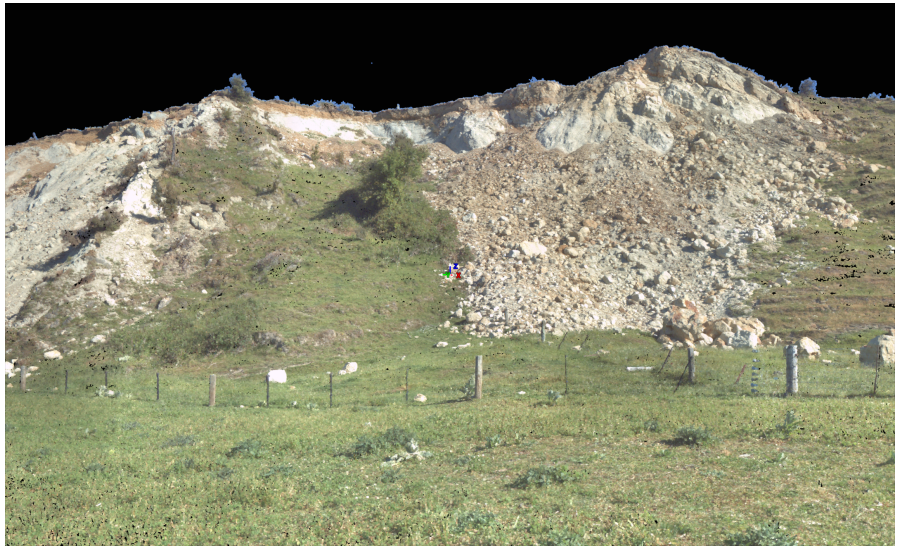
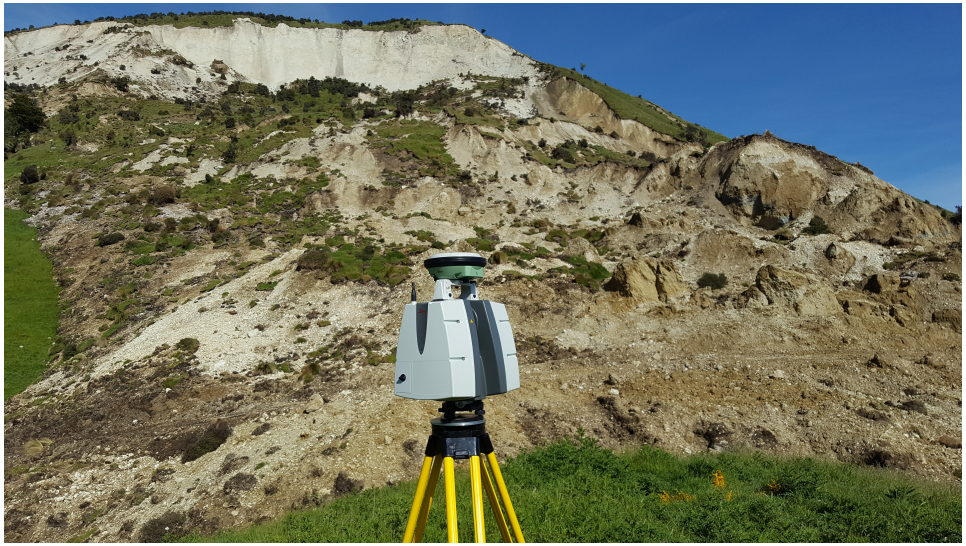
The NHERI RAPID Facility:
Enabling the Next-Generation of Natural Hazards Reconnaissance

Natural Hazards Engineering Research Infrastructure (NHERI) Program
of the National Science Foundation (NSF)

RAPID NHERI
Natural Hazards Reconnaissance Facility





UNIVERSITY OF WASHINGTON

Oregon State University
College of Engineering

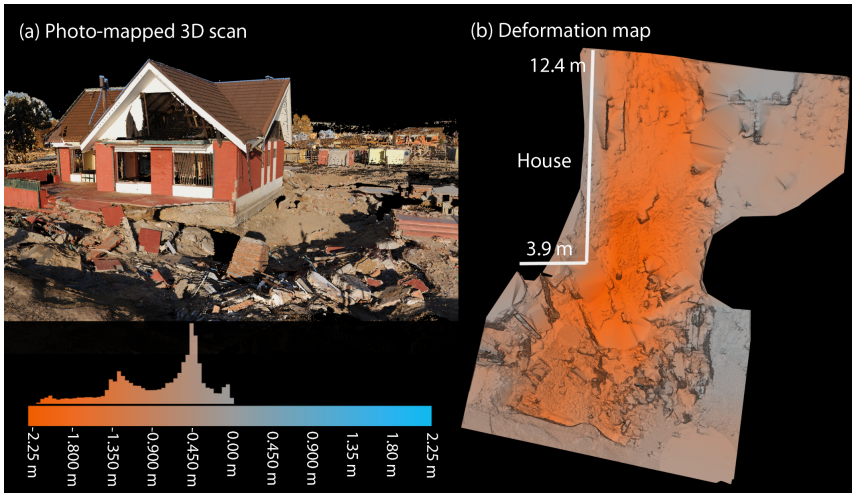
UF UNIVERSITY of FLORIDA

Joseph Wartman (UW), Jeffrey Berman (UW), Michael Olsen, (OSU), Jake Dafni (UW), Troy Tanner (UW; APL), Jennifer Irish (VT), Scott Miles (UW), Kurtis Gurley, (UF), Ann Bostrom (UW), and Laura Lowes (UW)

RAPID Facility Mission and Values

Mission: The RAPID facility provides investigators with the equipment, software, and support services needed to collect, process, and analyze *perishable data* from natural hazard events.

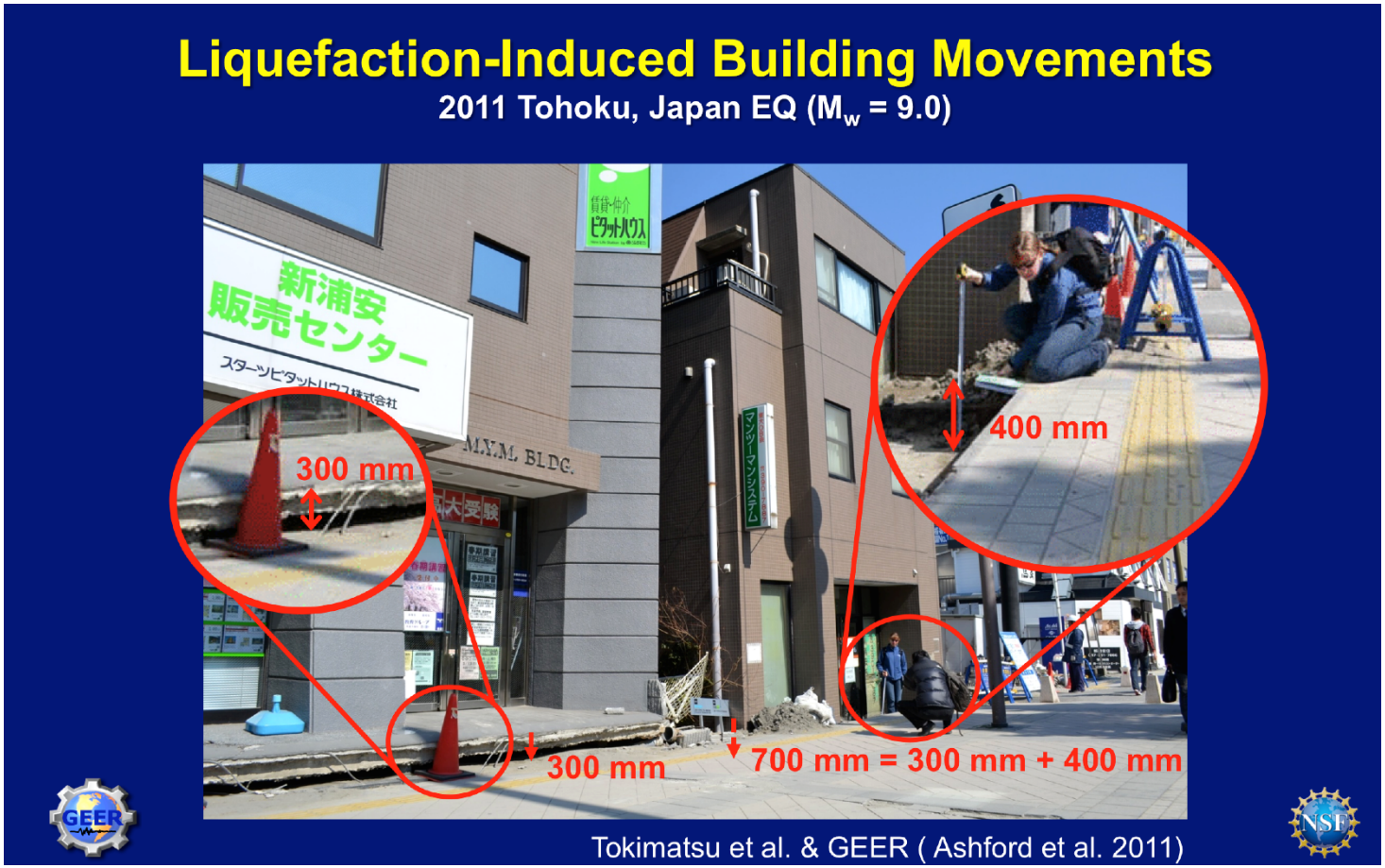
Values: We promote reconnaissance-based science, shared resources, open data, interdisciplinary research, community engagement, and innovation to reduce the adverse impacts of natural hazards.



Strategic **Activities:**

- Acquiring and operating data collection equipment
- Developing mobile applications
- Advisory services and logistics support
- Facilitating archiving, processing and visualization of data
- Training
- Engaging the public through citizen science.

Enabling the Next Generation of Natural Hazards Reconnaissance

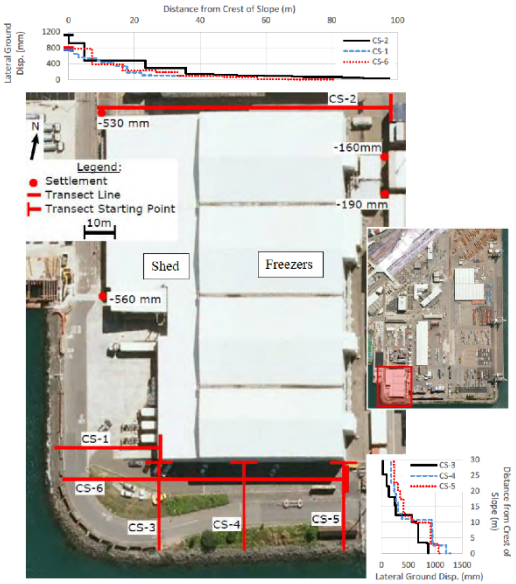


Courtesy of J. Bray, (2017) Ishihara Lecture, Simplified procedure for estimating liquefaction-induced building settlement

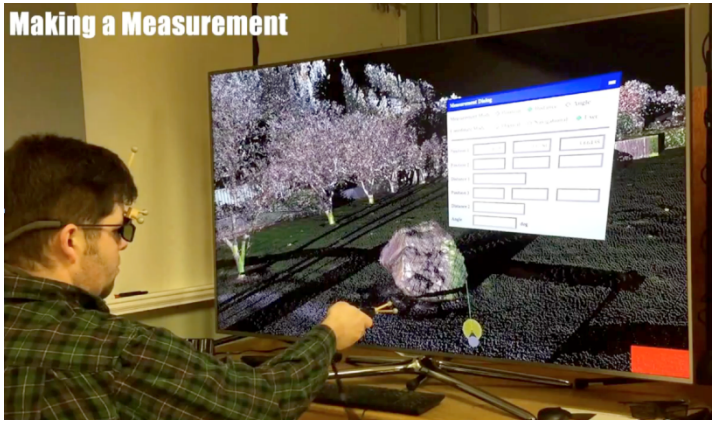
- *Fundamental insights*
- *Critical data for validation*
- *Lots of highly perishable data*
- 2D “point" data
- Manual measurements
- ~1 dm accuracy

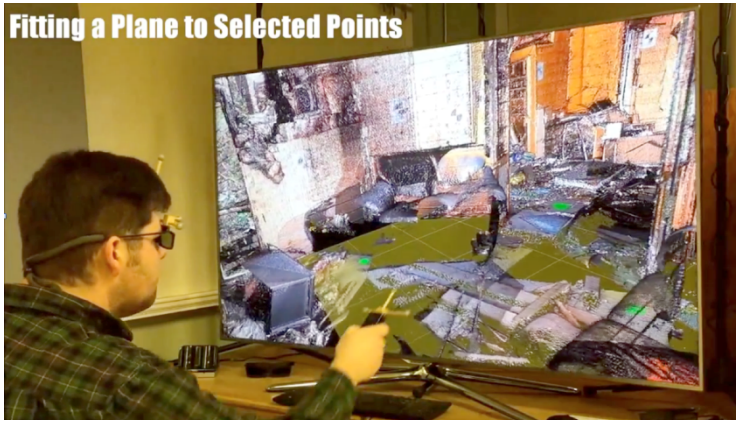
What is my measurement referenced to?
Where should/did I take it?

Enabling the Next Generation of Natural Hazards Reconnaissance



- Large amount of high-quality data QUANTITATIVE
- High-resolution (<1 cm), systematic data collection
- 3D (and 4D)
- Automation

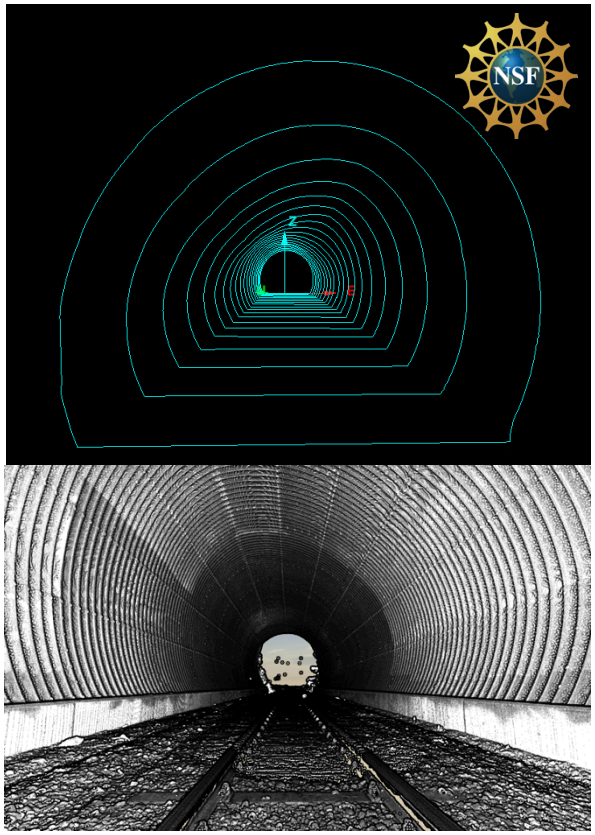




- Geo-referenced data sets that can be later analyzed and interrogated
- Open data archived in DesignSafe

Seeing the full picture

- Unprecedented quantity and quality of data
  - Digitally preserve scene
  - High-resolution, systematic data collection (reduce biases; increase certainty)
  - Shift from 2D to 3D\4D; leads to new analysis and scientific approaches that consider the 3D\4D nature of these hazards and the systems affected by them
  - Broad range of spatial and temporal scales
  - Observations in context



Damaged Train Culvert, New Zealand, GEER 2016

- Highly versatile: Collection and integration of engineering, natural hazards, earth science, and social science datasets

- Data availability = Greatly expanded community of reconnaissance investigators and expertise

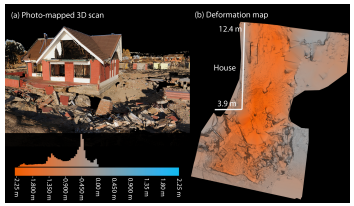
Reconnaissance analyses supported by 3D geomatics technologies

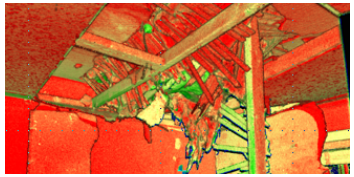
Geotechnical

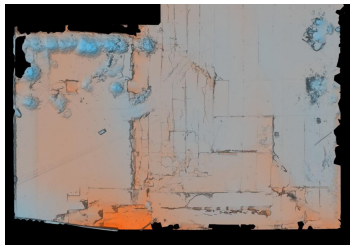
- Liquefaction\Lateral spreading
- Landslide\slope stability
- Coastal erosion
- Settlement
- Scour (depth distribution and volume)
- Surface rupture
- Quay, retaining & sea wall failures
- Topographic analysis
- Sediment accretion
- Subsidence
- Geomorphic change detection

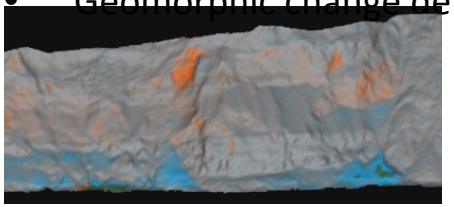
Structural

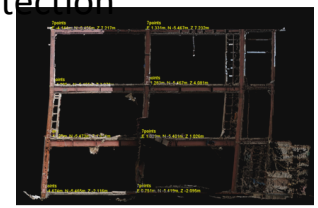
- Structural deformations, displacements, deflections, rotations
- Shear and other crack analysis (orientation, location, distribution, width (larger cracks), etc.)
- Bridge collapse analysis
- Spalled concrete quantification
- Concrete wall blow-out/in failure analysis
- Permanent soil structure interactions
- Fatigue analysis

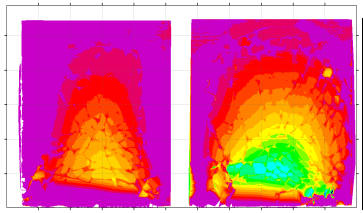


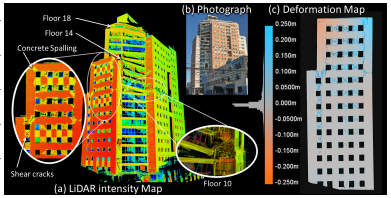


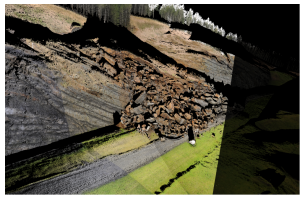




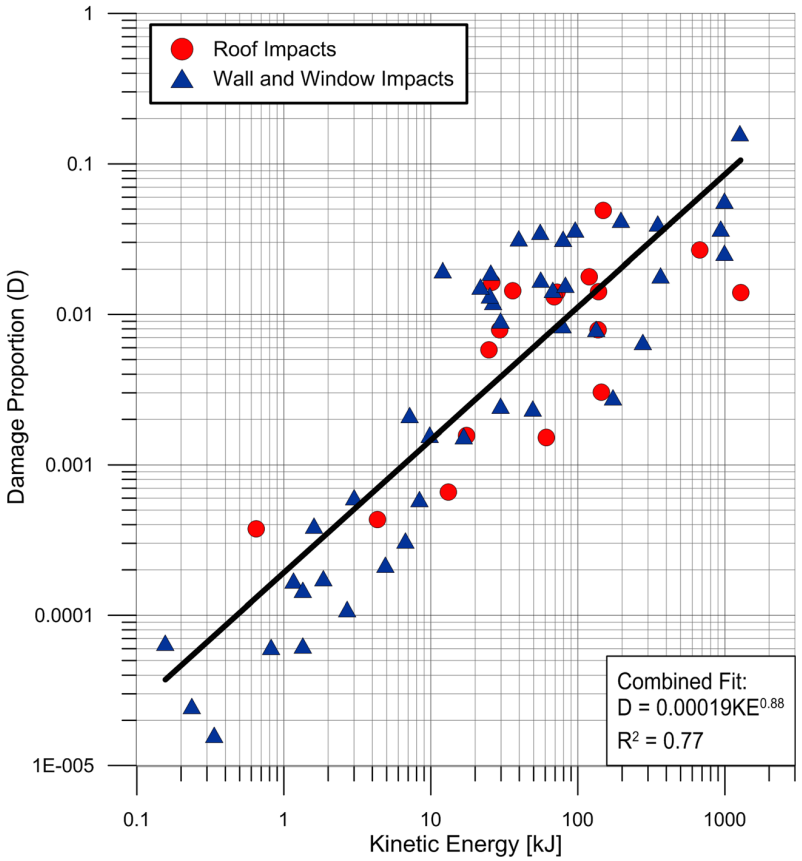


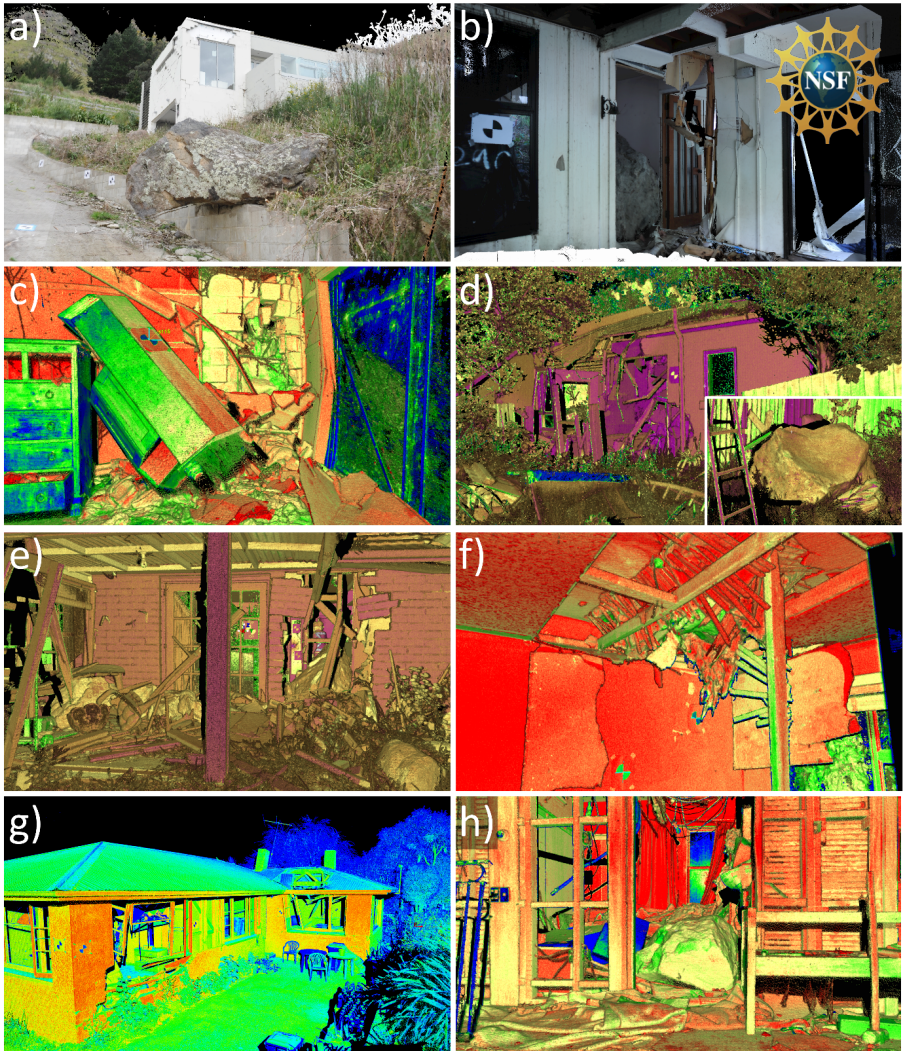






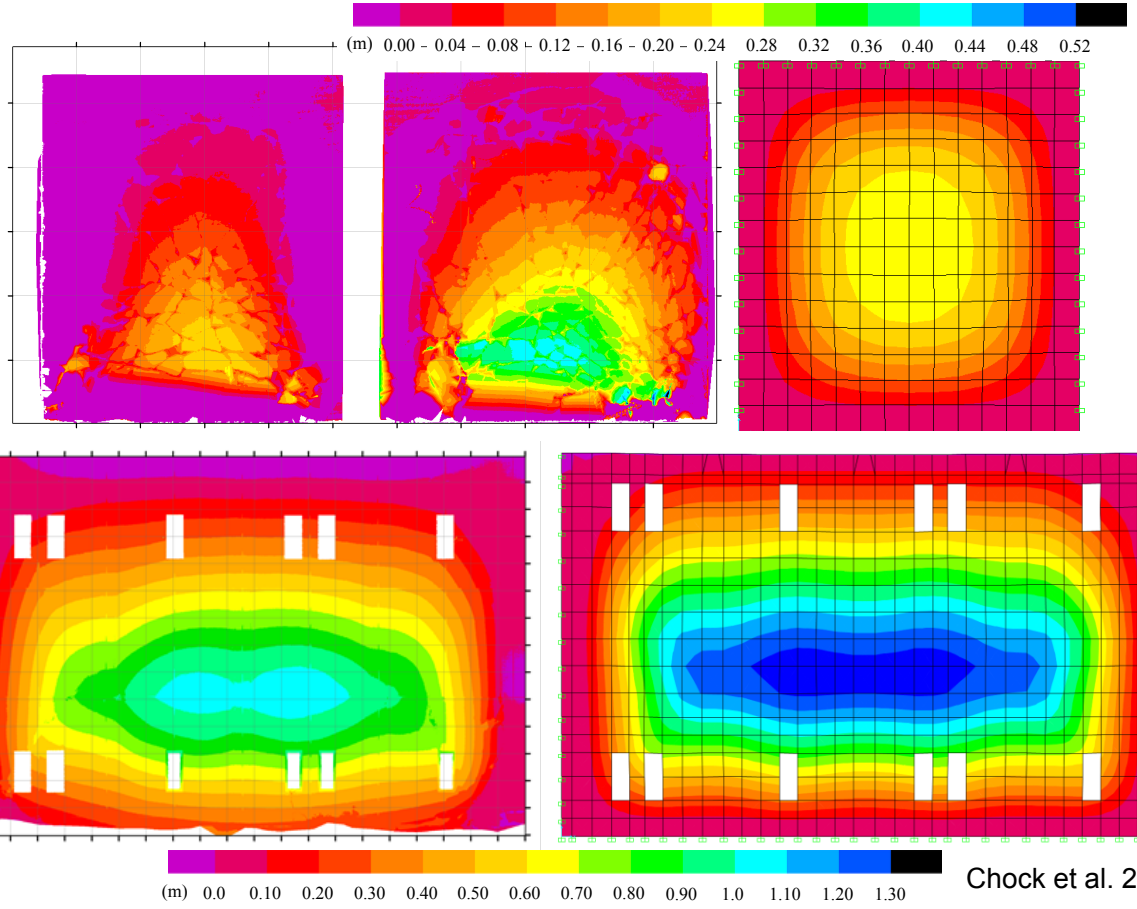
Cantebury New Zealand Earthquake Sequence Vulnerability (Fragility Curves)





Combined with HRT from airborne lidar for rockfall trajectory modelling

Tohoku Tsunami, Japan (2011)



Chock et al. 2013

Calibration of numerical models to support design guidelines (e.g., ASCE 7) and scientific theories

Instrumentation Highlights: 3D Laser Scanning

Leica BLK360 (x3)

Maptek LR3

Maptek XR3

- Short and long range systems
- Simple, easy to use interfaces
- Portable and durable
- Streamlined workflows

Instrumentation Highlights: Surveying Technologies

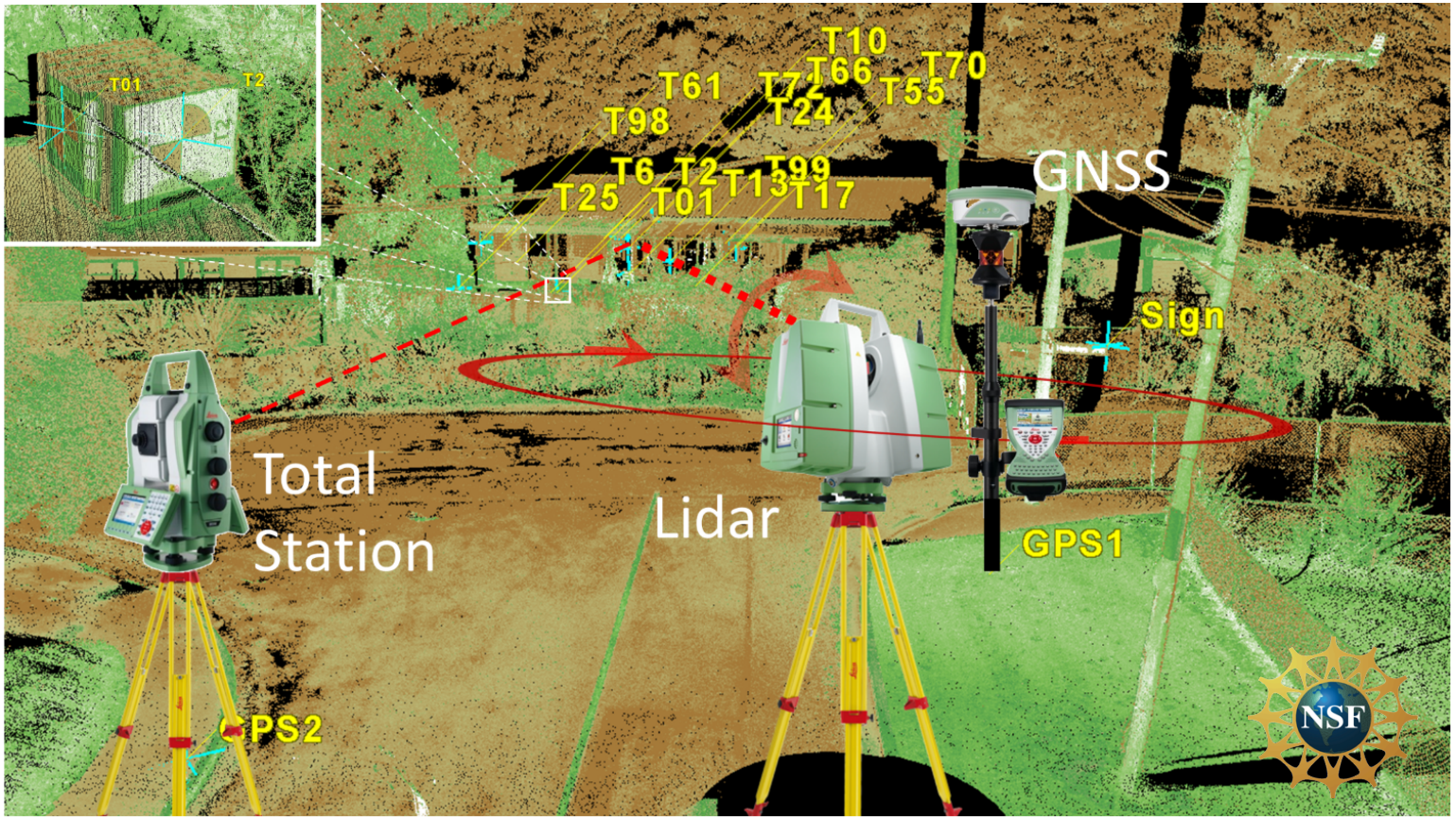
Leica TS16 Total Station

Leica GS18 GNSS (x4)

Leica LS15 Digital Level

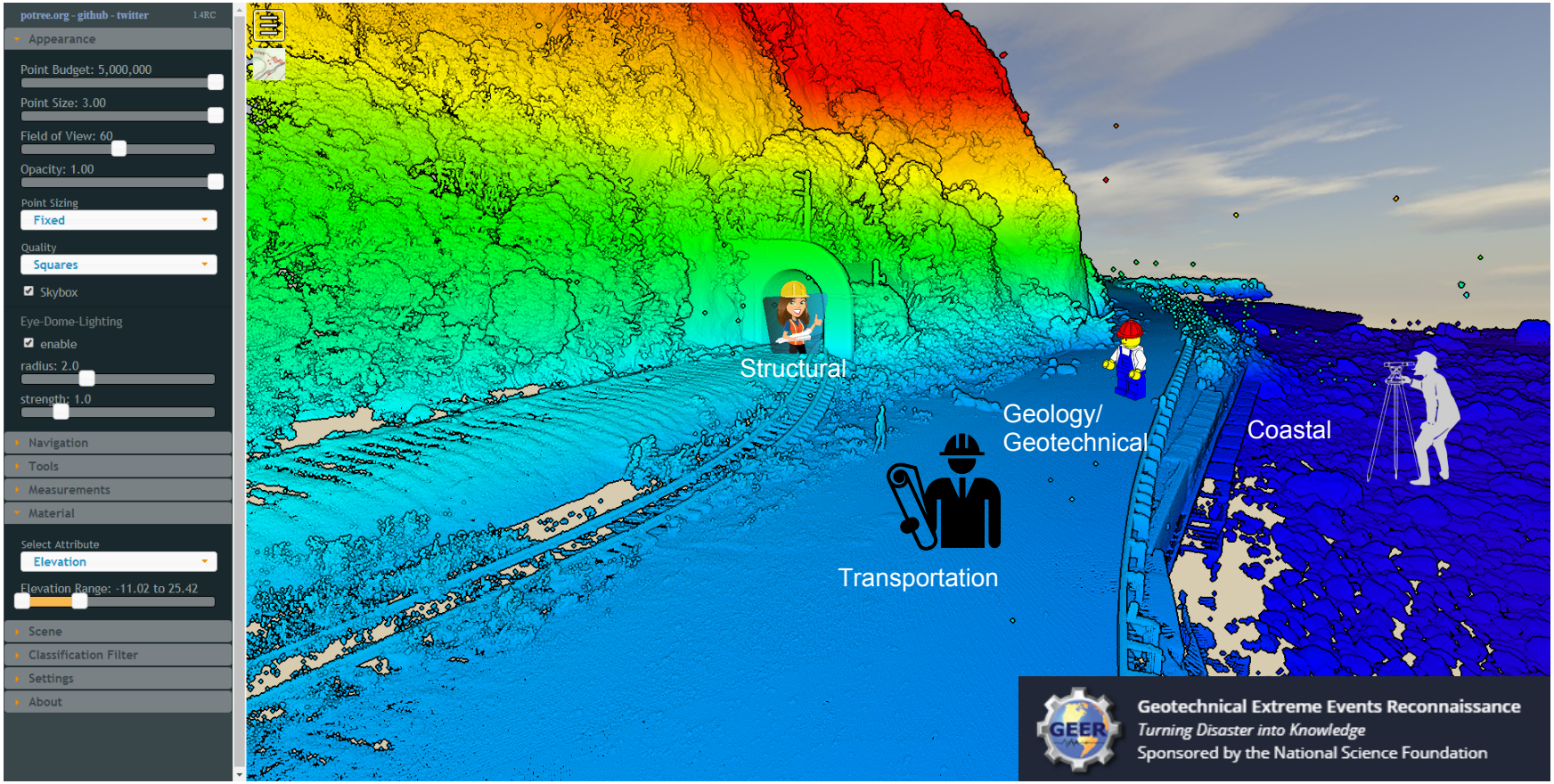
- Total station with reflectorless, robotics, and imaging capabilities
- GNSS receiver with improved positioning with obstructions
- High precision digital level

Integration of technologies



Seismic Rockfalls, Christchurch, New Zealand (Olsen & Gillins, 2015)

Kaikoura, New Zealand (2016)



Virtual Reconnaissance – Mini Cave

Instrumentation Highlights: Drones/UAS

- Hobbyist drones: lower resolution data for damage assessment
- Consumer-grade: aerial photography for SfM
- Industrial: weatherproof, high-resolution data for SfM
- MiniRanger: lidar system, survey grade, can also be mounted to vehicle

Mavic Pro/Air

Fixed Wing

Phantom 4 Pro+

Inspire 2

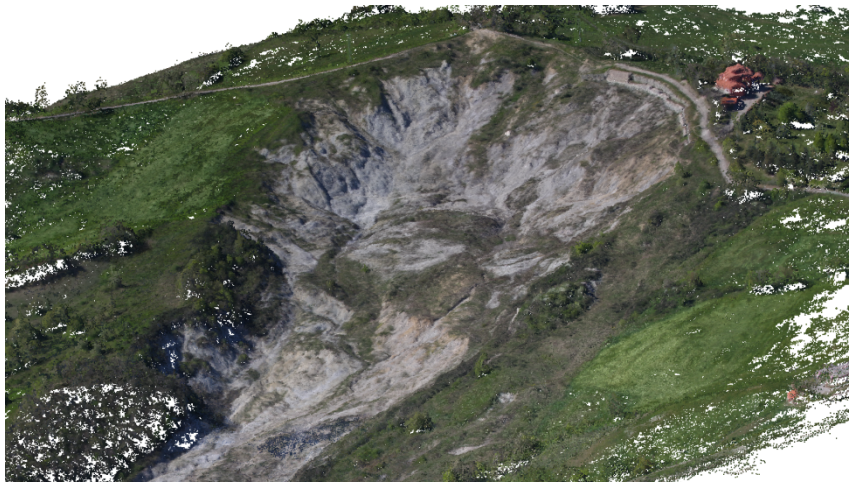
Matrice 200 Series

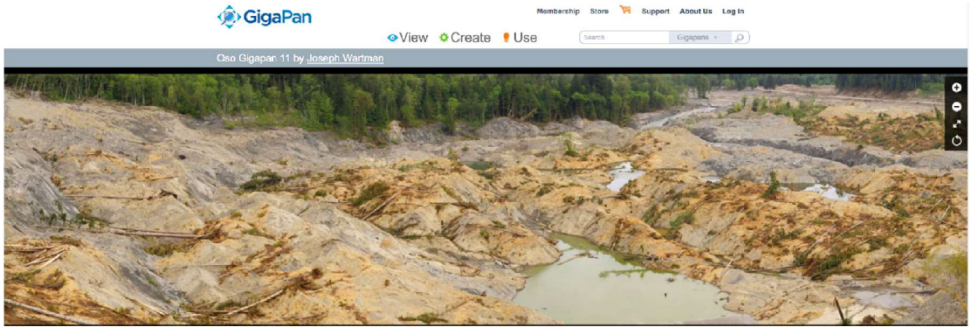
MiniRanger

Bungmati, Nepal (2015)

Data Courtesy of Andre Barbosa, Dan Gillins and Farid Javadnejad, OSU

Instrumentation Highlights: Imaging Technologies

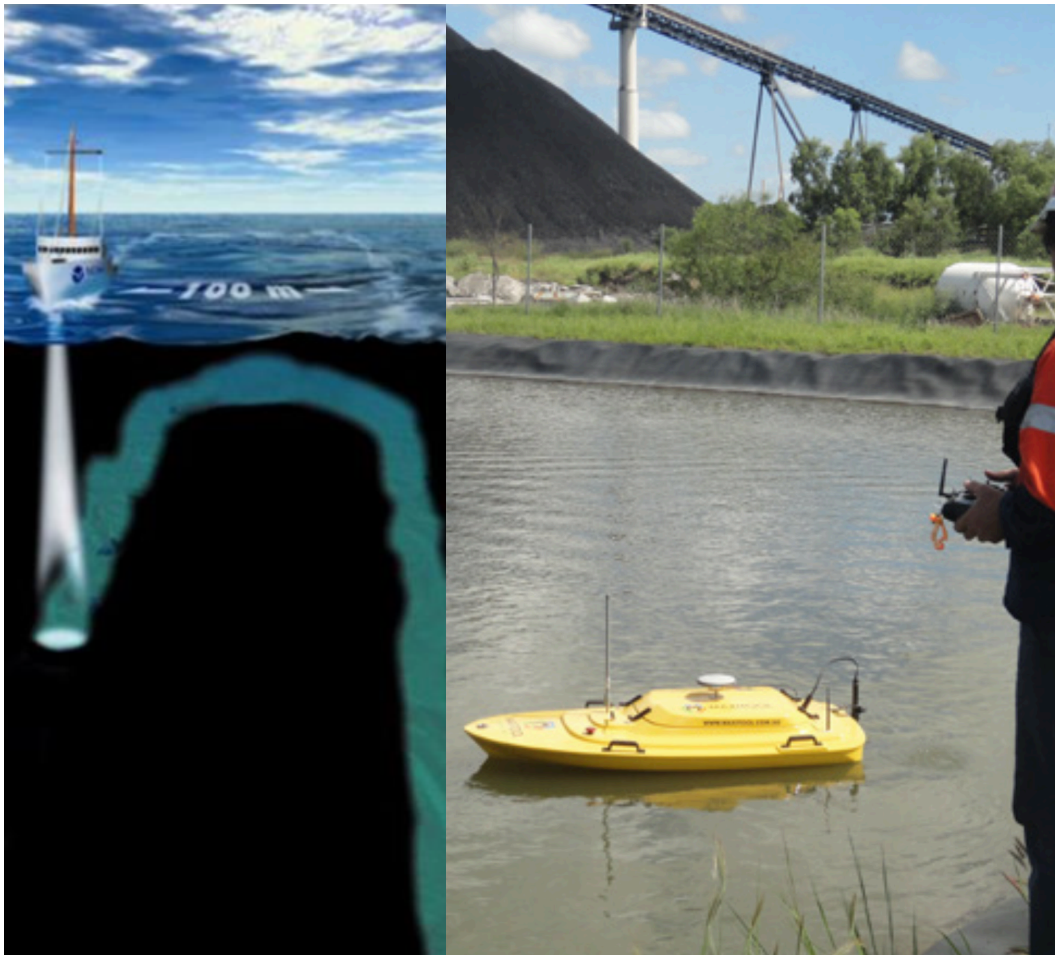




- With SfM, imaging is moving to forefront of 3D scene capture and DEM
- Captures context of scene (especially for 3D models)
- High resolution capture across a range of scales
- Immersive digital imaging products

Instrumentation Highlights: Bathimetry

- **Surface UAV with singlebeam sonar, underwater video**
- Accurate bathymetric transects
- Teledyne Z-Boat with Odom CV100 Echo Sounder
- Video – Z-Boat 1800 Camera
  - Bottom type/features
  - Erosion/deposition
  - Infrastructure damage
- Researcher-supplied equipment

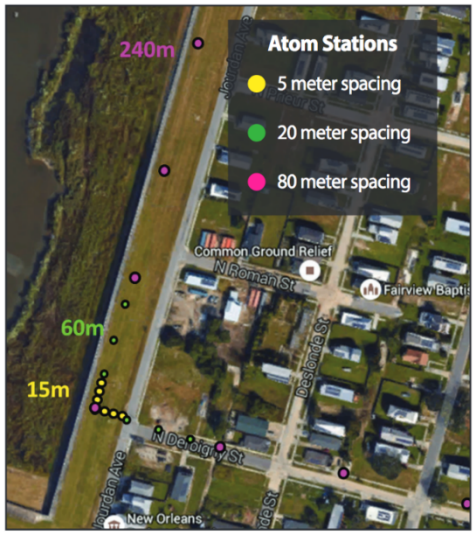


Instrumentation Highlights: Seismometers and Wireless Vs Profiling (MASW)

Trillium Compact Seismometer (x6)

ATOM wireless seismic data acquisition system (x24)

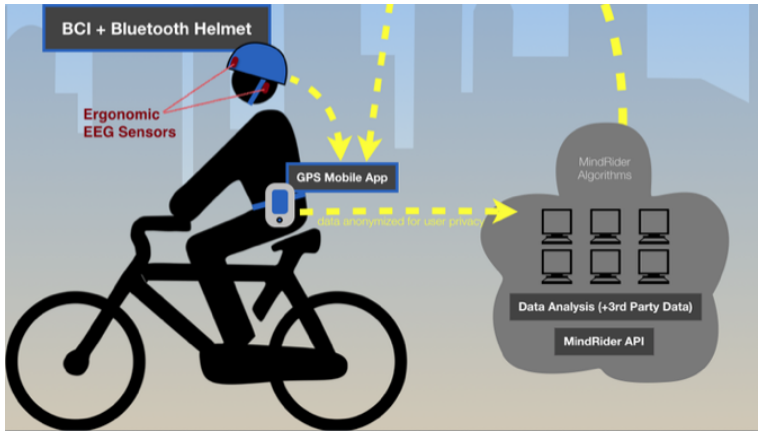
Centaur Digital Recorder



Instrumentation Highlights: Social & Citizen

- EMOTIV EPOC+ 14 channel wireless EEG (electroencephalography)
  - Mobile Wireless Brain-Computer Interface
  - Track conscious thought, emotions, facial expressions, head rotation, and location (w/ smart phone or tablet)

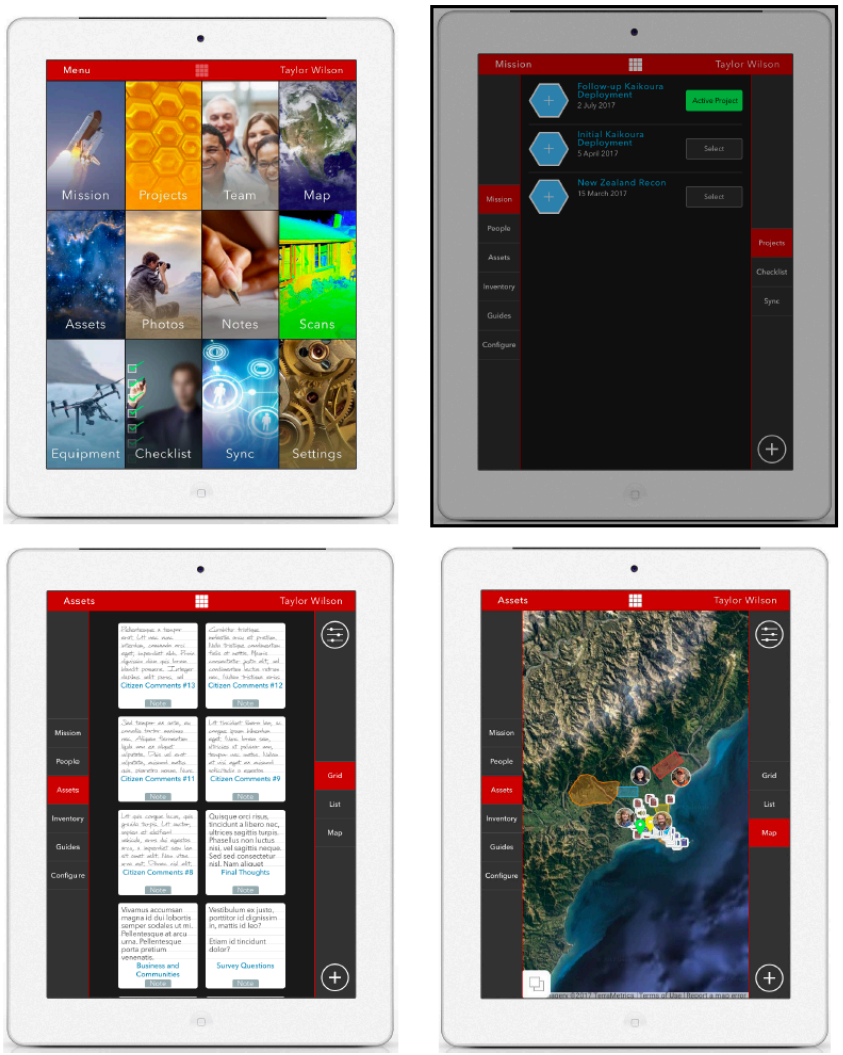
For example….



RAPID App or "RApp"

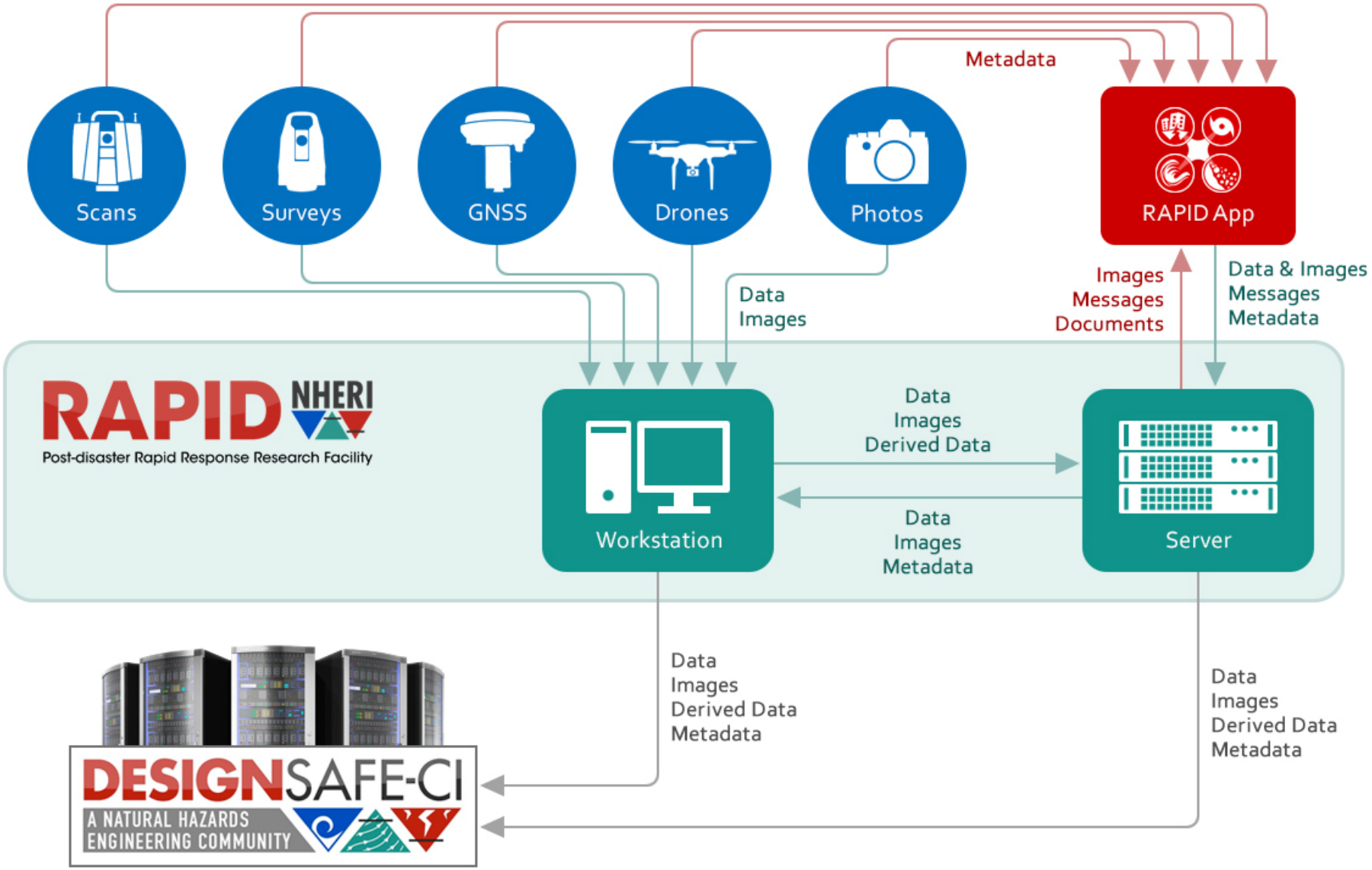
RApp integrates mission planning and coordination, data collection, and data management into a single, unified package

RAPID App graphical user interface prototype.



- Afford users the ability to identify, capture, aggregate, organize, store, and manage social science, engineering, and natural science reconnaissance data
- Disseminate, analyze, and visualize those data
- Facilitates communication, coordination, and collaboration among researchers across disciplines
- Designed with a human-centered approach that includes user research, prototyping, and iteration.

Data Workflow



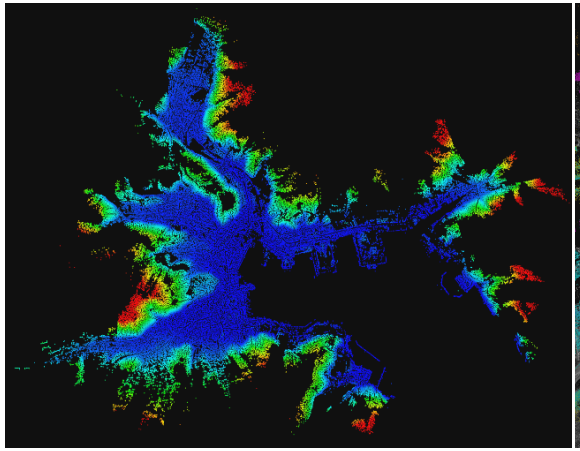
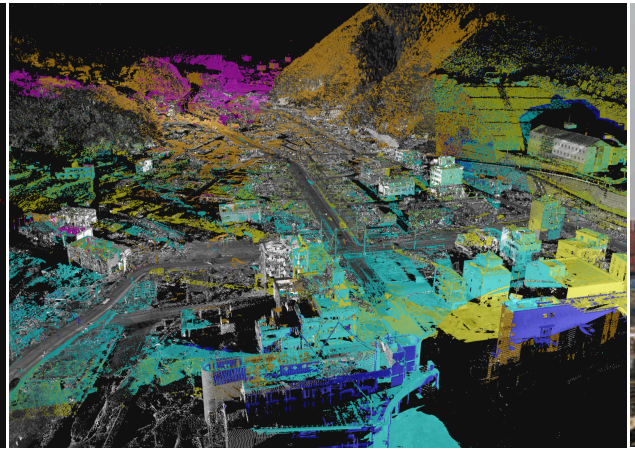
More information

RAPID NHERI
Natural Hazards Reconnaissance Facility

RAPID Facility Web Site (Reservations, Equipment list, Upcoming workshops, etc.)
https://rapid.designsafe-ci.org/ E-mail: uwrapid@uw.edu

Joe Wartman, Director
wartman@uw.edu

Jake Dafni, Operations Manager
dafnij@uw.edu


Overview articles published in mainstream media

"UW will host global center for disaster reconnaissance, research"
http://www.seattletimes.com/seattle-news/science/uw-will-host-global-center-for-disaster-reconnaissance-research/

"$4M grant funds new UW RAPID Facility to investigate natural disasters worldwide"
http://www.washington.edu/news/2016/10/05/4m-grant-funds-new-uw-rapid-facility-to-investigate-natural-disasters-worldwide/

Who can use the RAPID?

- Open to anyone:
  - Academics, government agencies, private industry, etc.
  - Different rates for NSF vs. non-NSF (RAPID equipment is subsidized by NSF)
  - Different priority for equipment requests
  - We aim to accommodate all requests
- NSF Grants:
  - RAPID equipment can be requested for any NSF research
  - Reconnaissance possibilities:
    - NSF RAPID grants
    - NSF supported reconnaissance organizations (GEER http://www.geerassociation.org/ , ISEER (https://hazards.colorado.edu/news/center-news/102)
    - Other NSF proposals

Where can the RAPID Equipment be Deployed?

- Locations following natural hazards:
  - Priorities are wind events (hurricanes, tornados), earthquakes, and tsunamis
  - Both immediate response and recovery monitoring possible, as are "pre-event" missions
- To supplement instrumentation at large-scale experimental facilities
  - Priorities are tests at other NHERI facilities
- Focus on short term deployments:
  - Longer term deployments possible but we need to talk
  - Deployments more than two weeks will require a user agreement to ensure equipment can be returned for high priority use if it is needed

How to Request RAPID Equipment?

- Steps:
  1. Go to the RAPID website at https://rapid.designsafe-ci.org/
  2. Determine the desired equipment from the equipment portfolio at https://rapid.designsafe-ci.org/equipment-portfolio/
  3. Check that it is available for the dates you want
     - New page coming soon showing deployment of RAPID equipment in a calendar format
  4. Complete the preliminary equipment request form at https://rapid.designsafe-ci.org/
     - Button coming to our main page soon
  5. Wait for us to contact you (typically less than 24 hours)
  6. Work through scheduling, logistics, and rates with us
     - Note that the NHERI NCO will assist with scheduling

RAPID Priorities for Equipment Requests

- The RAPID will make every effort to accommodate all requests
- When we can't, this table sets our priorities
- We have and will continue to establish MOU's with other organizations that have similar equipment to help handle intensive drawdowns

User	Data Collection Activity				
	Near-Term Response to a Priority Natural Hazard[1]	Recovery Phase for a Priority Natural Hazard[1]	Experiments at NHERI Facilities	Other Natural Hazards	Other Applications
NSF Supported	1	2	2	3	3
Non –NSF Federal Agency	4	5	5	5	5
Other	5	6	6	6	6

[1] Priority Natural Hazards: Hurricanes, Tornados, Other Windstorms, Storm Surge, Earthquakes, Tsunamis, and Landslides

Equipment Delivery

- The RAPID will organize the shipping of equipment
  - It may meet you in the field
  - You may retrieve from the UW
  - Our staff may meet you with it
  - You may receive a hand-off from another reconnaissance team
- You will be responsible for some of the delivery costs
- The site user manual (coming to the RAPID website) will have detailed requirements
- The RAPID will help with import/export controls
  - Instrument specific
  - Limitations on certain countries

User Rates and Fees *(tentative)*

- Final rates will be published in the coming weeks
- Preliminary rates (NSF users, for illustration only):
  - Equipment: $5 (small UAV) to $500 per day (long range lidar)
  - RAPID staff in field/lab: $500 per day + travel
  - RAPID staff data processing: $750 per day
- 8% overhead on all costs
- Estimated typical mission cost:
  - Long range lidar + medium UAV for 5 days in field without RAPID staff:
    - Equipment: $2750
    - Shipping: $1000 (conservative)
    - Overhead: $300
    - Total: $4050

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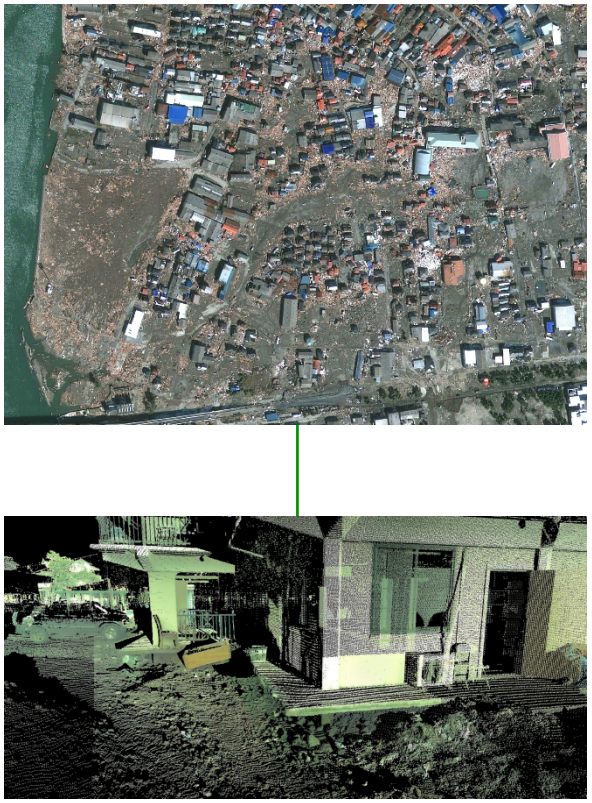

Tsunami Inundation

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Amanda South, reporter, Newstalk ZB, 8-5-12.

I: Right, let's start with February 22, can you describe your key experiences on that day?

IP: I was actually at home, ironically, because the Christchurch City Council was having its first dedicated earthquake recovery meeting so I would have started work at 1, so I was always haunted by that, but I was in Angus' bedroom getting him off for a nap and I guess the rest is history. The house started to explode around us. I just took him in by body in the middle of the room and things just fell around us. We were in this little bubble in the middle and it was horrific because everyone has that internal counter and you thought `Oh my god this is going to on too long, it's supposed to stop'. It got angrier and stuff was just erupting in the hallway. I can just remember knowing it was horrific and trying to think about my kid and I can remember my

Example Eyewitness Interview Transcript

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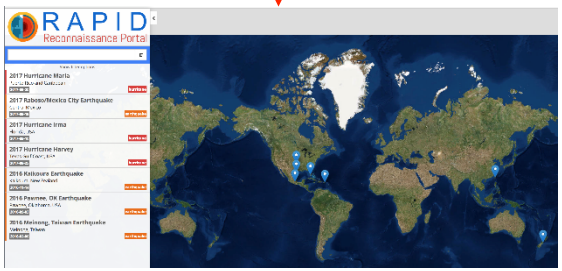
A NATURAL HAZARDS ENGINEERING COMMUNITY



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