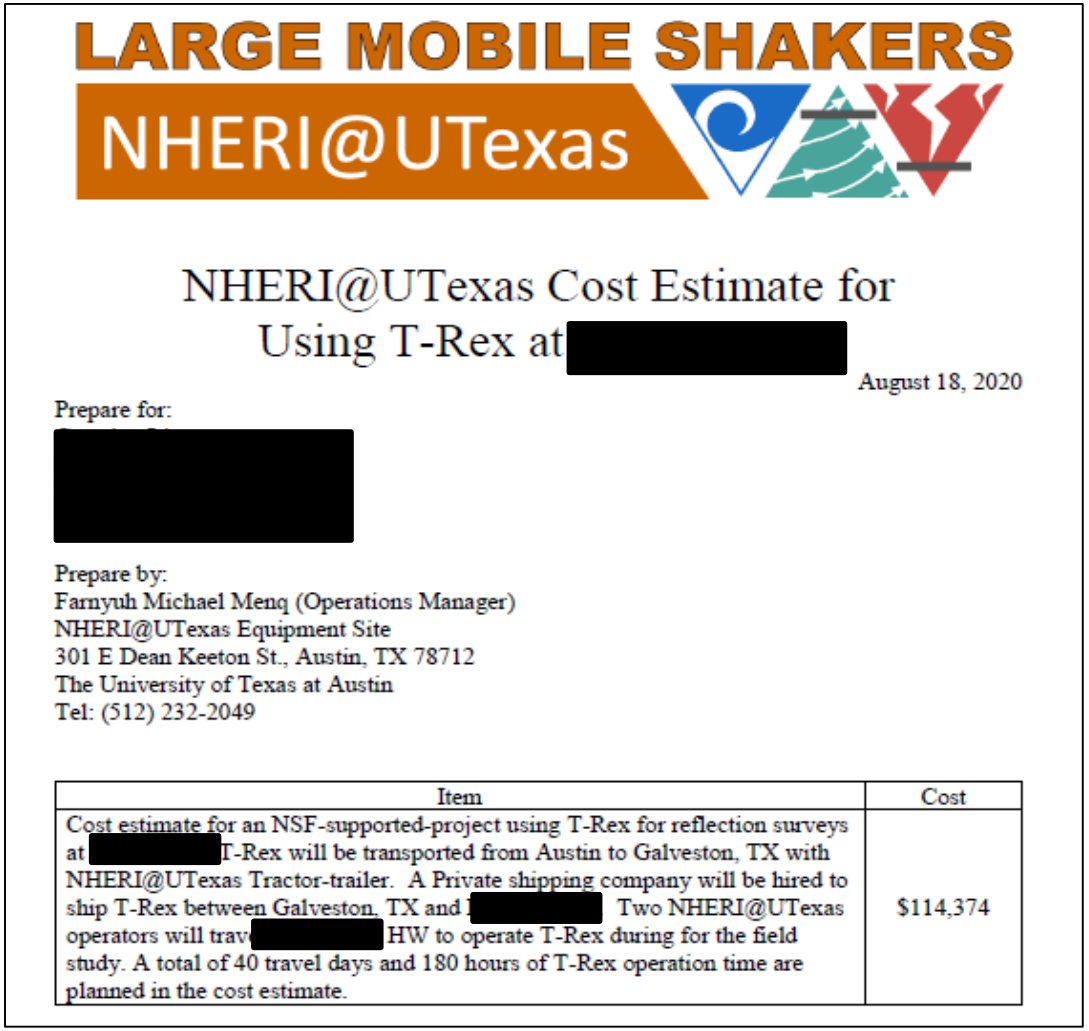
Equipment	
Seismic Source ("T-Rex")	
3 hours / day * 5 days * $27 /hour	$405
Seismic Source ("Thumper")	
3 hours / day * 5 days * $9 /hour	$135
(40 miles per day * 2 days) * $0.7 per mile	$56
Fuel Supply Pickup	
(40 miles per day * 10 days) * $0.45 per mile	$180
Tractor-Trailer	
(40 miles per day * 2 days) * $1.13 per mile	$90
Misc. field supplies	$500
Equipment Fuel and Supplies	**$1,366**
Overhead (56.5%)	**$772**
Total	**$2,138**

Note:

1. This cost was estimated in 2017.
2. A cost estimate template is available at https://utexas.designsafe-ci.org/resources/.

Demo Recharge Rates/Schedule and Example Budget

Example: Cost Estimate for a Recent Research Proposal (Testing at an Attractive Island)



LARGE MOBILE SHAKERS

NHERI@UTexas

NHERI@UTexas Cost Estimate for
Using T-Rex at [redacted]

August 18, 2020

Prepare for:
[redacted]

Prepare by:
Farnyuh Michael Menq (Operations Manager)
NHERI@UTexas Equipment Site
301 E Dean Keeton St., Austin, TX 78712
The University of Texas at Austin
Tel: (512) 232-2049

Item	Cost
Cost estimate for an NSF-supported-project using T-Rex for reflection surveys at [redacted] T-Rex will be transported from Austin to Galveston, TX with NHERI@UTexas Tractor-trailer. A Private shipping company will be hired to ship T-Rex between Galveston, TX and [redacted] Two NHERI@UTexas operators will trav[redacted] HW to operate T-Rex during for the field study. A total of 40 travel days and 180 hours of T-Rex operation time are planned in the cost estimate.	$114,374

Total Equipment Fuel Cost: $4,660

Travel Cost: $23,000

Ship T-Rex on a boat: $44,500

Overhead: $42,214

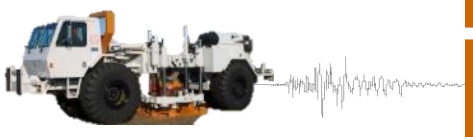
Total Cost: $114,374

Additional Information & Proposal Help

- Dr. Kenneth Stokoe (PI) k.stokoe@mail.utexas.edu
- Dr. Brady Cox (co-PI) brady.cox@usu.edu
- Dr. Patricia Clayton (co-PI) clayton@utexas.edu
- Dr. Farnyuh Menq (Operations Manager) fymenq@utexas.edu

- NHERI@UTexas website at www.designsafe-ci.org
  - Webinar slides & updated budgetary info will be posted

Questions?



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