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# Applicability of Photogrammetry for Inspection and Monitoring of Dry-Stone Masonry Retaining Walls

Alexandra Hain, PhD, Assistant Research Professor, University of Connecticut
Arash E.  Zaghi, PhD, PE, SE, Associate Professor, University of Connecticut

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# Presentation Outline


Research Motivation


Field Trials

Future Work

[1] "Photos of buildings with heavy damage." *EERI*, 12 Jan. 2010, http://learningfromearthquakes.org/2010-01-12-haiti/images/2010_01_12_haiti/photos/DSC_0047_2_resize.jpg/.

# 1 Background & Motivation

- Dry-stone masonry retaining walls are built by interlocking stones without mortar.
- Lack of cohesion allows for internal deformation and sliding between the stacking planes.
    - Prone to **bulging and leaning**
- Assessed by visual inspections and traditional surveying tools.
- The unpredictable behavior of this type of wall can lead to maintenance problems and need for monitoring

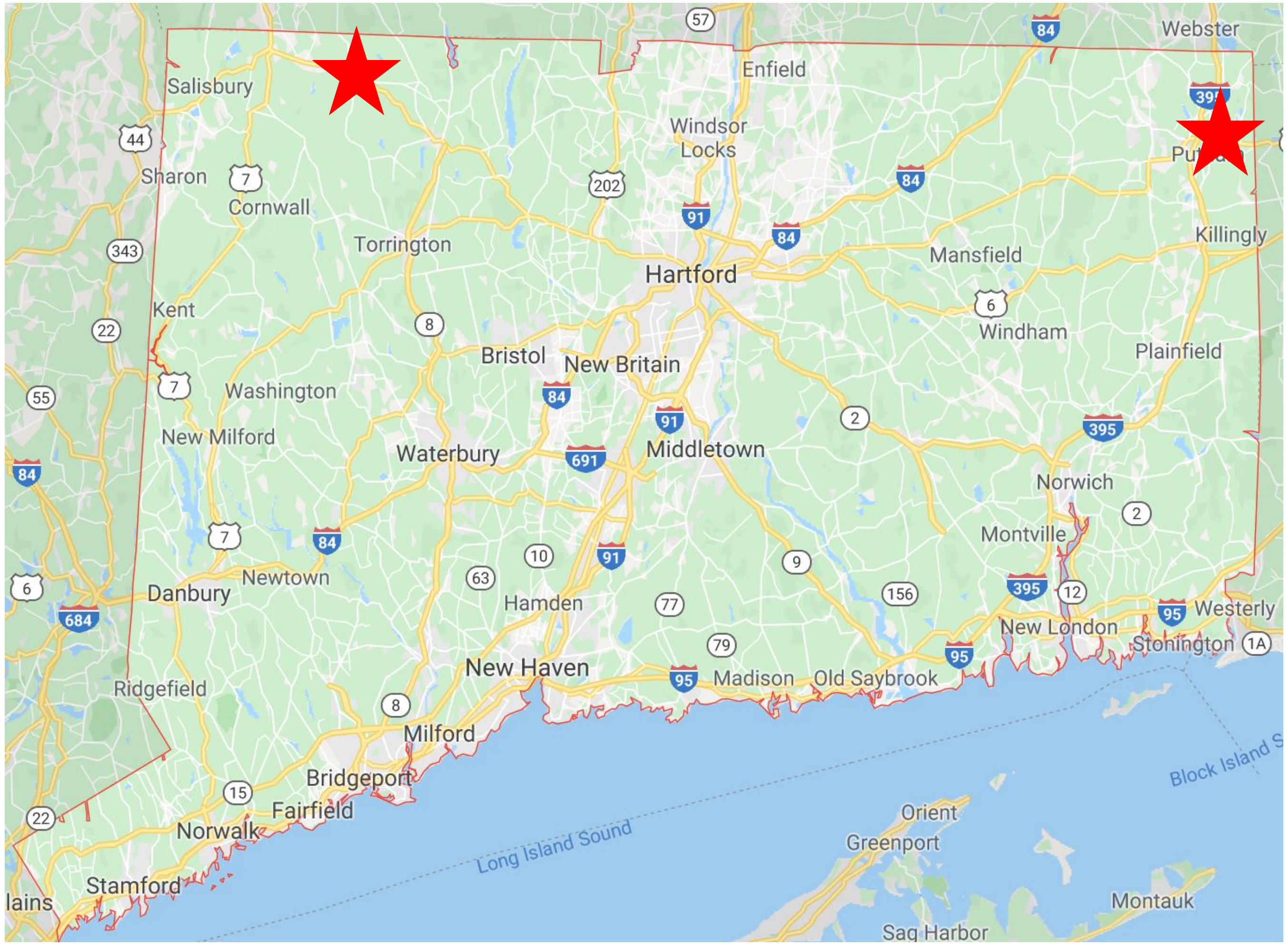


[1] "Photos of buildings with heavy damage." *EERI*, 12 Jan. 2010, http://learningfromearthquakes.org/2010-01-12-haiti/images/2010_01_12_haiti/photos/DSC_0047_2_resize.jpg/.

[2] Eschenasy, D., *Condition Assessment of Old Stone Retaining Walls*. 2015, STRUCTURE magazine.

# 2 Field Trials – Overview

- Two field trials were conducted on masonry retaining walls.
- Both walls had areas of concern (bulge and/or tilt).
- Trail 1: Norfolk, CT
  - ~45 m (150 ft) long
  - Maximum height of ~4.5 m (15 ft)
- Trail 2: Putnam, CT
  - ~ 90 m (295 ft) long
  - Maximum height of ~9 m (30 ft)

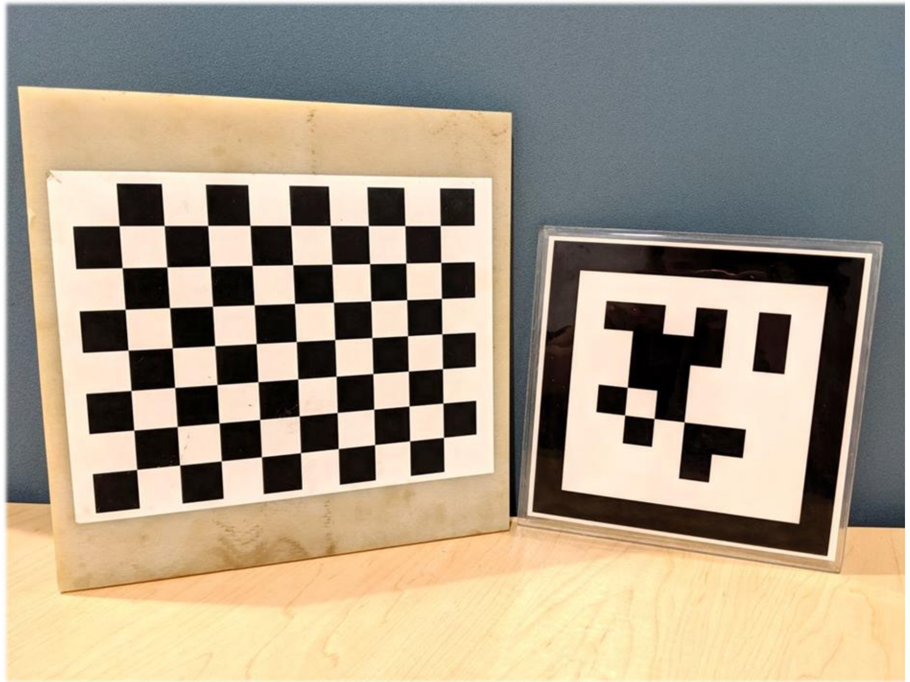


# 2 Field Trials – Equipment

Equipment used included:

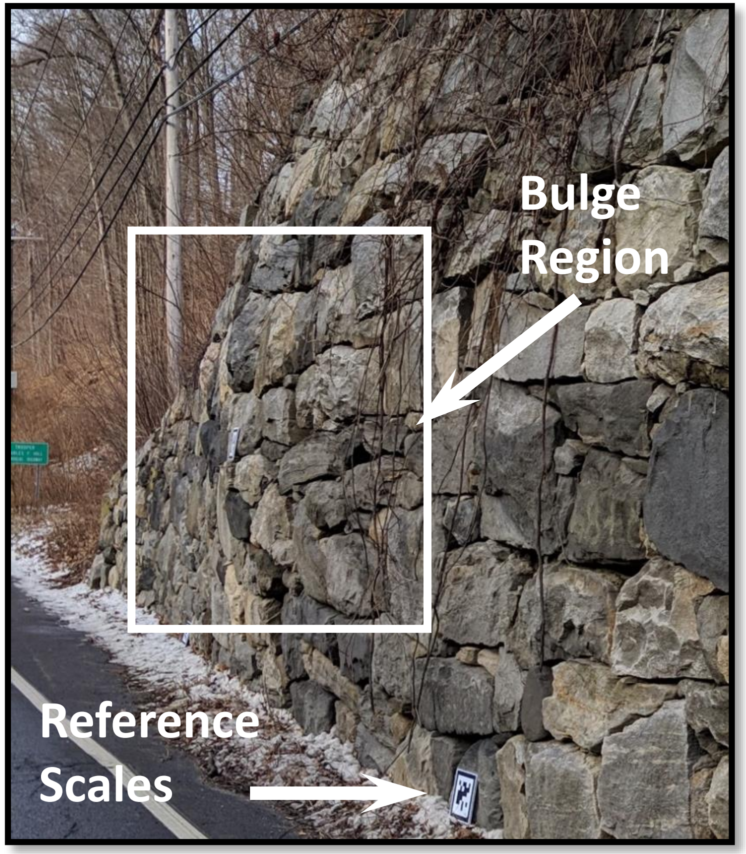
- Sony a7RIII (42-megapixel 25-mm full-frame sensor)
- Low-distortion Zeiss Batis 2/25
- Godox flash

RealityCapture software was used for model generation

# 2 Field Trial 1

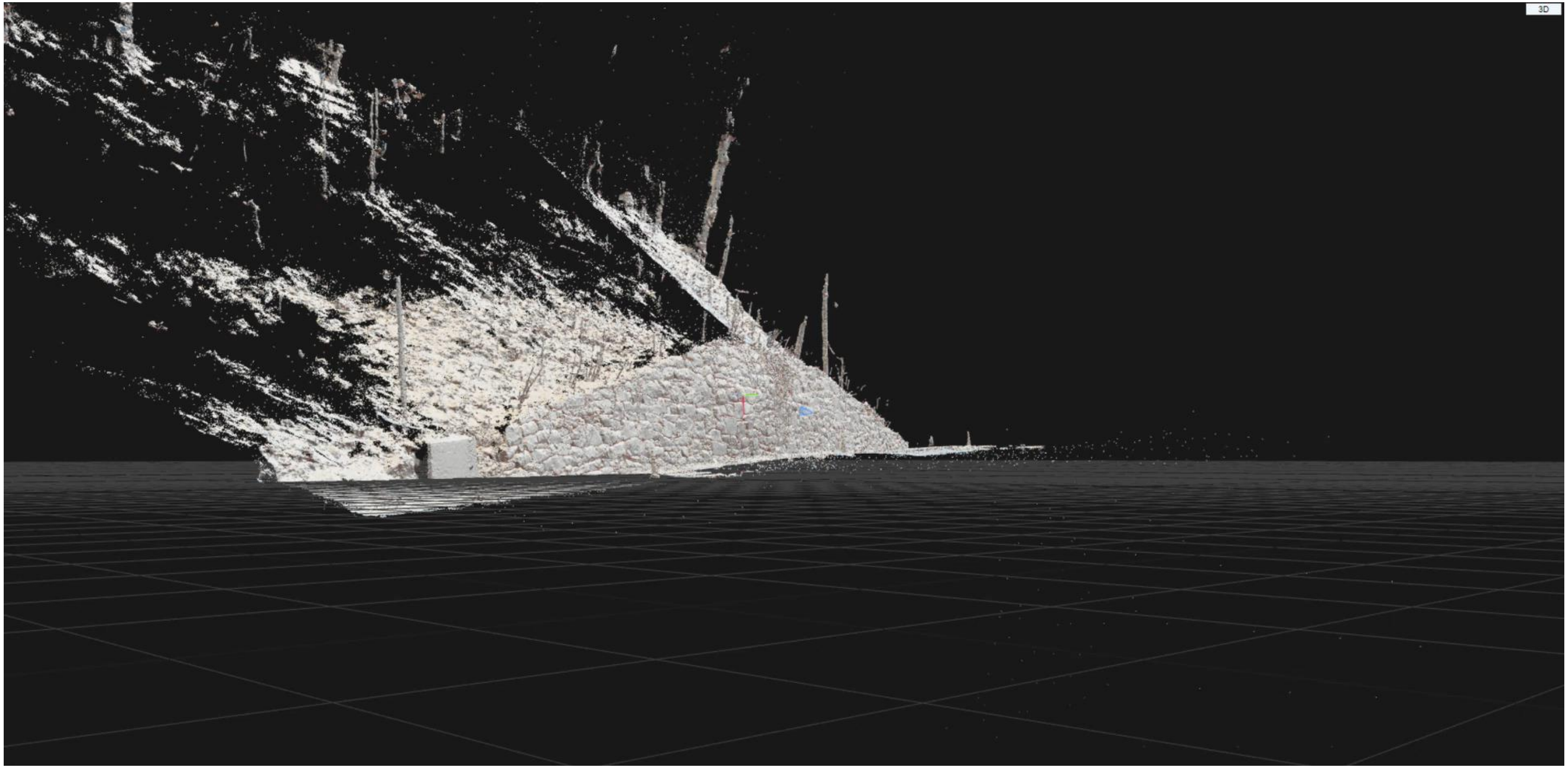
Focus: Determine if the wall was actively bulging following heavy rain.




# 2 Field Trial 1

- Data collection took ~1 hour with ~850 images collected
- The final models:
  - Represented an area of ~150 $m^2$ (1,615 $ft^2$)
  - Consisted of >4 million vertices
  - Exported to a ~1 GB mesh

# 2 Field Trial 1



# 2 Field Trial 1

Sample view of 3D model with color applied

# 2 Field Trial 2

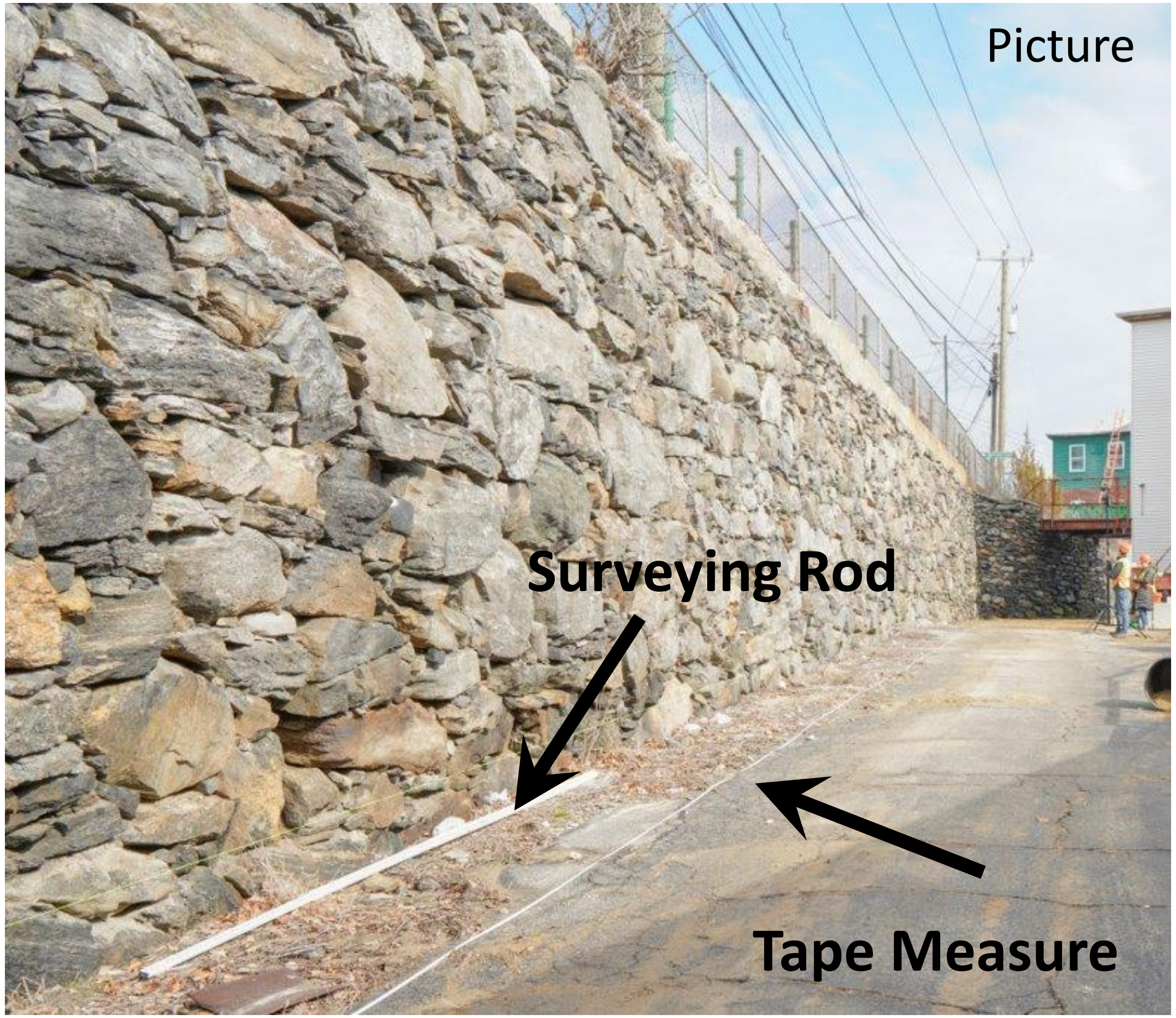
Focus: Obtain condition of retaining wall following fire hydrant burst.


# 2 Field Trial 2

- Data collection took ~2 hours with ~1,250 images collected
- The final models:
  - Represented an area of ~600 $m^2$ (6,500 $ft^2$)
  - Consisted of ~30 million vertices
  - Exported to a ~5 GB mesh

# 2 Field Trial 2

# 2 Field Trial 2




# 2 Field Trials – Key takeaways

The accuracy, quality, and completeness of the 3D model generated from photogrammetry is dependent on serval factors including:

- Coverage
  - Overlap, pictures from different orientations, pictures from different distances
- Scale references
- Lighting- flash helps
  - Particularly with changing environmental factors

# 3 Post-Processing

Having the 3-D model allows for further processing compared to traditional surveying methods including:

- Section cuts
- Color maps to show changes in movement over time
- Color maps to highlight bulges
- VR visualizations

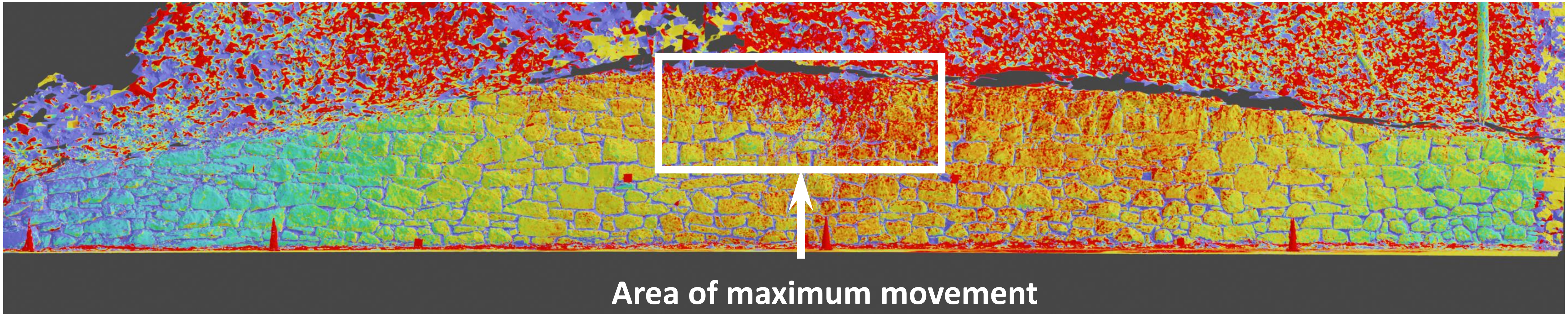
RealityCapture

Artec 3D

blender®

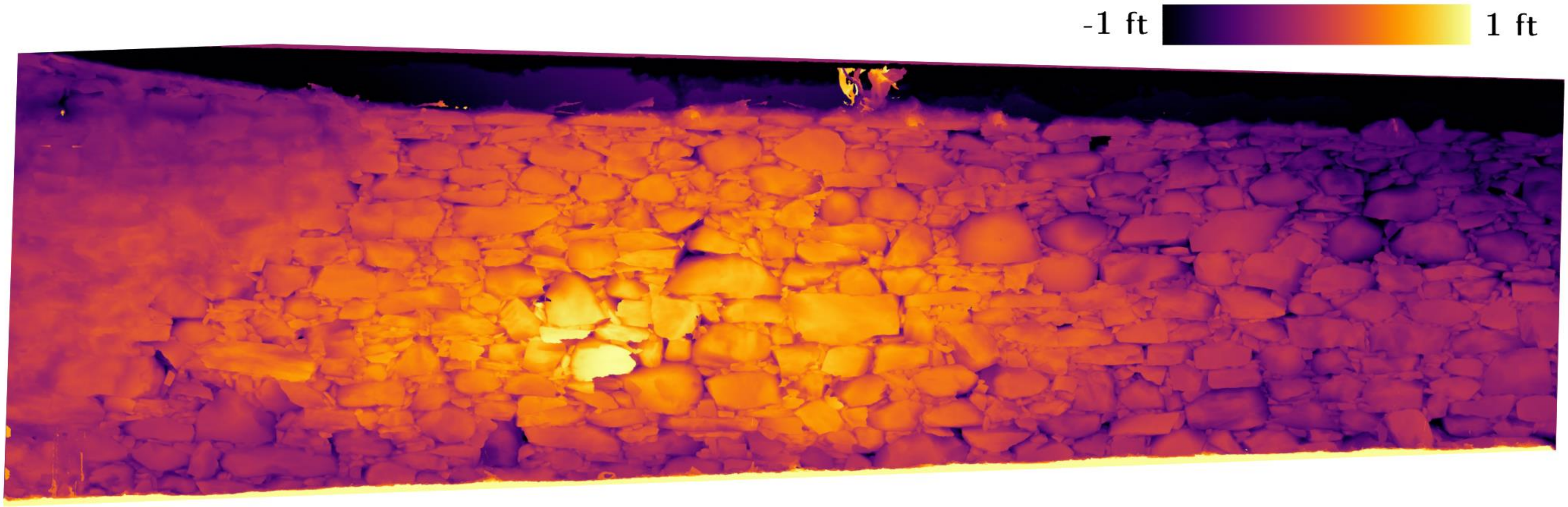
# 3 Post-Processing – Field Trial 1

- Overlaying 3D models from data collected at different times allows engineers to **visualize the rate of movement**.
- This helps to **anticipate future rehabilitation needs**.



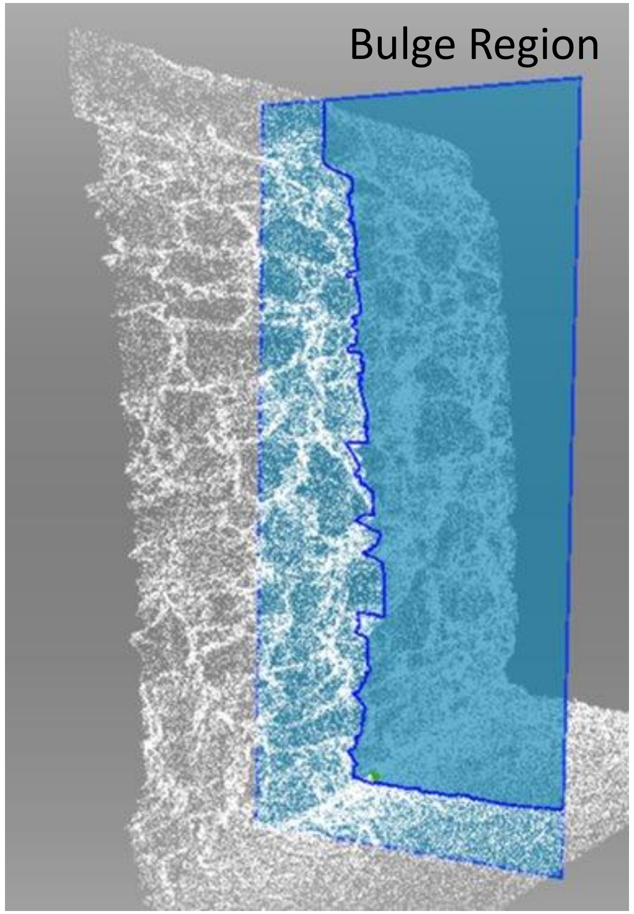
# 3 Post-Processing – Trial 2

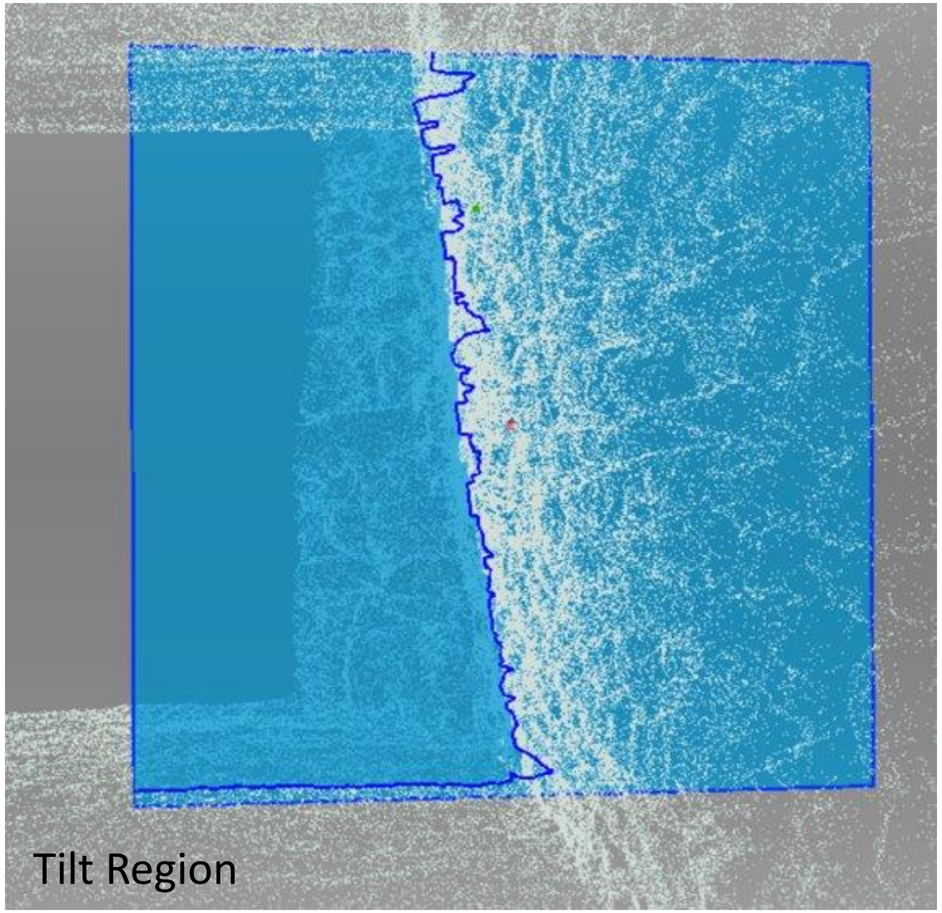
- Color mapping can also be used to show the severity of the bulge.



# 3 Post-Processing – Field Trial 2

- Section cuts can be used to highlight areas with bulging and tilting.
- This model shows a point cloud representation that had been down sampled



# 4 Summary & Conclusions

- Photogrammetry can be used to produce <u>**accurate 3D models**</u> of masonry retaining walls.
- Using photogrammetry in subsequent inspections would provide an <u>**enhanced method to track movement**</u> over time both at the local and global levels.
- Accurate 3D models of in-situ conditions enable engineers to make <u>**informed decisions**</u> regarding the need for <u>**repair, replacement, or increased monitoring**</u> of structures.

# 5 Concurrent Work– Corrosion Assessment

# 6 Acknowledgements


- FHWA and CTDOT Project SPR-2310
- The help of Jim Mahoney, Michael McDonnell, Leo Fontain, Aron Steeves, Scott Bushee, Sara Ghatee, Robert Pion, and Mathew Calkins in coordinating field trials
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# Thanks! Questions?

Alexandra Hain, PhD
Assistant Research Professor
University of Connecticut
alexandra.hain@uconn.edu

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