RAPID NHERI
Natural Hazards Reconnaissance

RAPID Applications for Large-Scale Experiments

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Operations Director

2020 UCSD/RAPID Joint Workshop

NSF Award Number: CMMI 1611820

Objectives

- Generate interest in using RAPID tools to support data collection in laboratory and field experiments…especially the UCSD shake table
- Get you thinking about how RAPID tools can help you learn more about your experiments
- Spur ideas for innovative measurement and processing methods
- Consider unconventional uses of RAPID equipment

RAPID Deployments to Experiments

- 2018: Capturing Wave Evolution with Lidar , PI: Adam Young (Scripps/UCSD)
  - Kelly Slater's Surf Ranch, California
  - Investigated lidar use for capturing wave evolution
- 2018: Light-Frame Wood Buildings, PI: Maria Koliou (TAMU)
  - E-Defense Shake Table Facility
  - Monitored progressive development of damage to structural and nonstructural components with consecutive ground motions
  - Lidar used extensively
- 2019: Reinforced Concrete Moment Frame, PI: Paolo Calvi (UW)
  - E-Defense Shake Table Facility
  - Monitored increasing cracking and spalling of reinforced concrete elements
  - used lidar extensively
- 2019: Blast Induced Liquefaction Experiments, Jonathan Hubler (Villanova)
  - New Zealand
  - Characterizing soil conditions before and after blast induced liquefaction
  - Lidar, MASW, seismometers

Key RAPID Equipment

- Lidar
  - Short Range: Leica RTC 360, BLK 360
  - Long Range: Maptek XR3/LR3, Leica P50
  - UAS mounted: Phoenix MiniRanger with a Riegle miniVUX
- UAS (many systems)
  - Photos
  - Video
  - Multispectra
- Accelerometers (Nanometrics Titans)
- MASW (Atom)
- Seismometers (Nanometrics Trillium Compact)
- What else is just waiting for creative applications?

The Leica P50 is RAPID's highest accuracy and precision scanner (and the best currently available). It is recommended for applications such as crack detection/quantification

Example Project 1: Reconnaissance of Large Volume Low Rise Buildings

PI's: David Roueche, Justin Marshall (Auburn U.)
Jeff Berman (UW)

NSF Awards: 1904653 and 1904327
DesignSafe Archived Data: https://doi.org/10.17603/ds2-3jpz-sk97

Hurricane Michael Background

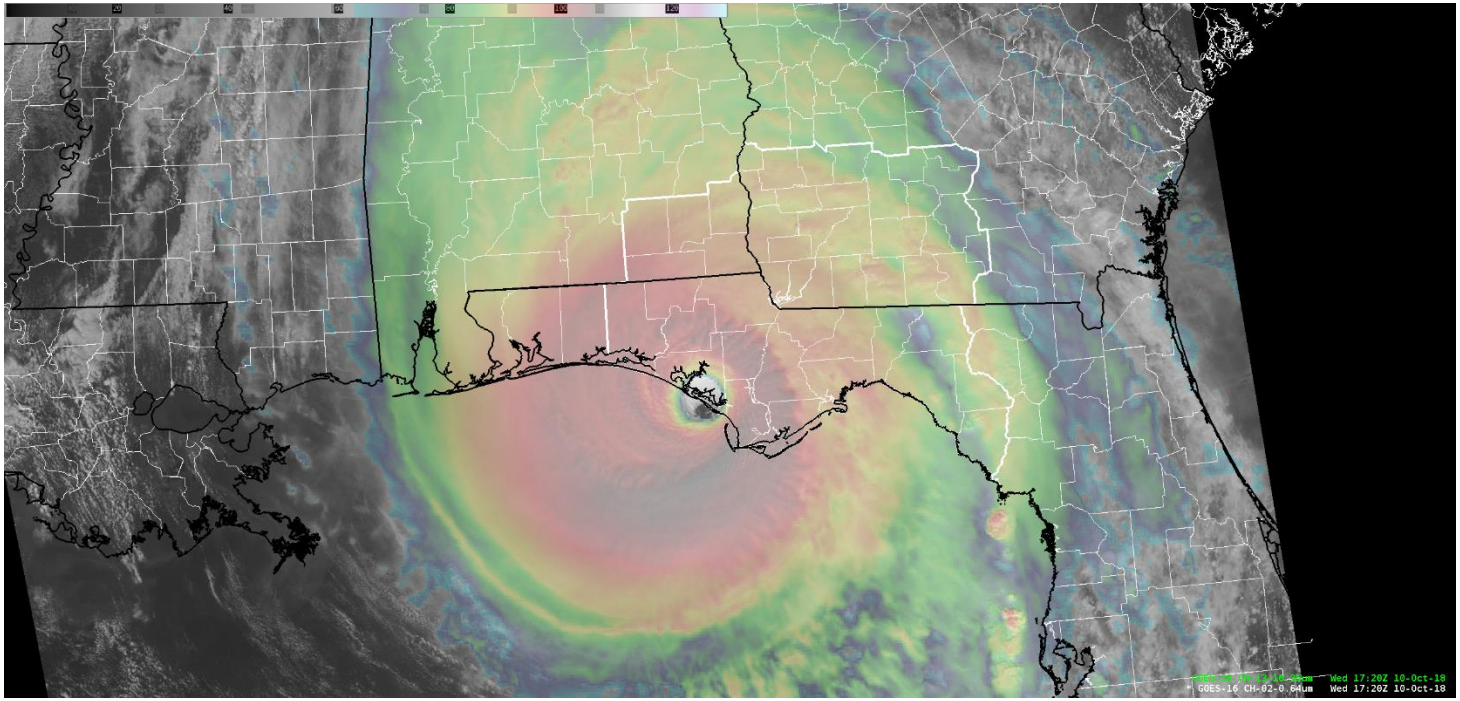


Image from NOAA

- Category 5 Hurricane
- Made landfall in the Florida panhandle on October 10, 2018
- Heavily impacted Panama City to Port St. Joe
- 3-Sec wind speeds up to 150+ mph, storm surge over 7 ft, and heavy rains

Reconnaissance Activities

- StEER Teams:
  - Virtual Assessment Team
  - Field Assessment Team
  - Reports produce very quickly: EARR and P-VAT
  - In the field about 5 days after landfall
- Observations made it clear that damage to large-volume low-rise buildings was significant
  - Warehouse type buildings
  - Potentially a much larger failure rate than expected
  - Seemed to be potentially similar failure modes
- RAPID proposal discussed with and submitted to NSF
  - In the field by November 5
  - Team included: Roueche, Marshall, Berman, and RAPID staff Jake Dafni and Sean Yeung

RAPID Equipment Utilized

- UAS:
  - DJI Matrice with Zenmouse X4s Camera
  - DJI Pantom Pro4
- Lidar:
  - Leica BKL 360
  - Maptek I-Site XR3
- GNSS receivers for ground control
- Leica Robotic Total Station
- Cameras
- IPads with RApp for collection of metadata
- Rapp packs with conventional reconnaissance equipment

Life in the Field

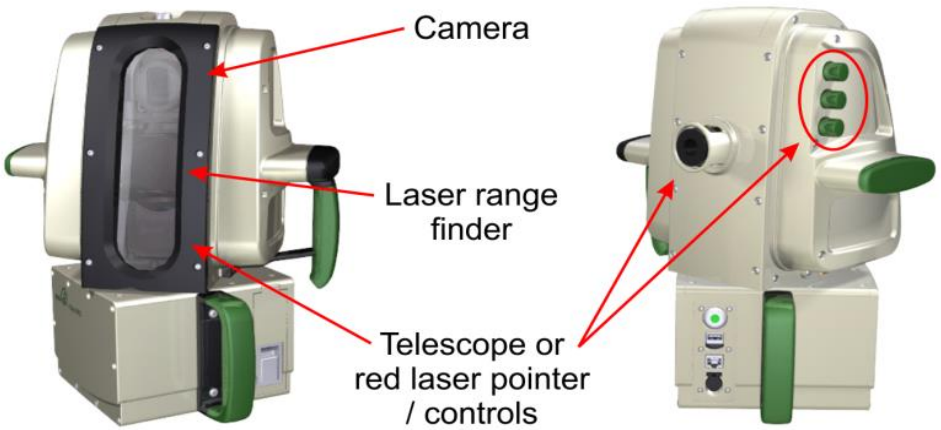
- Pre-7AM departures
- Long days at buildings sites:
  - Setup GNSS base station
  - Fly UAVs
  - Scan as much of the building as possible with both short range and long range scanners
  - Mark ground control with rover GNSS
  - Survey control points with the total station
  - Conventional (hand) measurements of key structural elements
- Scouting done to gain access to sites (usually Justin)
- Field work ends at or shortly after dark
- Dinner and data backup and battery charging until after midnight
- Note: This is a similar schedule to what we did at E-Defense!

Description of Lidar Systems: BLK 360

- Distance measurement system: High speed time of flight enhanced by WFD technology.
- Wavelength: 830 nm
- Field of view: 360° (horizontal) / 300° (vertical)
- Range*: min. 0.6 - up to 60 m
- Point measurement rate: up to 360,000 pts/sec
- Ranging accuracy*: 4mm @ 10m / 7mm @ 20m
- Measurement modes: 3 user selectable resolution settings

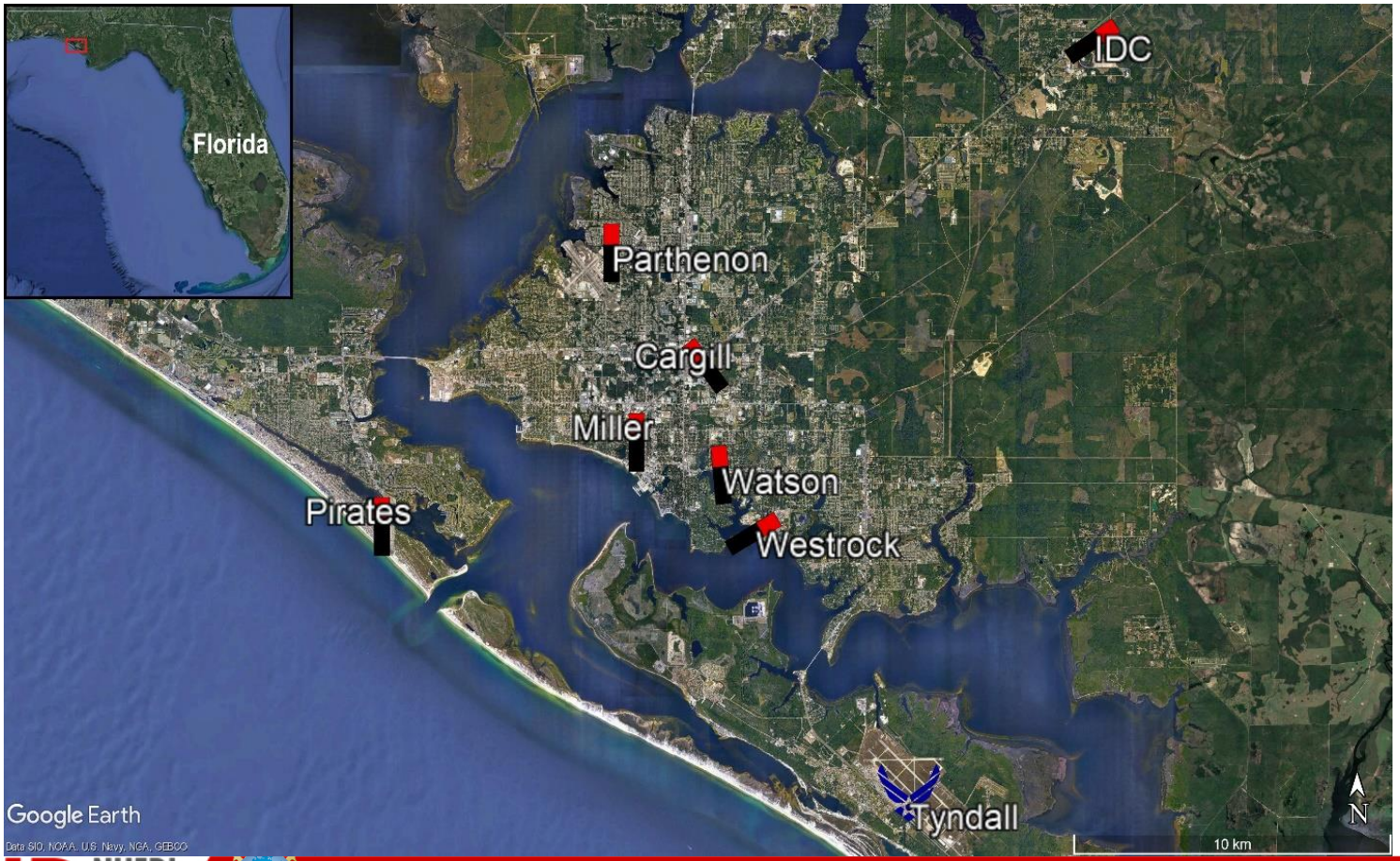
Description of Lidar Systems: XR3

- Maximum range: 2400m
- Minimum range: 2.5m
- Range accuracy: 5mm
- Repeatability: ±4mm
- Acquisition rate: 200 kHz 100 kHz 50 kHz
- Angular scanning range: 100° vertical (-40° to +60° with no camera), 360° horizontal.



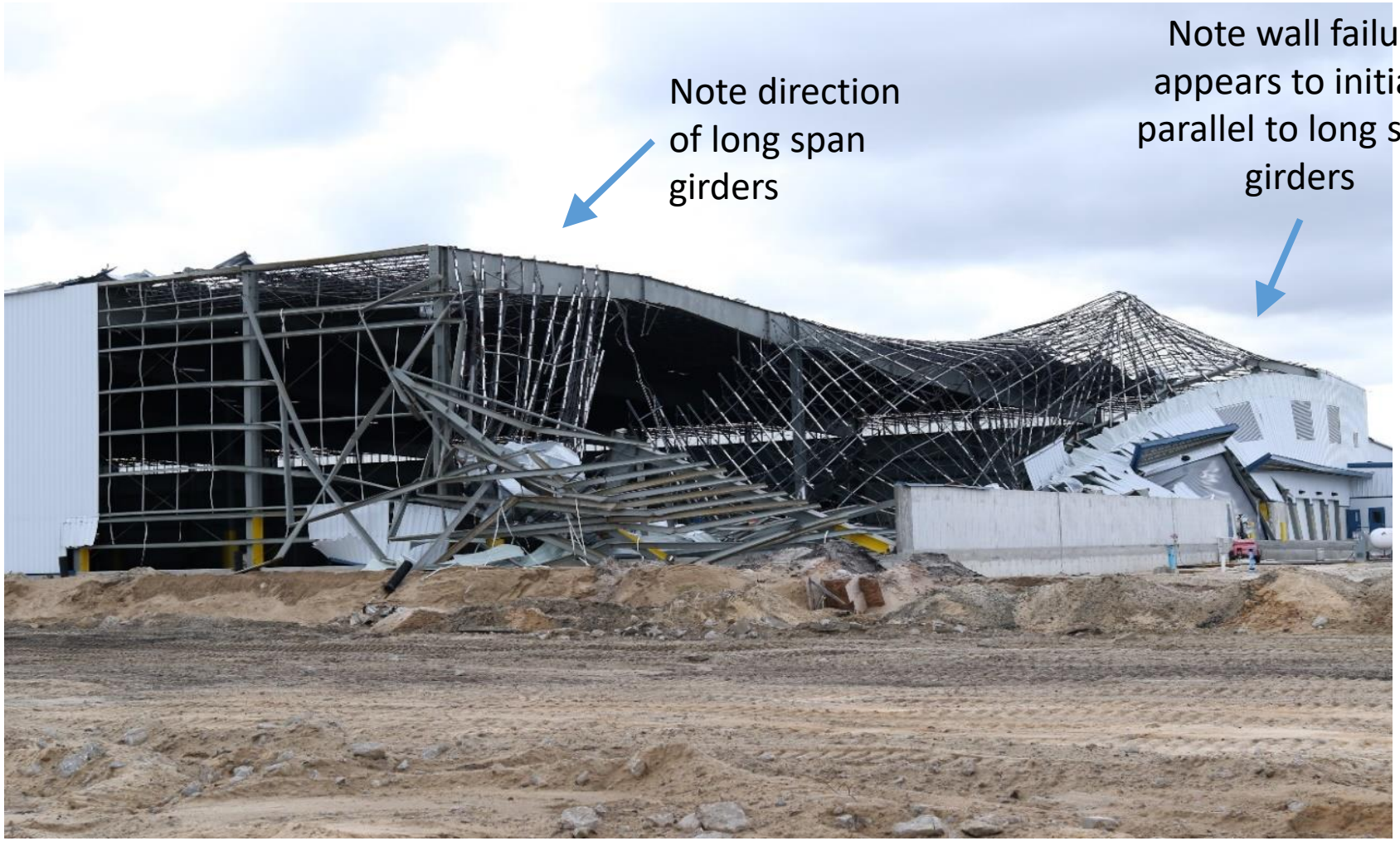
Buildings Visited

- Gathered data at twelve buildings
  - Data collected varied depending on access, time and other factors
  - Five were on Tyndall Air Force Base



Building Damage Examples

Building Damage Examples



Westrock East Terminal

Building Damage Examples

Watson Landings Marina

Building Damage Examples

Intermodal Distribution Center

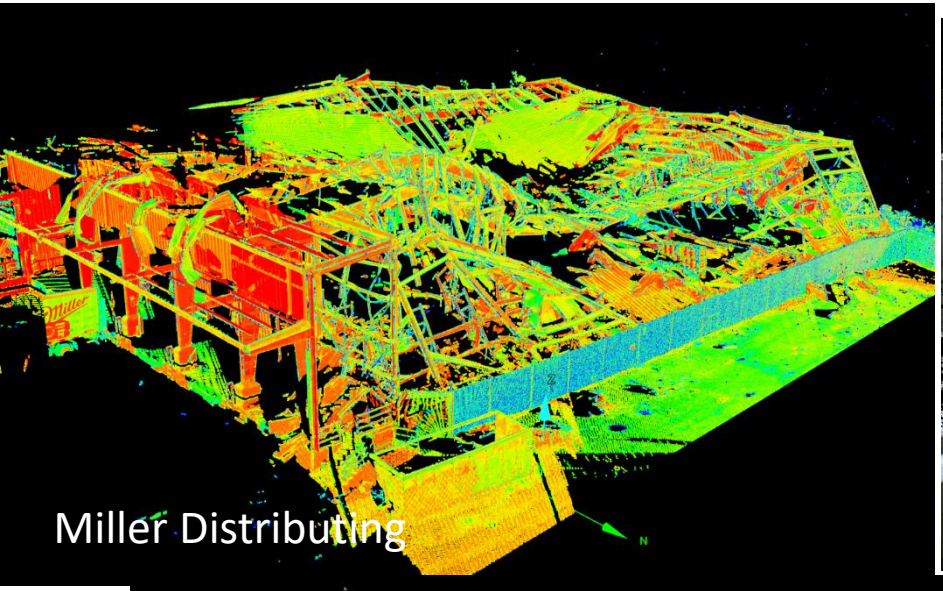
Building Damage Examples

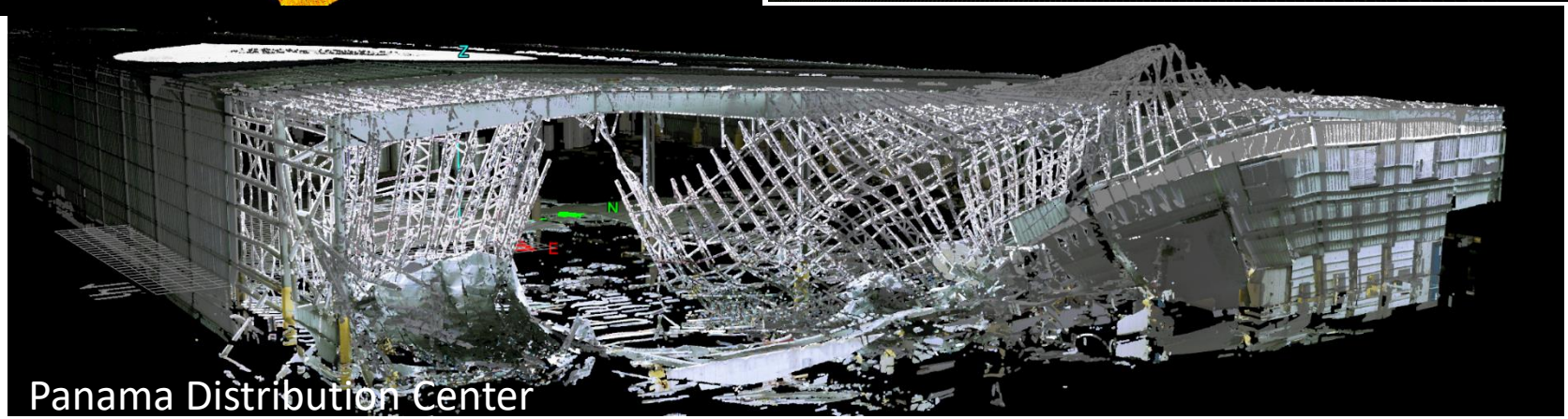
Miller Distributing

Data Processing

- Registration of lidar scans
  - Done without survey control at first
- Process UAS images for SfM models of exterior
  - Done with survey control at first
- Calculation of control points from GNSS and total station
- Update lidar registrations with control points
- Still to do:
  - Process SfM models with ground control
  - Combine lidar interiors with SfM exteriors
- Huge amounts of data and a lot of processing time

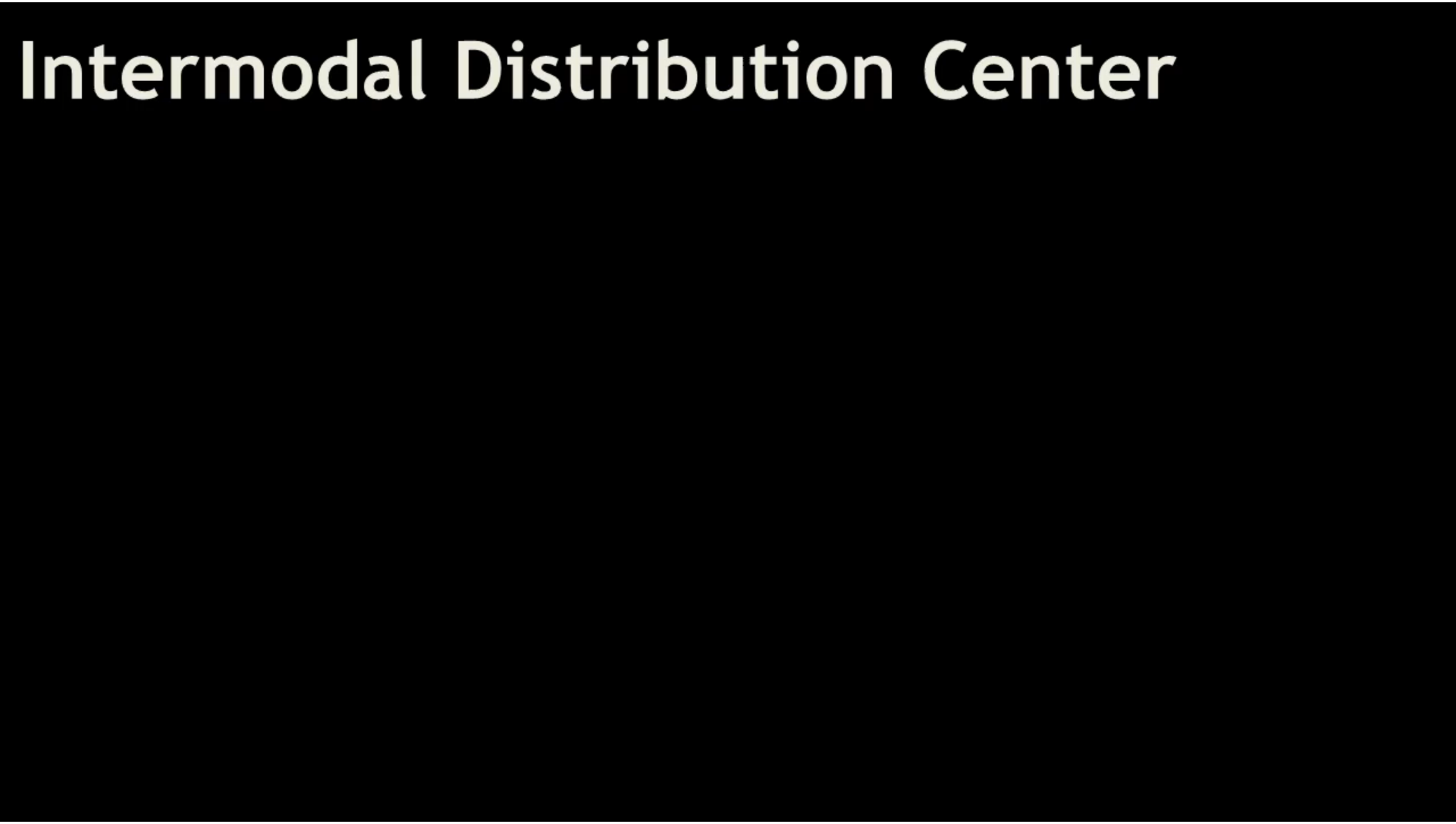
RAPID-Derived Data Products: Hurricane Michael Large Volume Buildings





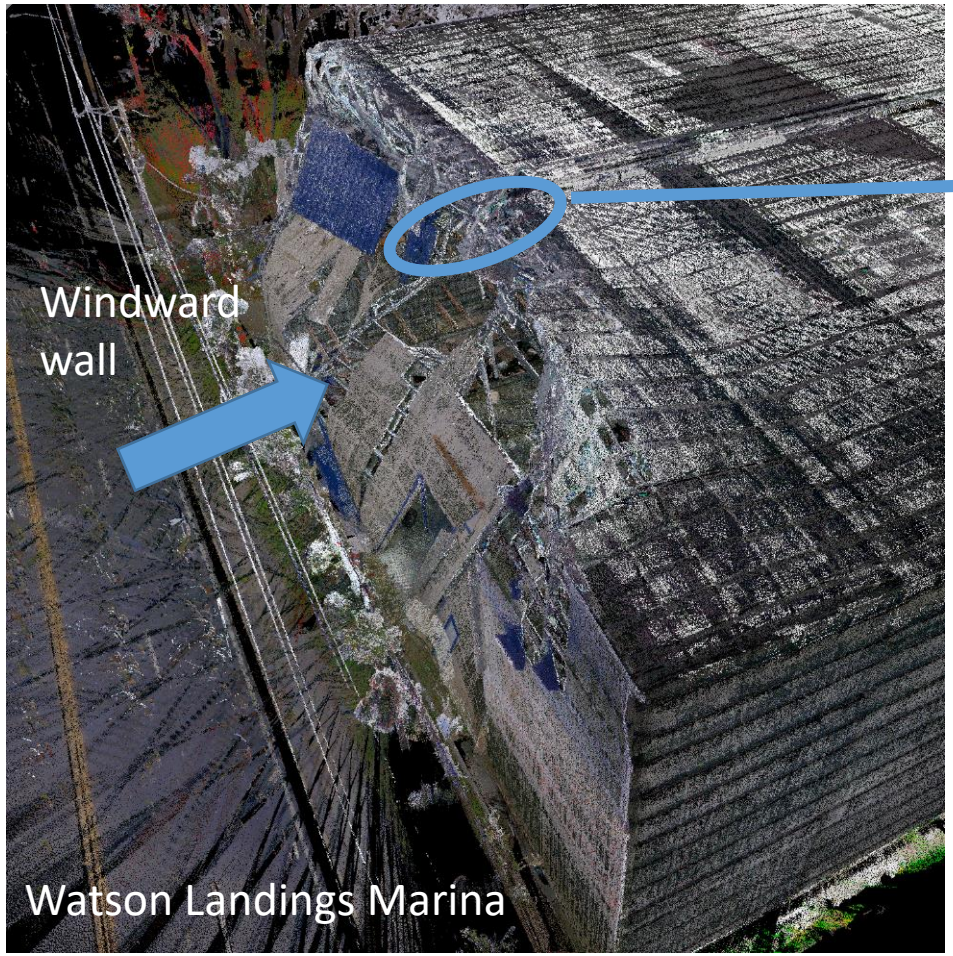
Data products: sub-cm level accuracy point clouds of 10 buildings with similar failure modes

Fly Through: Intermodal Distribution Center

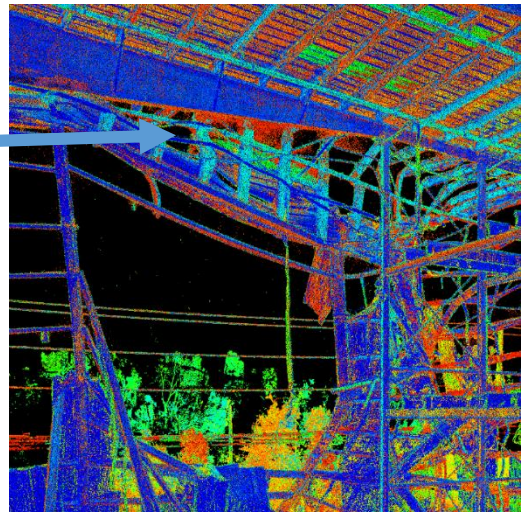


Fly Through: Watson Landings Marina

Mission Impact: Hurricane Michael Large Volume Buildings



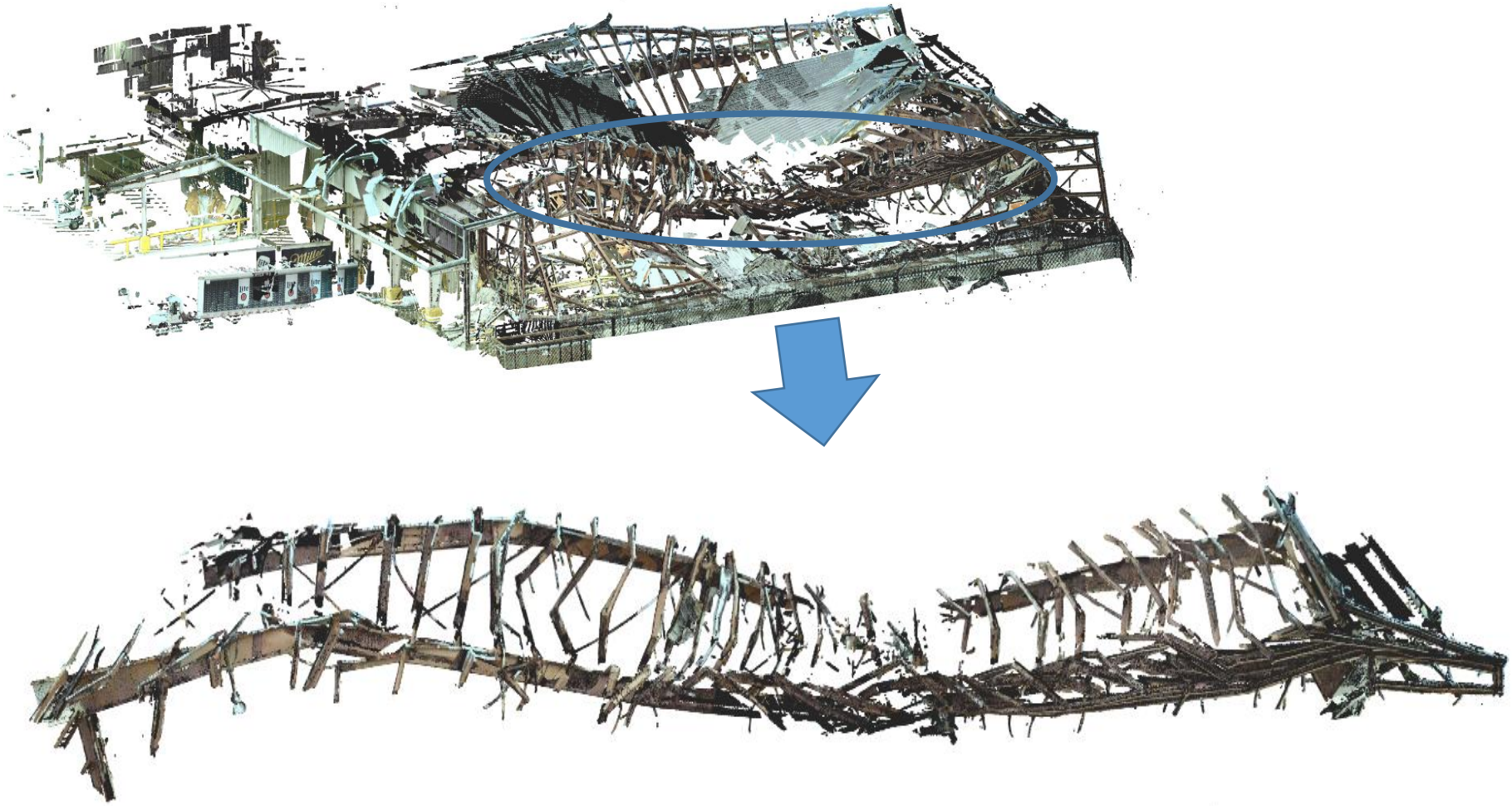
Discovery of a common failure mode for 12 large volume steel buildings



Roof purlins under large compression (from windward wall pressure) and bending (from uplift due to vortices)

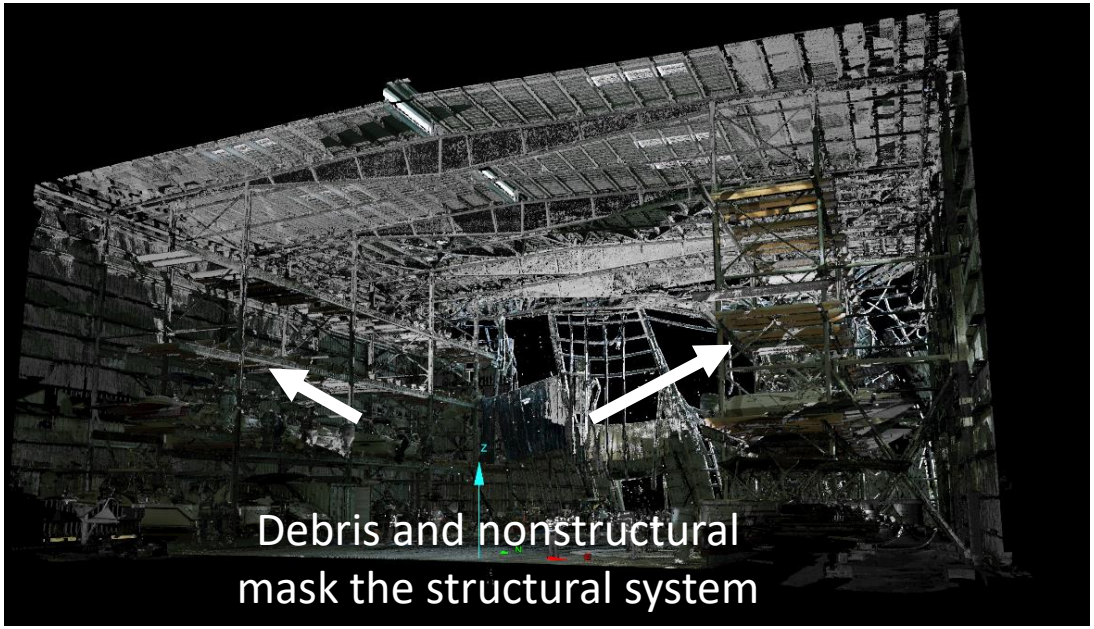
Purlins buckled and caused collapse of the windward wall frames. Occurred in all LVBs surveyed.

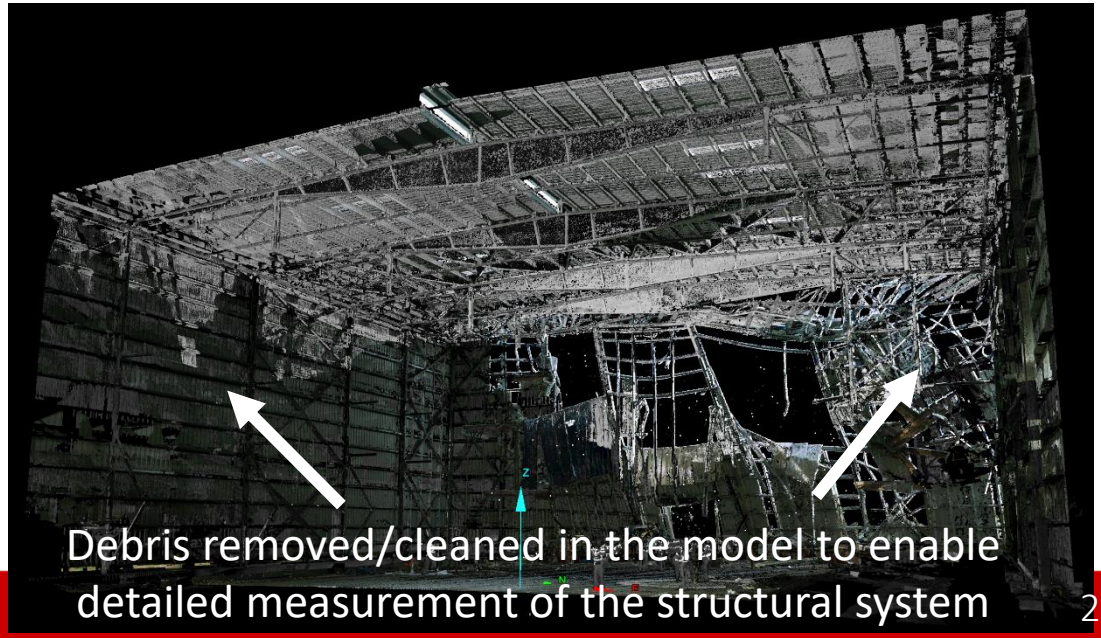
Mission Impact: Hurricane Michael Large Volume Buildings



Mission Impact: Hurricane Michael Large Volume Buildings

- Informing models and performance assessment
  - Developing computational models of the buildings to estimate demands under hurricane loading
  - Comparing demands with design demands to address potential code changes
- Potential impact on design codes
  - Uplift pressures at windward edge of large volume buildings appears larger than current design forces
- Inspiring research
  - Considering proposals under for larger projects to solve the large-volume building problem





Example Project 2: E-Defense Deployment for Light Frame Timber Building Tests

PI's: Maria Koliou (TAMU), Keri Ryan (UNR)
Shideh Dashti (CU)

NSF Award: 1829433
DesignSafe Archived Data: Coming soon

Mission Highlight: E-Defense Shake Table Test (RAPID Grant)

RAPID-user interactions

- PI Koliou (Texas A&M) developed the proposal following NHERI-E-Defense meetings

- Collected recon. type data from large-scale experiments on two wood frame houses at E-Defense

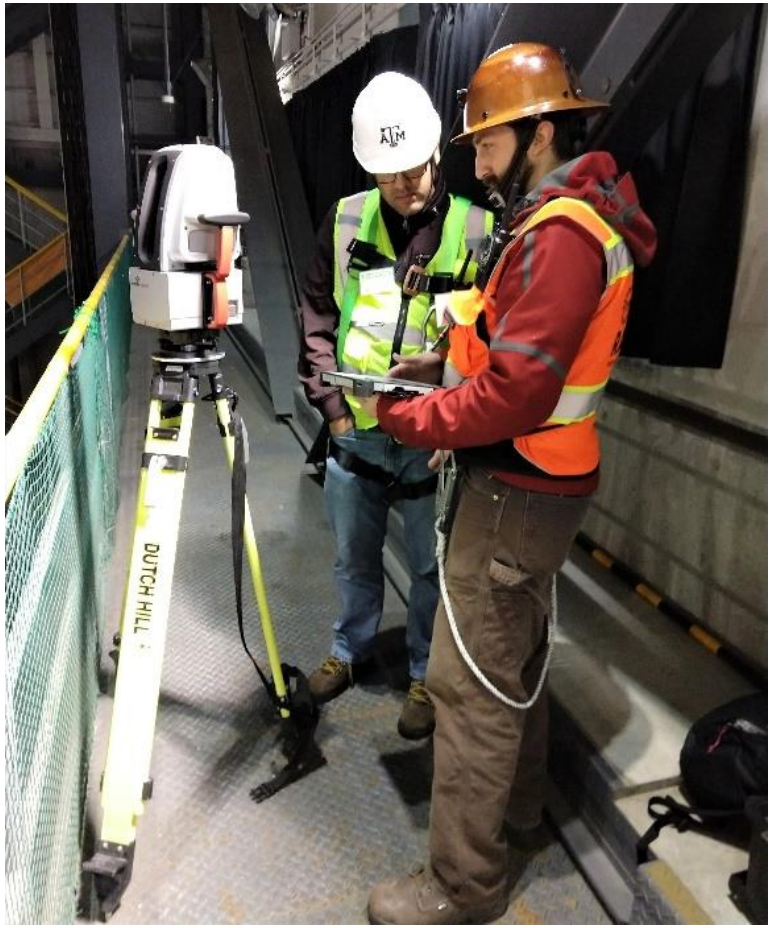
- Accommodated a tight window for deployment dictated by the Japanese research team

- Trained large team of researchers both at E-Defense and at UW before deploying

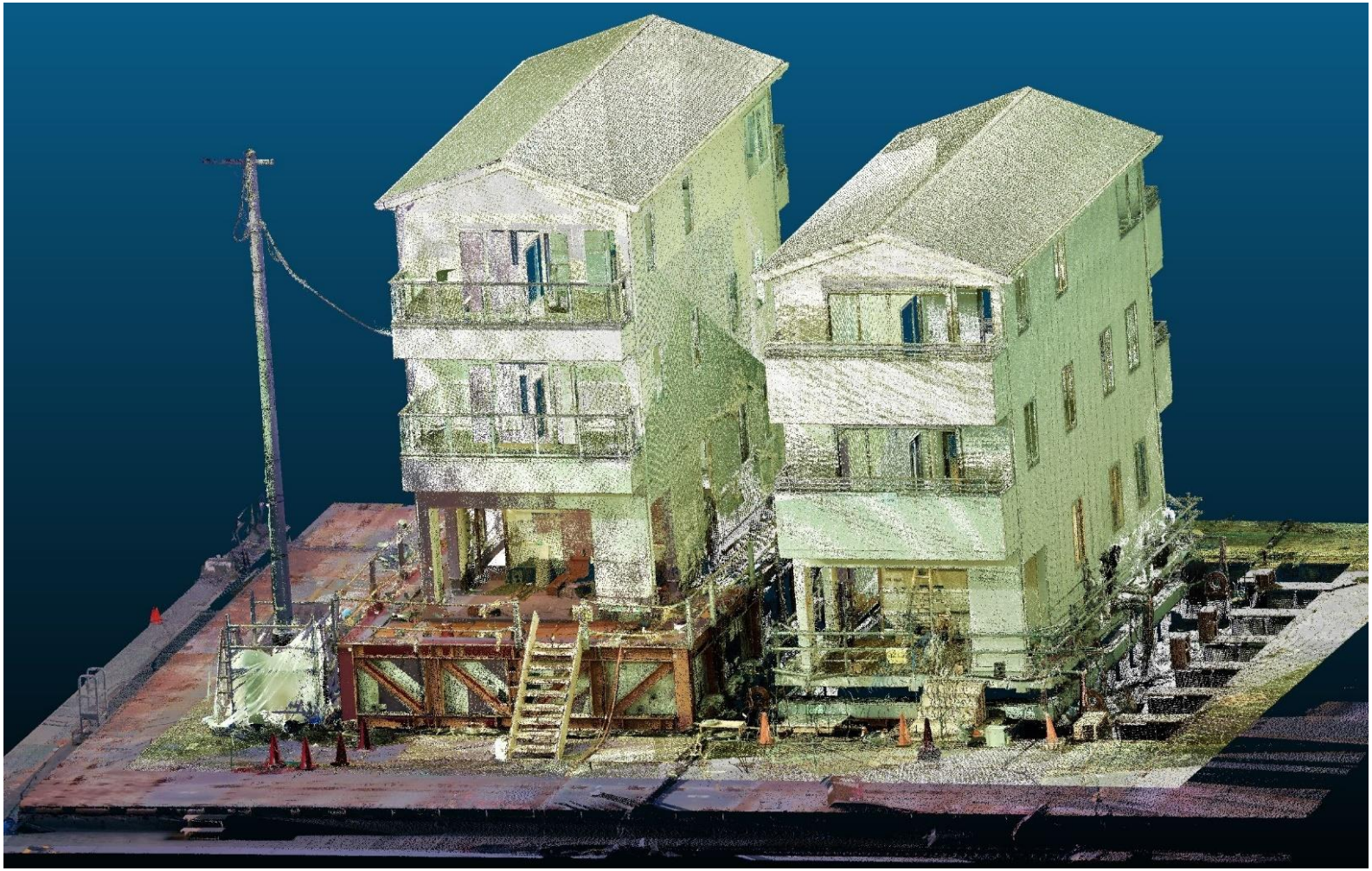
- Deployed RAPID staff along

RAPID Equipment Utilized

- Lidar:
  - Leica BKL 360
  - Maptek I-Site XR3
- Leica Robotic Total Station
- Cameras
- IPads with RApp for collection of metadata



RAPID-Derived Data Products: E-Defense Shake Table Test (RAPID Grant)



Data products: sub-cm level accuracy point clouds of the two buildings before testing and after each of 6 ground motions

Mission Impact: E-Defense Shake Table Test (RAPID Grant)

Damage progression to nonstructural components measured to sub-cm accuracy for the entirety of the two buildings

Discovered residual building torsion not observed in the conventional instrumentation

Example Project 3: Wave Characterization with Lidar

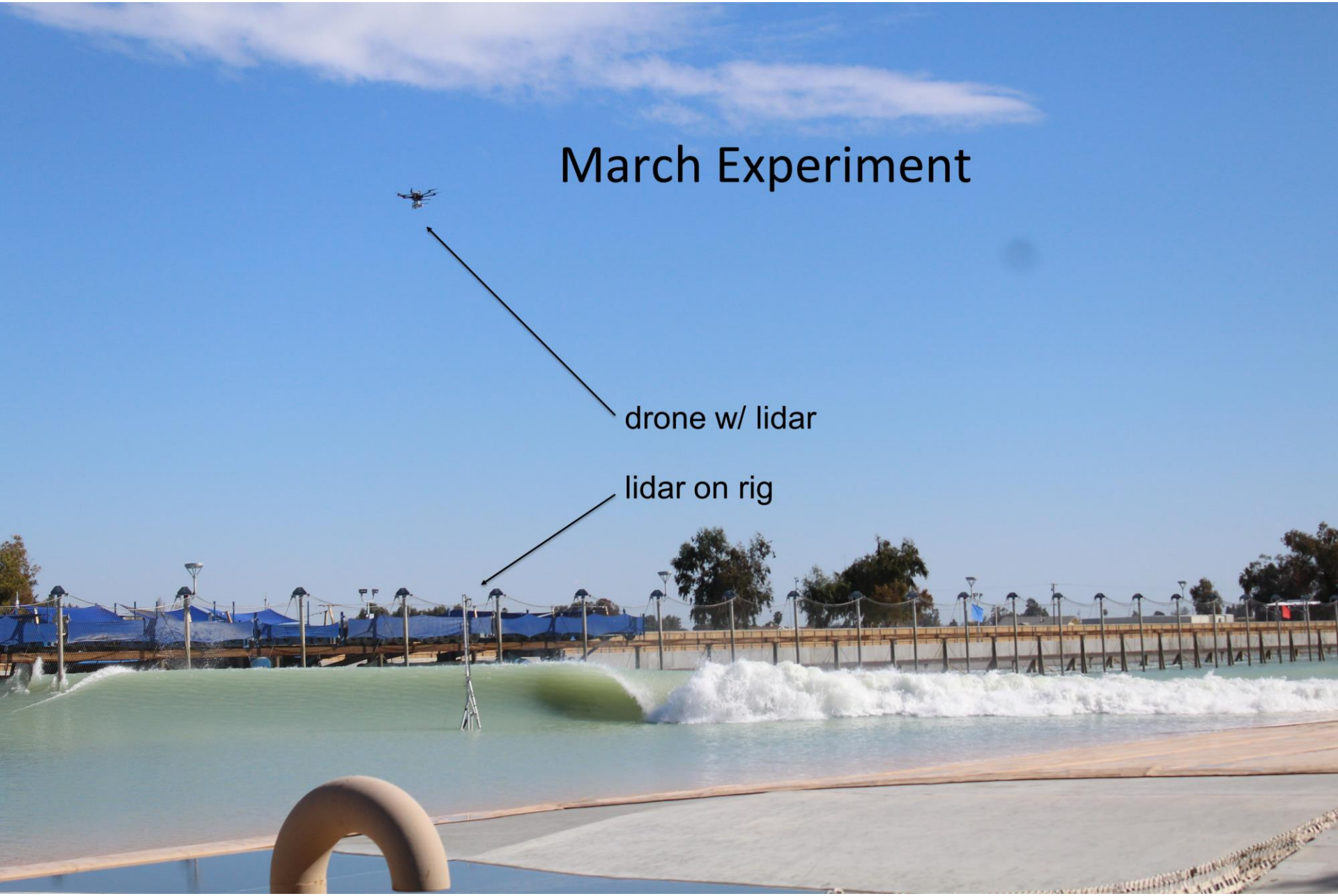
PI's: Falk Federssen (UCSD/Scripps),
Adam Young (UCSD Scripps)

Mark Walk Wolfinger
Surf Zone Processes Research Fund

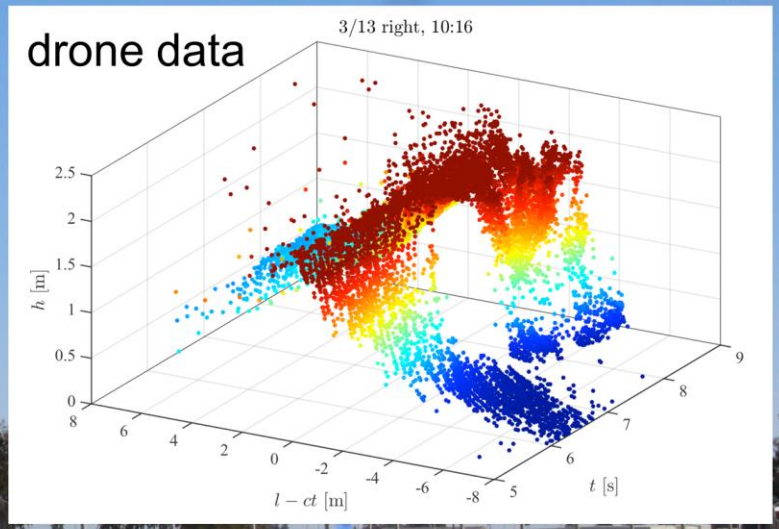
SCRIPPS INSTITUTION OF OCEANOGRAPHY

The Campaign For
UC San Diego

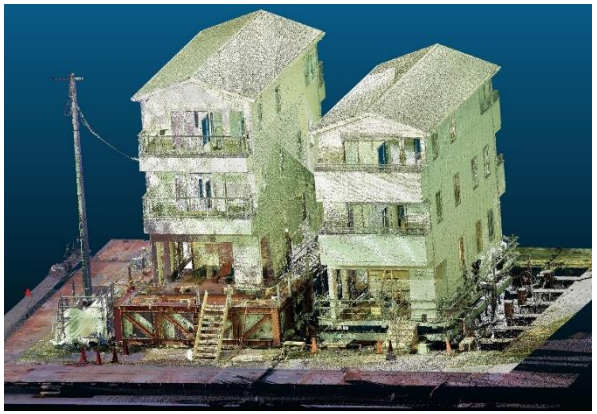

MiniRanger UAS with Lidar


March Experiment
drone w/ lidar
lidar on rig

March Experiment



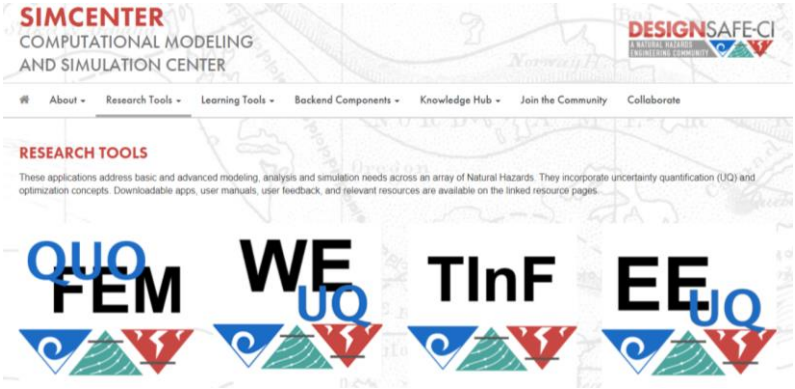
Field Observations



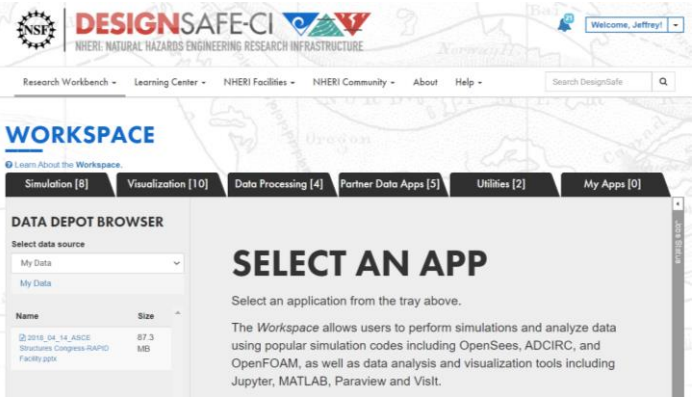
Laboratory Experiments

Solutions for Grand Challenges in Natural Hazards Engineering

Development of Simulation Tools



Computational Resources and Data Sharing



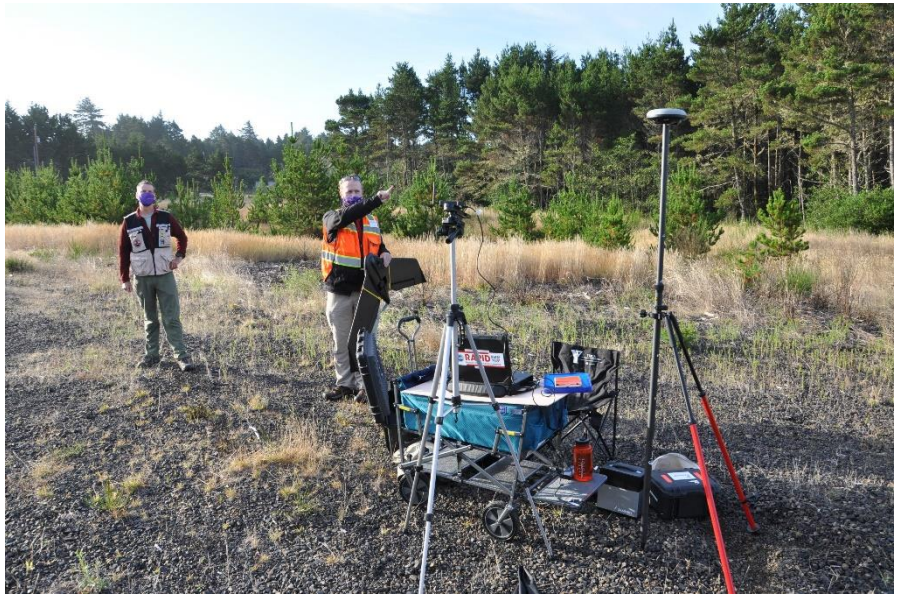
Example Project 3: CoPe EAGER: Coastal Hazard Planning in Time

PI's: Daniel Abramson, Bo Zhao, Harold Tobin, Ann Bostrom, Jeff Berman (UW)

NSF Awards: 1940024
DesignSafe Archived Data: Coming Soon

RAPID Equipment Utilized

- UAS:
  - DJI Matrice with Zenmouse X4s Camera
  - DJI Pantom RTK
  - Ebee Sensefly Fixed Wing
- Lidar:
  - Leica RTC 360
- GNSS receivers for ground control
- NCTech Streetview
  - Car and bike mounts
- Cameras
- IPads with RApp for collection of metadata
- Rapp packs with conventional reconnaissance equipment



Creating a Digital Twin of a Coastal Town

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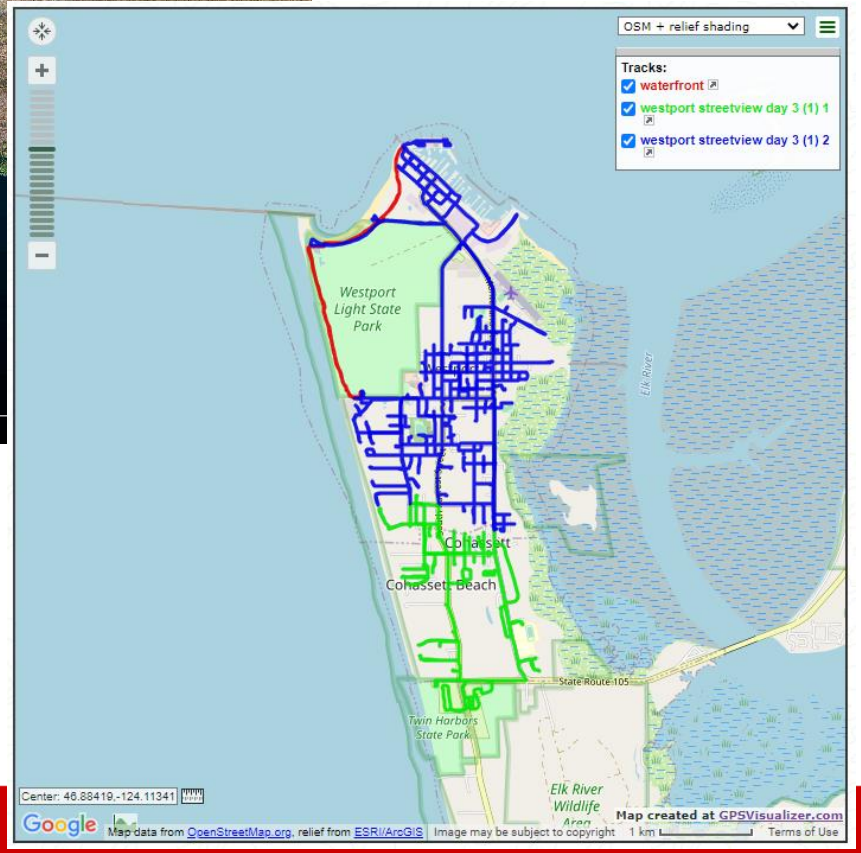

Thank You

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