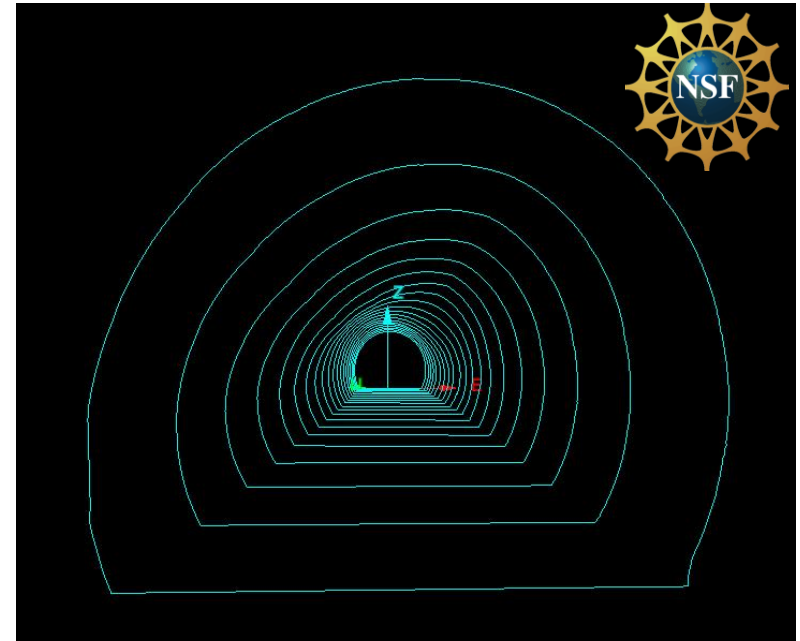


Hardware, Software, and Instrumentation

Advancing Your Science with the RAPID Equipment

- ◆ Unprecedented amount of high-quality, open-source disaster data
 - 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
- ◆ Collection and integration of engineering, and natural and social science data sets
- ◆ Greatly expanded community of reconnaissance investigators
- ◆ Rapid equipment making proposals sexy since 2018

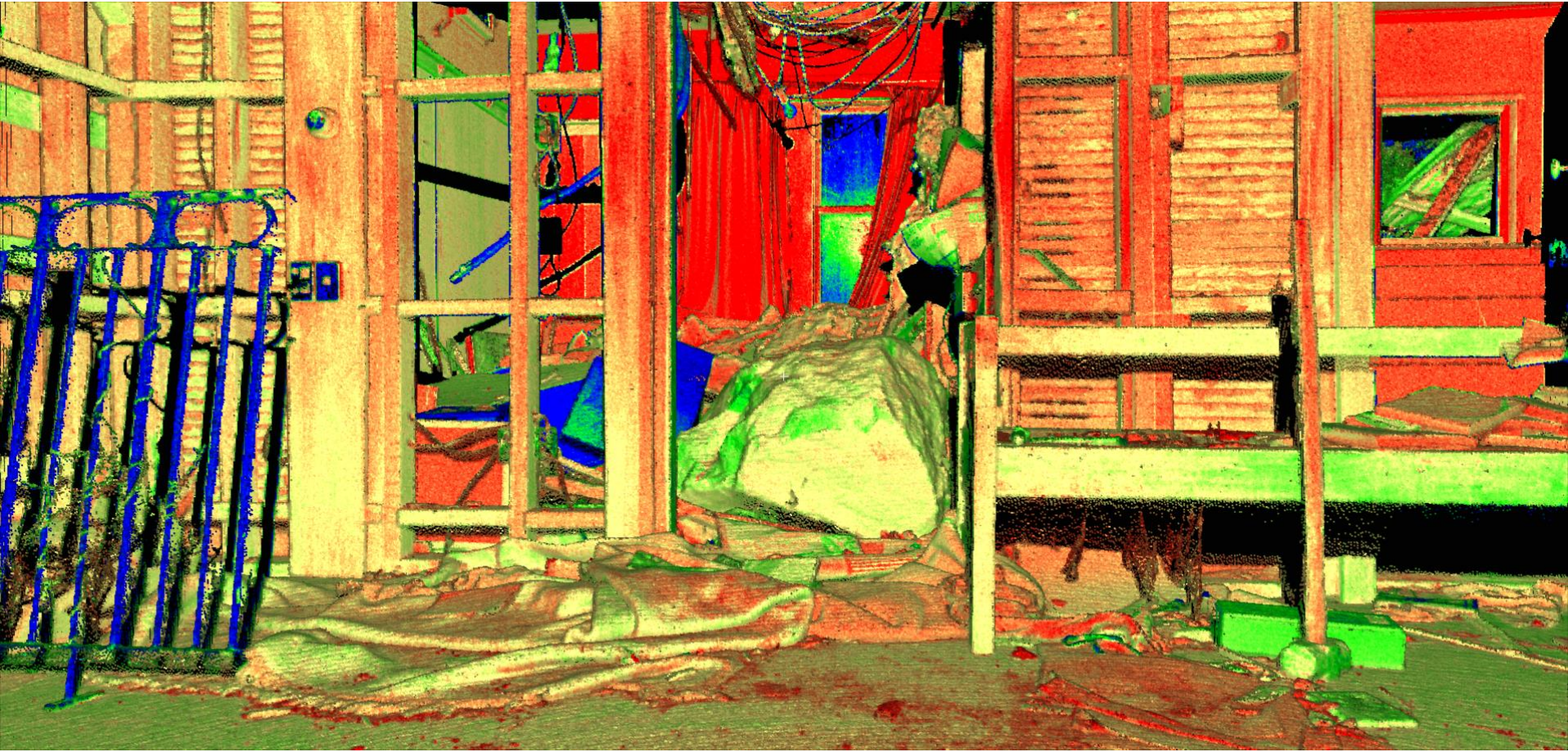


Damaged Train Culvert, New Zealand, GEER 2016

MULTI-HAZARD INTERDISCIPLINARY INSTRUMENTATION



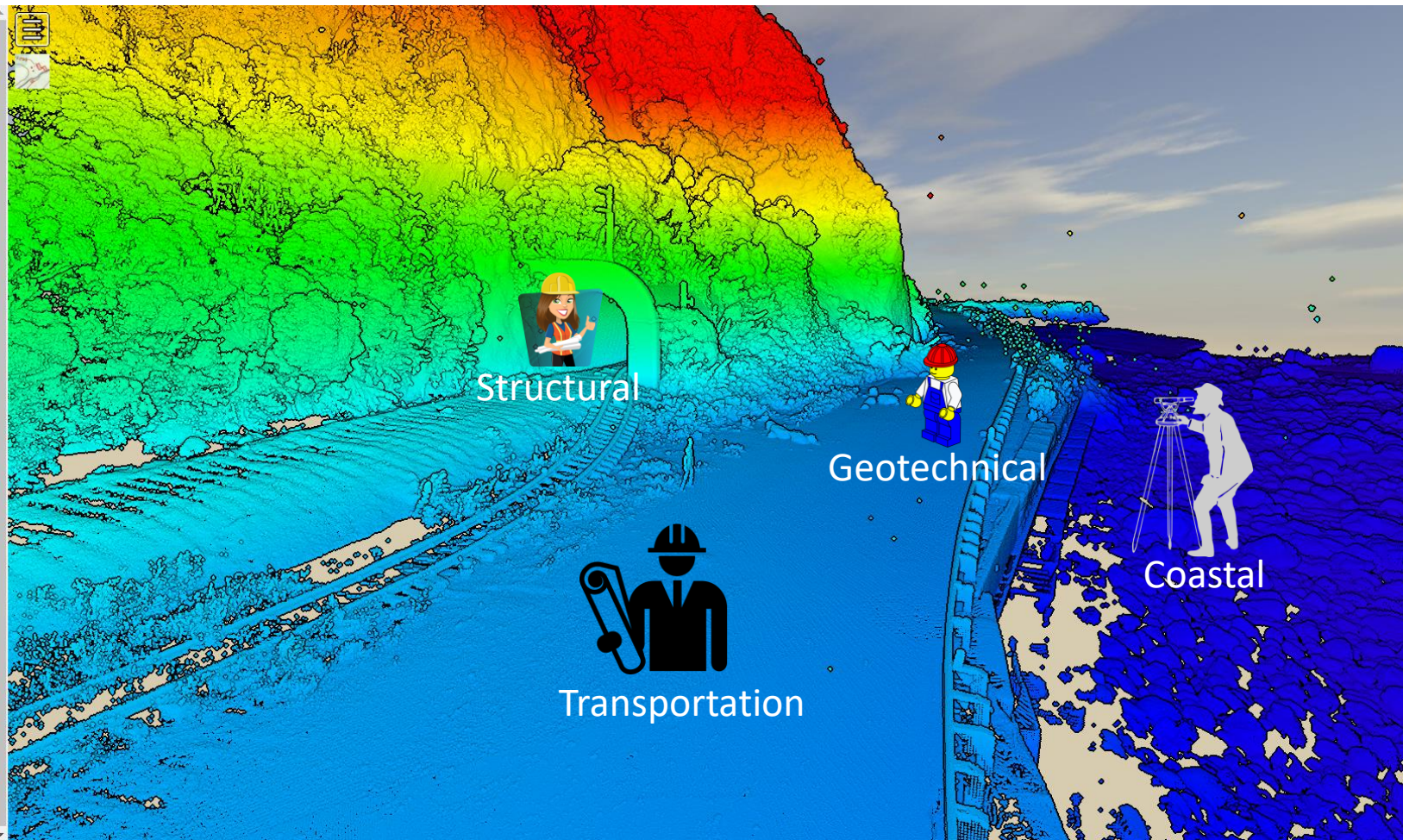
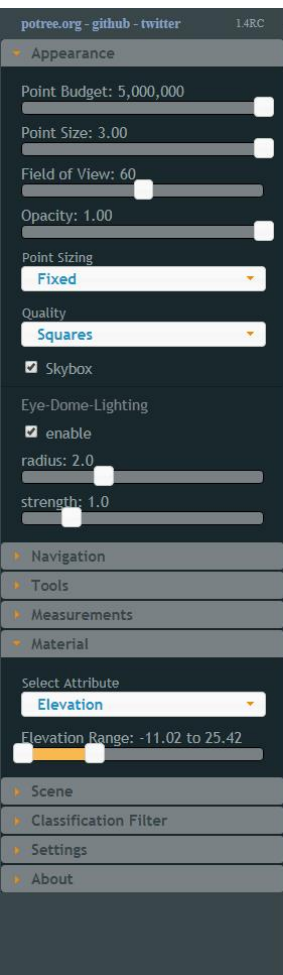
3D Laser Scanning



- ◆ Highly versatile – Collect once, use many
- ◆ Digitally preserve scene at high detail, accuracy
- ◆ Applicable across spatial scales

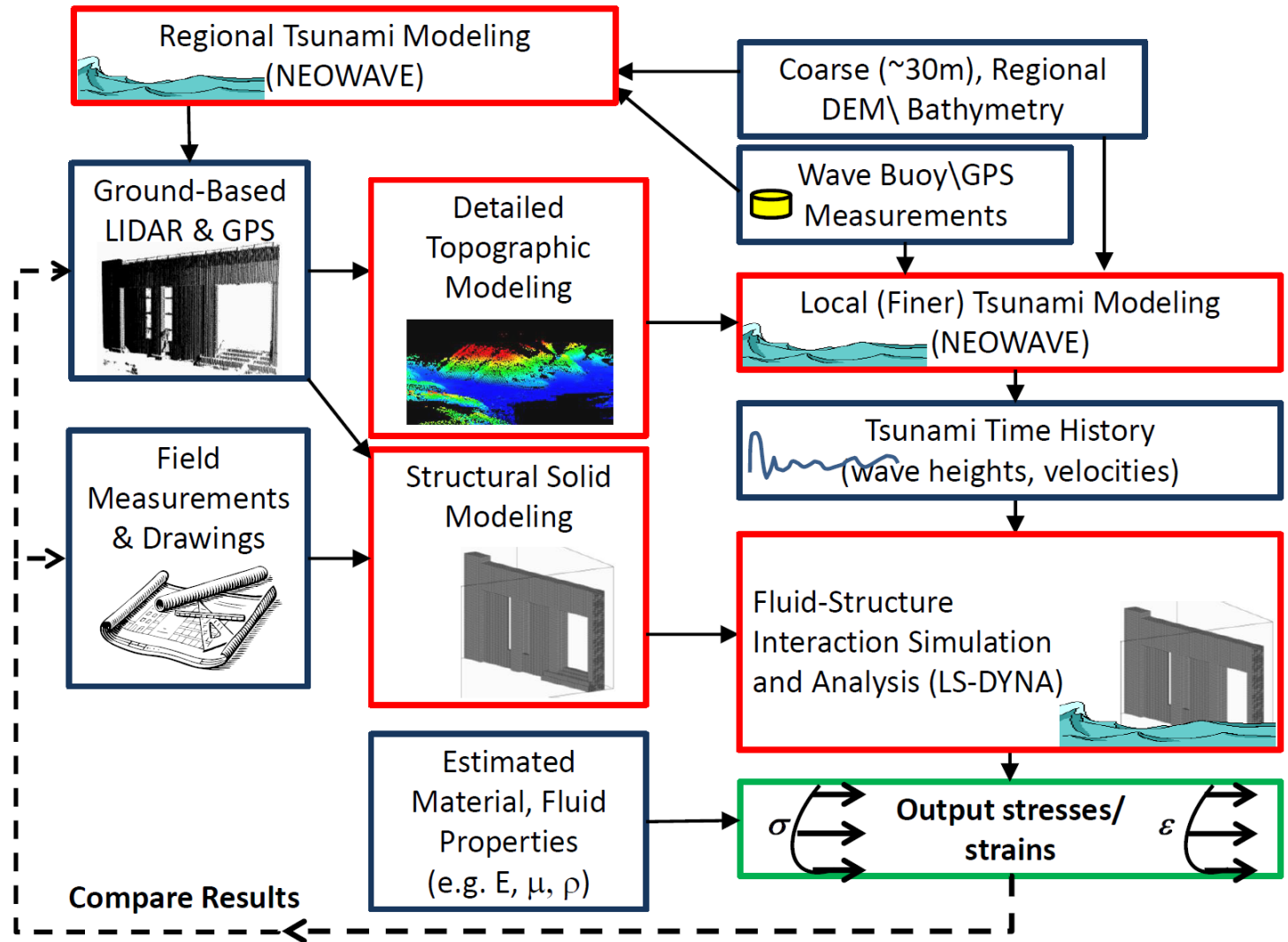
3D Lasar Scanning: Overview and Intellectual Merit

2016 Kaikoura Earthquake



Geotechnical Extreme Events Reconnaissance
Turning Disaster into Knowledge
Sponsored by the National Science Foundation

3D Laser Scanning: Example Applications



2011 Japan Earthquake\Tsunami

Yim et al. 2014

3D Laser Scanning: Equipment



Leica BLK360 (x3)



Maptek LR3



Maptek XR3

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

Surveying Technologies



- ◆ Standalone surveys or integrated with other devices
- ◆ Ensures high quality geo-referencing capabilities

Surveying Technologies: Equipment



Leica Nova TS16 Total Station



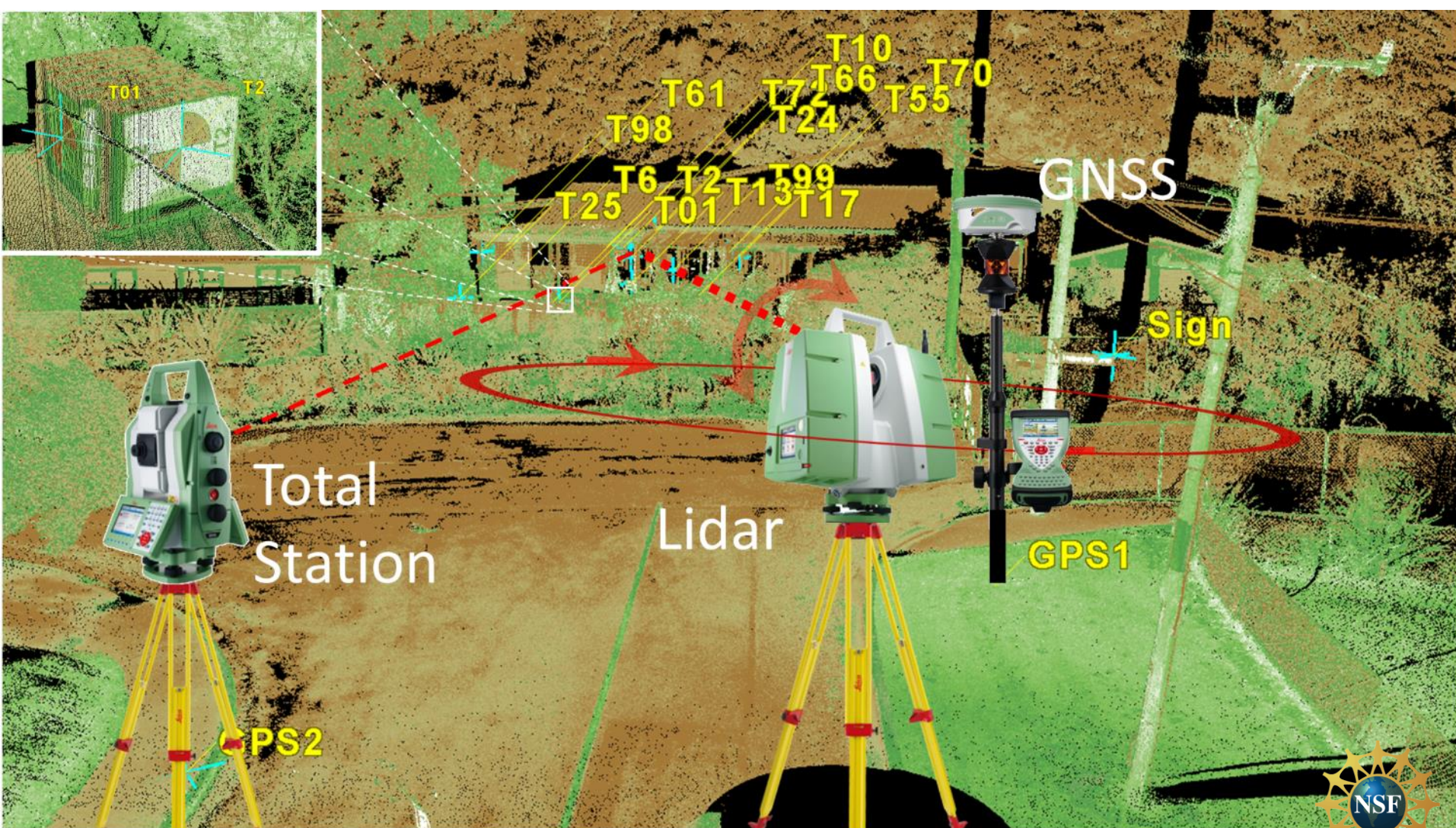
Leica GS18 GNSS (x4)



Leica LS15 Digital Level

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

Surveying Technologies: Example Applications



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

Unmanned Aircraft Systems (UAS), or *Drones*



- ◆ Provide a range of perspectives and scales
- ◆ Cost effective, safe, and relatively easy to use compared to manned aircraft
- ◆ Access areas otherwise inaccessible
- ◆ Versatile; can be outfitted with multiple data acquisition tools and sensors

Unmanned Aircraft Systems (UAS): Example Applications



Data Courtesy of Dan Gillins and Farid Javadnejad, OSU

Bungmati, Nepal (2015)

UAS: Equipment

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



Mavic Pro/Air



Parrot Disco Adventurer



Phantom 4 Pro+



Inspire 2



Matrice 210



MiniRanger

Applied Streetview



- ◆ Your own, personal Streetview
- ◆ 360-degree, car-mounted camera
- ◆ GNSS georeferencing
- ◆ Scrub sensitive info (faces, license plates)
- ◆ Easy mount to vehicle
- ◆ Visualization Software for organizing and querying projects
- ◆ Interest already from social science and engineering



Google Streetview deployment after Tohoku Earthquake

DJI Osmo and Insta360



DJI Osmos & 4K Camera (x3)

- ◆ Stabilized, walkthrough imagery
- ◆ 4k resolution



Insta360 ONE (x5)



NYTimes Daily 360

- ◆ Ability to capture high resolution data quickly
- ◆ Ideal for “tight” spaces

Digital SLR Cameras and GigaPan Epic Pro V



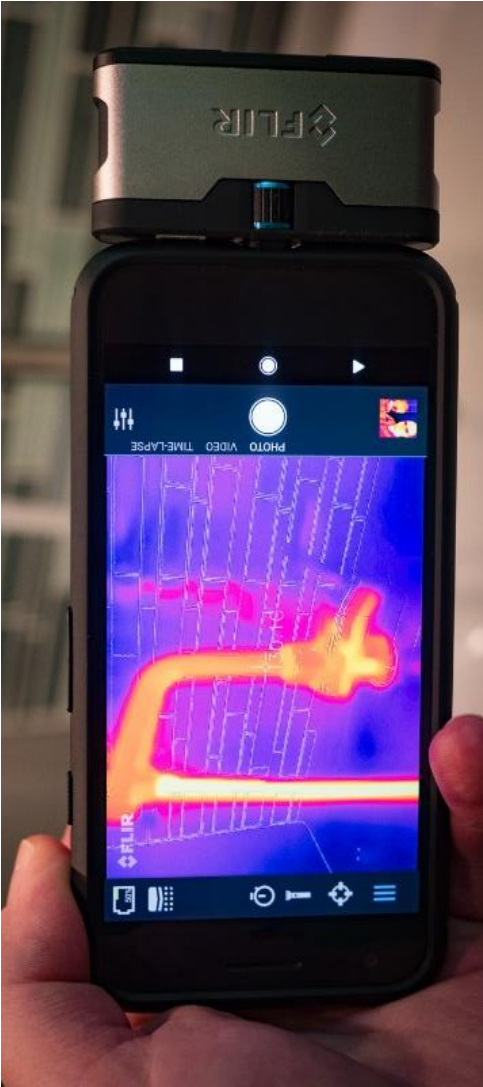
Canon 7D Mark II (x2)



Gigapan Epic Pro V

- ◆ Build SfM/MVS models with high quality images!
- ◆ Detailed images of damaged components in structure or images collected for quantitative computational analysis
- ◆ Works with the digital SLR cameras (and others)
- ◆ Rock slope or panoramic view of terrain
- ◆ High quality imagery of the façade of a structure
- ◆ Overview oblique imagery of a town from a hillslope viewpoint to put observations/measurements in context, etc.

Thermal Imaging

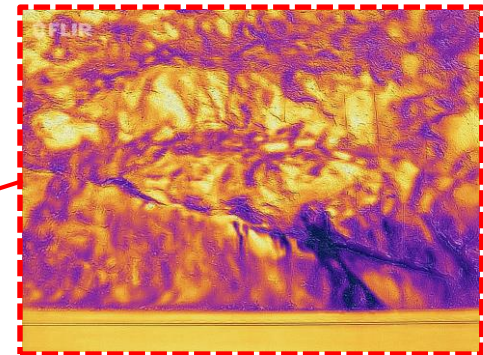
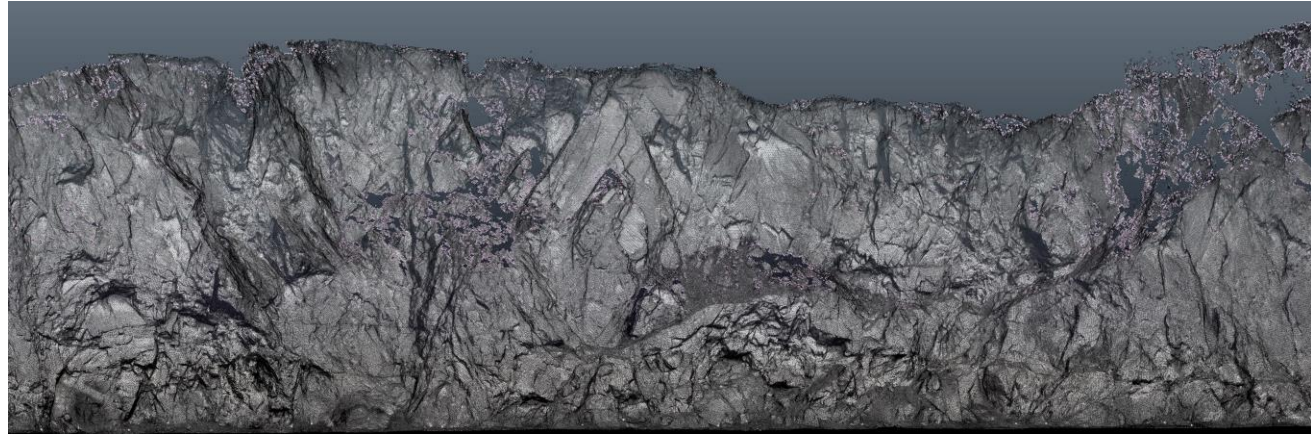


FLIR One Pro (x5)

- ◆ MSX-enhanced thermal images
- ◆ Plugs directly into mobile device
- ◆ Measures temperatures $< 400^{\circ}\text{C}$
- ◆ Damage assessment, electrical signatures, water damage

Data Products

Alaska



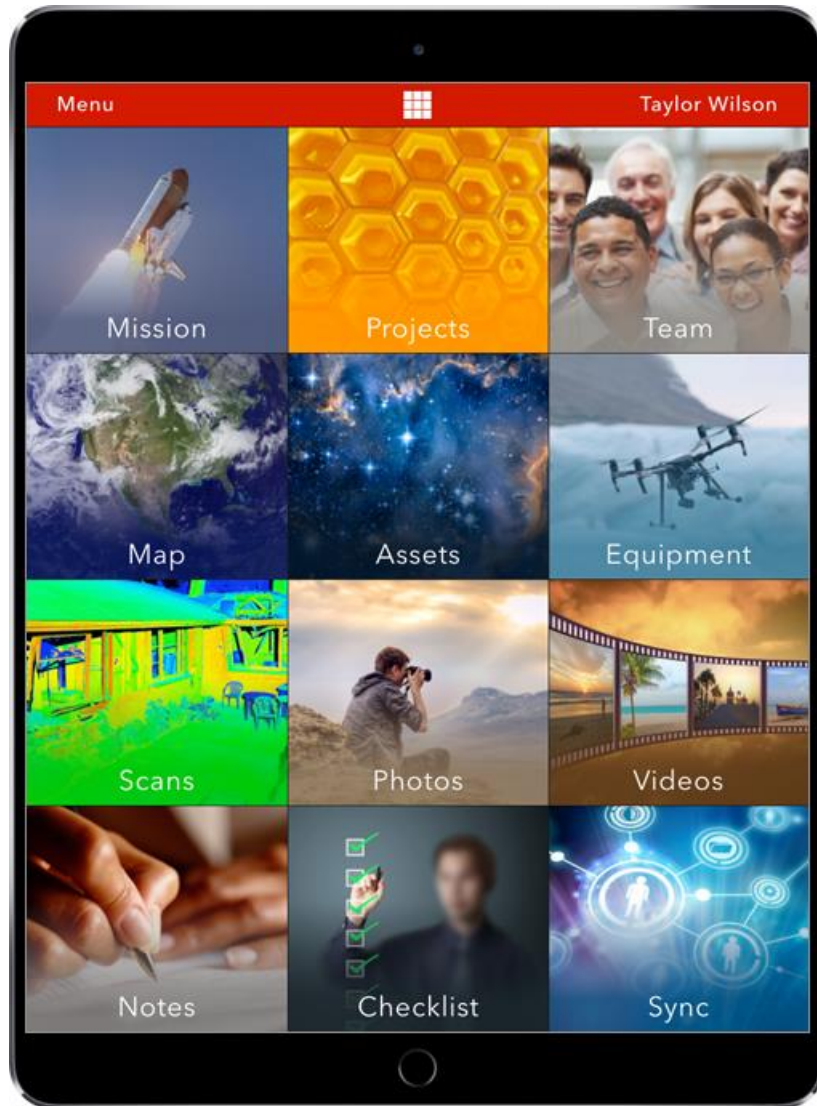
RAPID App

The RAPID App integrates mission planning and coordination, data collection, and data management into a single, unified package



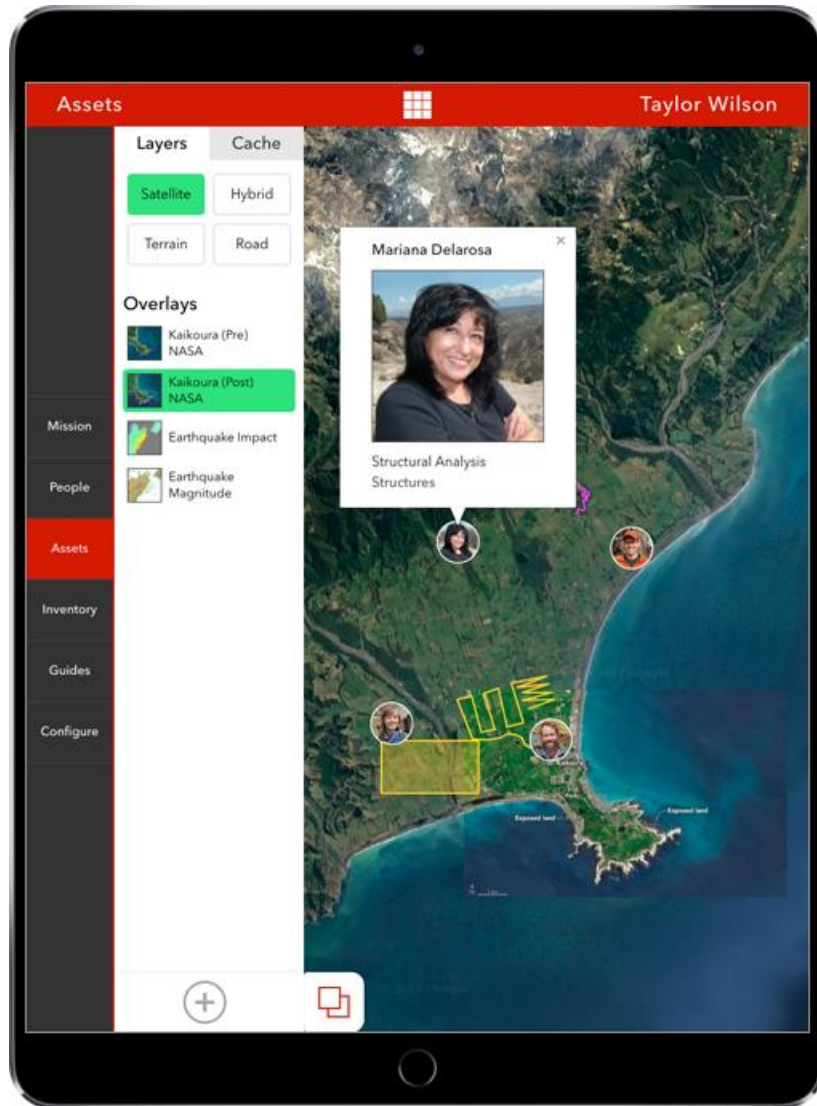
- ◆ All data collected is treated equally, allowing novel approaches to organization and comparisons
- ◆ Tedious tasks are simplified, allowing field recon teams to spend more time on data collection efforts

RAPID App: Development Stages



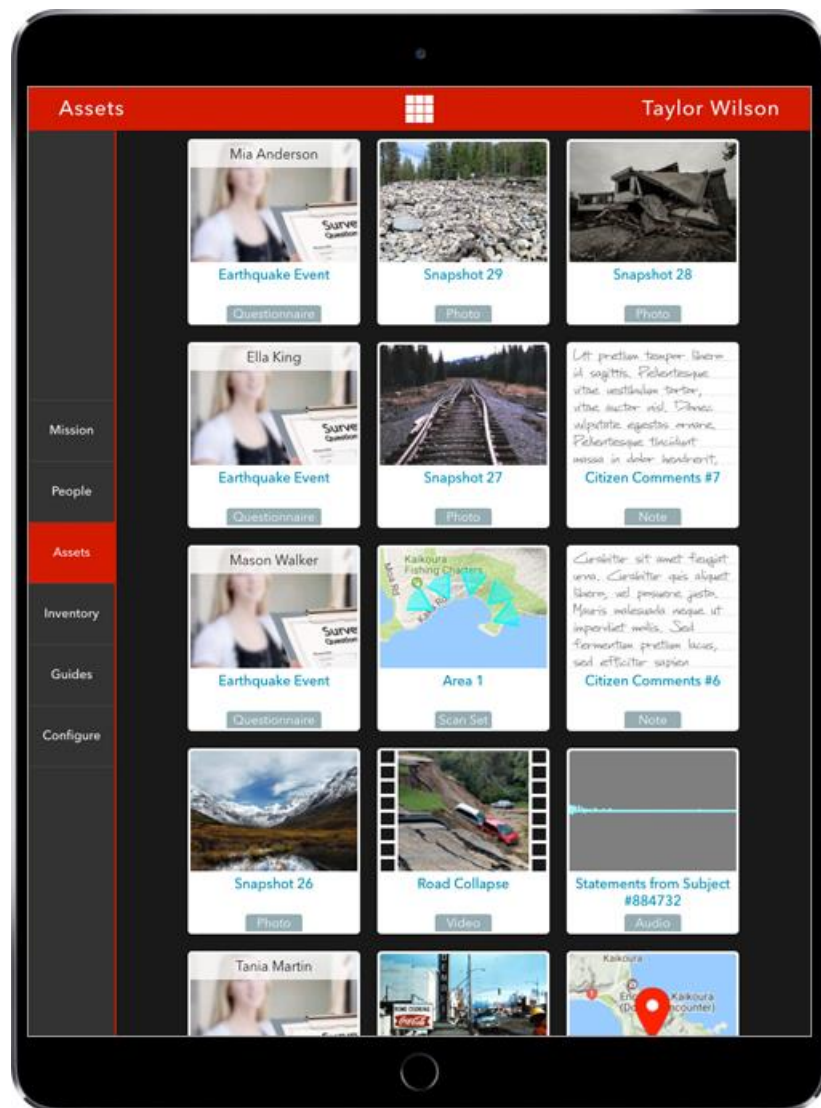
- ◆ Concept
- ◆ Directed Research Group (DRG) Student Research
- ◆ DRG Student Prototyping
- ◆ Feasibility Studies
- ◆ Professional Prototyping
- ◆ Design Iteration
- ◆ Coordination with DesignSafe
- ◆ Development
- ◆ *Years 3-5: Updates*

RAPID App: Mission Planning



- ◆ Mission Coordination
- ◆ Cacheable Maps
- ◆ Route, Area, and Location Planning
- ◆ Location Tracking
- ◆ Inventory
- ◆ Checklist
- ◆ Data Synchronizing
- ◆ *and Much More*

RAPID App: Data Collection



- ◆ Photos, Videos, Audio, Notes, Scans, Surveys, Questionnaires, and More
- ◆ Data Tagging
- ◆ Data Linking
- ◆ Guides for Multi-Disciplinary Data Collection
- ◆ Data Upload to DesignSafe
- ◆ *and Much More*

MISCELLANEOUS



Rap Pack, Communications and Safety

- ◆ Ready to go backpacks with smaller tools important for recon
- ◆ Additional items:
 - Portable Power Generators
 - NHERI RAPID safety vests with iPad pocket
 - Pelican Cases
 - Power Inverters

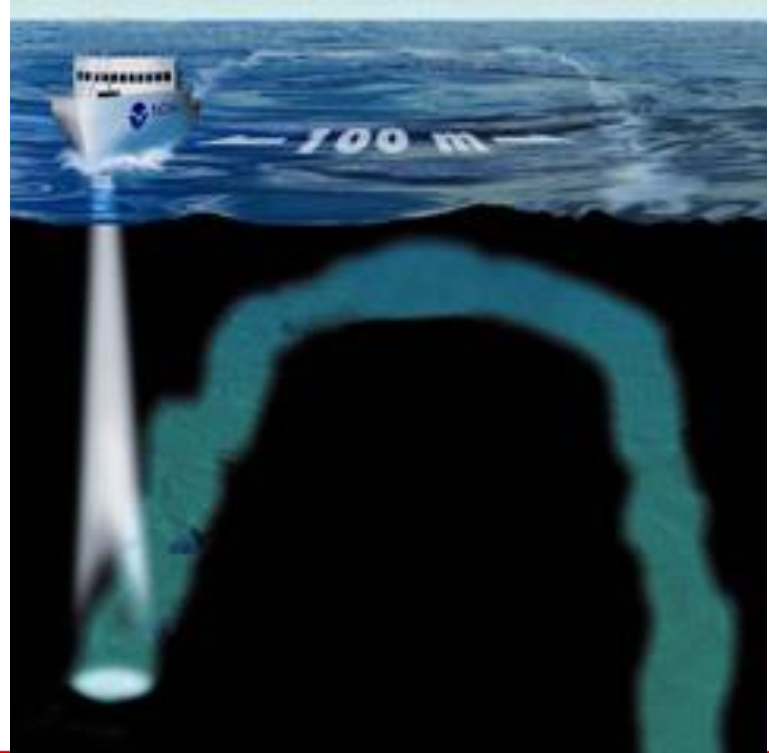


COASTAL HAZARDS EQUIPMENT



Coastal: Equipment

- ◆ Surface UAV with singlebeam sonar
- ◆ Accurate bathymetric transects
- ◆ Teledyne Z-Boat with Odom CV100 Echo Sounder
 - Bottom type/features
 - Erosion/deposition
 - Infrastructure damage
- ◆ Researcher-supplied equipment



Coastal: Equipment

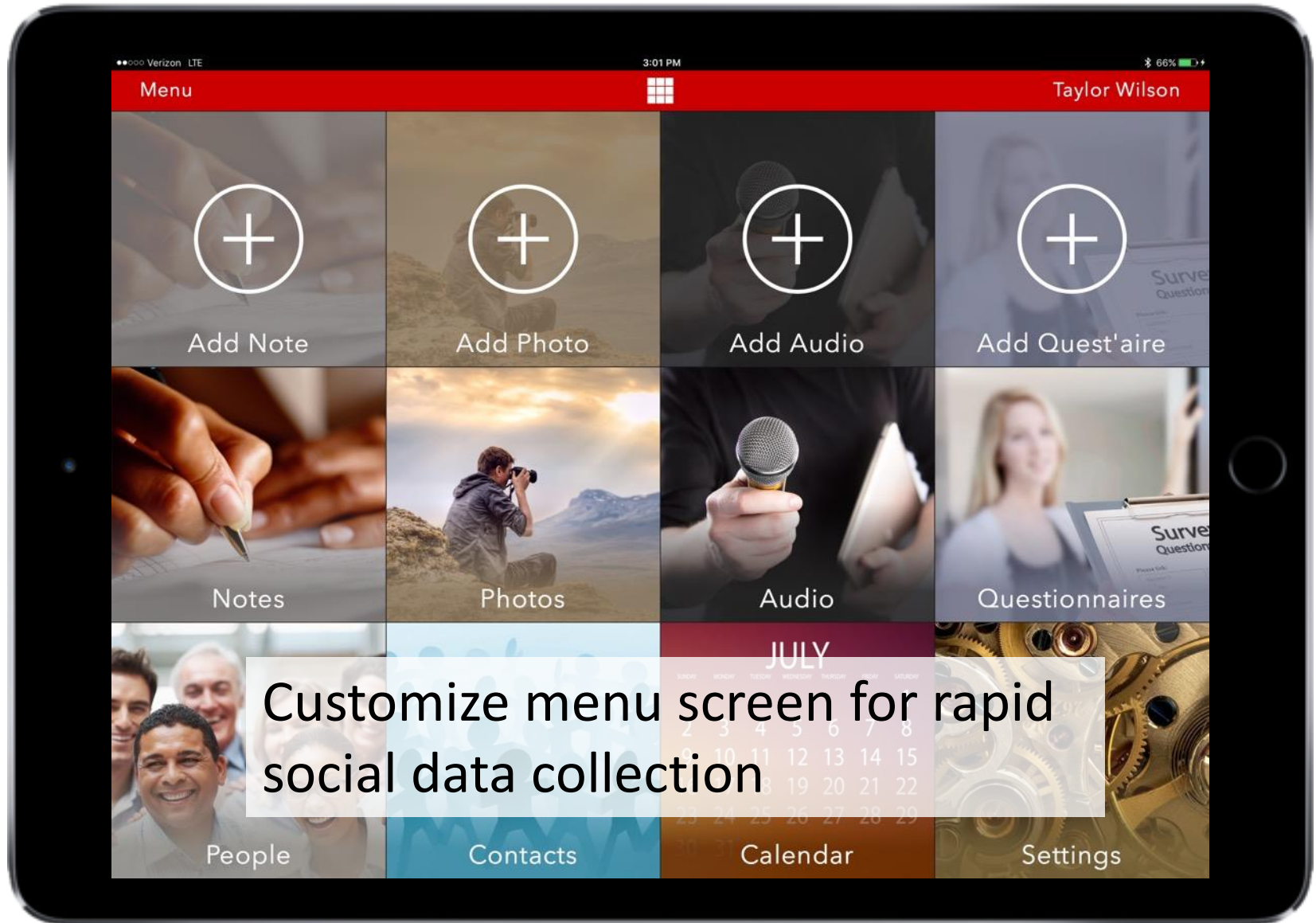
- ◆ **Pressure sensors (20)**
- ◆ Time series of:
 - Flow depths
 - Surge heights
 - Runup heights
 - Storm waves
- ◆ TruBlue 255 x 20
- ◆ Water level and wave measurement. Onshore and nearshore/offshore (using beacons) for storm surge etc.



SOCIAL SCIENCE



Social & Citizen Science: RApp for Social Data



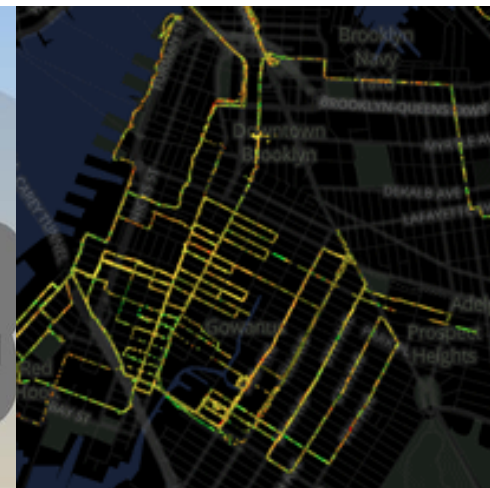
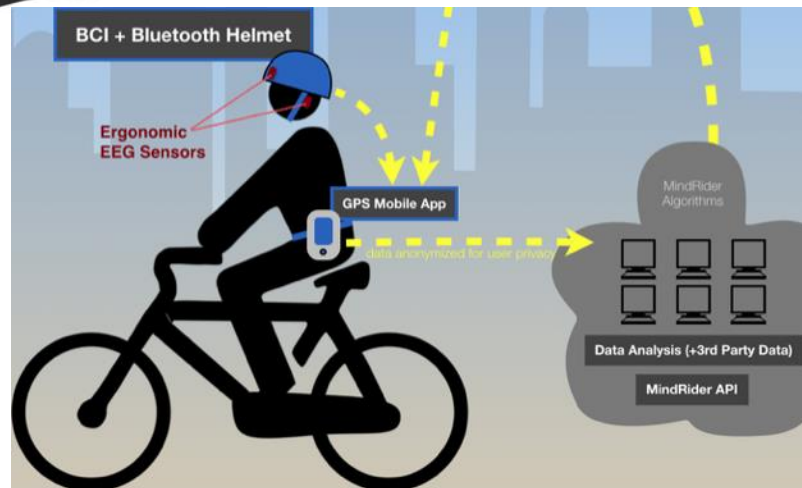
Social & Citizen Science: Equipment

◆ 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....



SITE CHARACTERIZATION AND GROUND INVESTIGATION APPLICATIONS



Trillium Compact Seismometers and ATOM Wireless Seismic Data Acquisition



Trillium Compact Seismometer (x6)

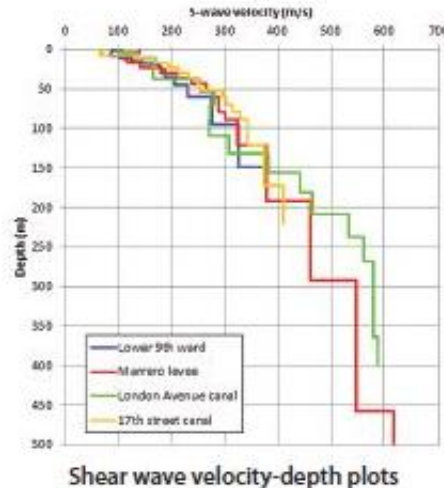


Centaur Digital Recorder (x6)

- ◆ Broadband seismometers (x6)
- ◆ Robust recorders (x6)
- ◆ Easy to use, easy to carry



ATOM wireless seismic data acquisition system (x24)



- ◆ Wireless seismic data acquisition system
- ◆ For: multichannel analysis of surface waves (MASW)
- ◆ Shear wave data up to 1km deep
- ◆ GPS controlled timing
- ◆ Retrieve data with WiFi

Ground Investigation: Equipment



Hand-held Smart Dynamic Cone Penetrometer



Basic Soil Sampling Kit



SilverSchmidt and RockSchmidt Hammer



Pocket Penetrometer

COMPUTING

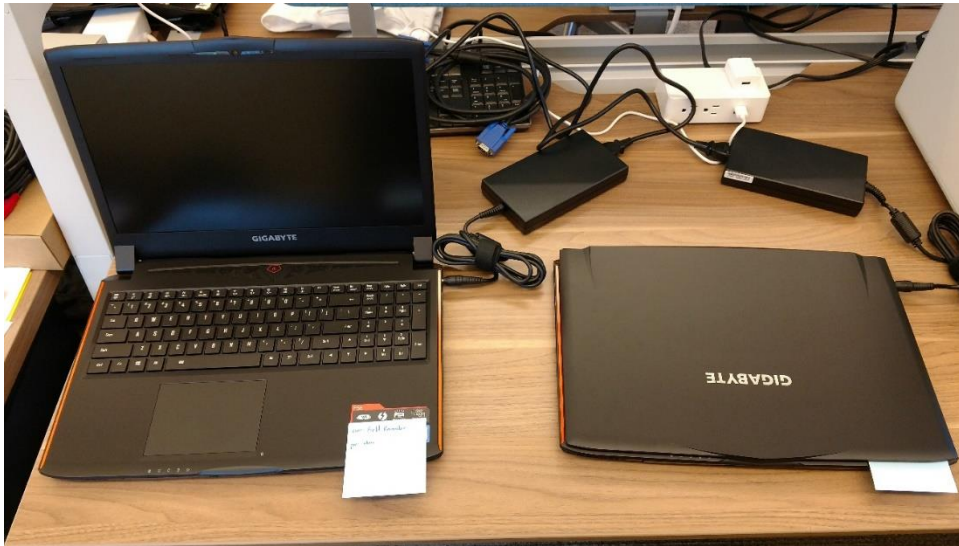


RAPID Computing



◆ Processing workstations (x2)

- Custom-built high end for point cloud processing



◆ Field Laptops (x6)

- High-end graphics cards for in-field verification of point-cloud data
- Some assigned to specific equipment (miniRanger, Z-Boat, etc.)

RAPID Computing



10.5-inch iPad Pro



256GB Wireless Stick



Tripod



HD Microphone



Tripod Adapter



External Battery



DJI Fly 2TB Drive

Processing software @ RAPID

- ◆ Leica Infinity – GNSS and total station processing
- ◆ Leica Cyclone and Register 360 – Laser scanning software
- ◆ Autodesk Recap – Laser scanning software
- ◆ Maptek I-Site Studio – Laser scanning software
- ◆ Terrasolid – Processing UAS lidar data
- ◆ Cloud Compare – open source point cloud processing
- ◆ Pix4D – Structure from Motion & UAS flight planning
- ◆ Agisoft Photoscan – Structure from Motion & UAS flight planning
- ◆ EmotivPro – EPOC+ EEG data collection software
- ◆ Custom processing programs to make data processing\analysis efficient and simpler – “the secret sauce”
- ◆ Additional instrumentation specific software
- ◆ Software available @ RAPID and on field laptops

Virtual Reconnaissance – Mini-CAVE



Virtual Reconnaissance – Mini Cave

