CHEI
CULTURAL HERITAGE ENGINEERING INITIATIVE

ALERTCalifornia

UC San Diego

Politecnico di Torino
Dipartimento di Architettura e Design

Salvation Mountain

October 25th, 2023
Niland, California

Field Report prepared December 20th 2023

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John Driscoll

Expedition Overview:

Salvation Mountain is a widely acclaimed American folk art installation of national significance, built by Leonard Knight over a 30 year period from 1984 until his death in 2014. It includes an area of approximately 9.5 square kilometers, an artificial slope rising approximately 11.5 meters, creating a vista overlooking the Salton Sea (west) and Slab City (east). Atop the slope stands a large wooden cross rising another 7.5 meters above the adobe construction. On the southern side of the mountain are several interior chambers: the *hogan,* a Navajo term for a mud covered dwelling, consisting of 3 chambers, and the *museum,* a 10 meter high church-like structure which was also temporarily closed awaiting restoration work. The structures are composed of bales of straw and locally sourced clay, covered in latex paint, which is periodically reapplied. Various other framing materials are employed to shore up the walls, including pipes, telephone poles, ladders, branches, and full trees. Across this area are a number of sculptures and vehicles, painted and decorated in the same style. The site is currently preserved by Salvation Mountain Inc, a non-profit entity charged with supporting the restoration and conservation of the compound, directed by the on-site groundskeeper and restorer Ron (no last name given).

Following hurricane Hillary in August of 2023, The site had suffered minor damage to the painted facade, and some significant erosion on the eastern slopes behind the mountain, causing temporary closure of the access path running along the back eastern slope. Another major storm had occurred some three years before. Such storms are rare in this desert region, and can cause significant flooding and soil erosion. Staff working for the Cultural Heritage Engineering Initiative (CHEI) and AlertCalifornia at the University of California San Diego (UCSD) and visiting members of the Department of Architecture and Design (DAD) of the Polytechnic University of Turin, Italy, (PoliTo), reached out to Bob Levesque at Salvation Mountain Inc. to organize architectural site documentation.

On October 25th 2023 a multi-modal 3D survey was performed under the guidance of Ron, the site caretaker and president of Salvation Mountain Inc. The goals of this survey were to:

1. To document the culturally significant structure for posterity, and to provide high quality, high resolution references for future architectural and conservation studies.
2. To provide useful maps and references for ongoing operation and planning efforts.
3. To provide useful media for the ongoing fundraising efforts by Salvation Mountain Inc.

The majority of the site is covered by this survey, including the main facade, vehicles, museum interior, and surrounding topography. The first two chambers of the hogan are imaged, but we are missing the easternmost chamber which was boarded up and supporting a gate between the hogan and museum area.

Minor damage on the facade on the southern side of the mountain, caused by hurricane Hilary, Aug. 21, 2023

Wash out of the pathway built on the western side, behind the mountain. Caused by hurricane Hilary, Aug. 21, 2023

Ron had recently built and smoothed the area, hoping that tourists would be able to walk up the yellow brick road, then descend down this more gentle slope.

In some places these furrows are more than 40cm (1.3ft) deep.

Prior damage to the northern nook, unrelated to the August 2023 storm.

Survey Team

Professor Filiberto Chiabrando (Lead) - Assistant Professor of Geomatics at DAD, PoliTo
Loren Clark - PHD student at UCSD
John Driscoll - Research engineer at CHEI and AlertCalifornia, UCSD
Scott McAvoy - Data Scientist at CHEI and AlertCalifornia, UCSD
Dr. Dominique Rissolo - Research Scientist , CHEI and AlertCalifornia, UCSD
Dr. Alessandra Spreafico - Postdoctoral Researcher at DAD, PoliTo
Beatrice Tanduo - PHD student at DAD, PoliTo

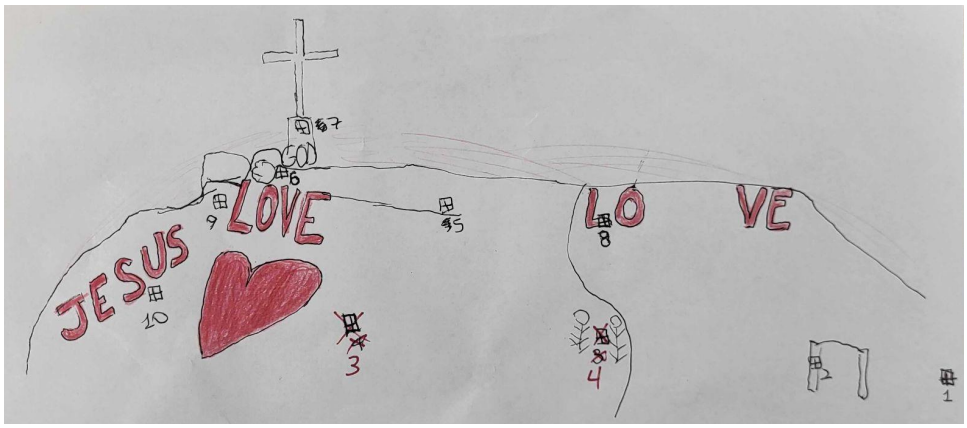
All activities were performed under the direction of Ron, the site caretaker and President of Salvation Mountain Inc.

Data Processing Team

Professor Filiberto Chiabrando - Assistant Professor of Geomatics at DAD, PoliTo
John Driscoll - Research engineer at CHEI and AlertCalifornia, UCSD
Eric Lo - Research Engineer at CHEI and AlertCalifornia, UCSD
Scott McAvoy (Lead)- Data Scientist at CHEI and AlertCalifornia, UCSD
Tanner Norton - GIS Specialist AlertCalifornia, UCSD
Beatrice Tanduo - PHD student at DAD, PoliTo

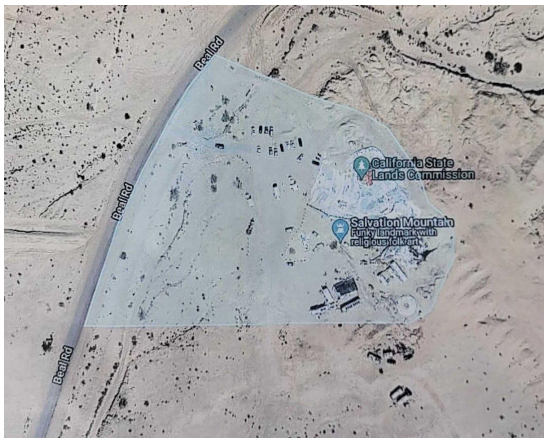
Survey Plan

The geomatic survey was led by Prof. Filiberto Chiabrando. A professor of geomatics, he is an expert in planning, capturing, and resolving observation networks via GNSS/RTK/total station workflows. A GNSS base station was deployed near the northeast corner of the fence surrounding Ron's trailer. A GNSS paired rover was used to capture the geographic positions of two observation points from which the total station was used to observe, looking eastward, 10 individually numbered checkered targets placed on the mountain's west-facing facade, and an additional 33 features points on the vehicles parked to the west of the observation points. Numbered targets were placed during the initial aerial survey, and are not available for many of those images. They are visible within the terrestrial LiDAR, terrestrial photogrammetry, and mobile mapping system datasets. Vehicle feature points are visible within the terrestrial LiDAR and photogrammetry.



Target reference, showing placement of individually numbered checkerboard targets across the mountain

In addition to the high accuracy survey, a larger area, but lower accuracy, contextual survey was performed by John Driscoll, using an aerial drone pairing with the GNSS base station. Where as the terrestrial surveys cover only the mountain and associated structures and vehicles, the aerial survey includes the parking lot area up to the road,



Drone Survey acquisition area, extending beyond the mountain to parking area, road, the plateau on the northeastern side.

Survey Equipment

GNSS - Emlid reach 2 base station and rover (spec sheet)

Collected by:
Filiberto Chiabrando, Alessandra Spreafico, Beatrice Tanduo (total station)
John Driscoll (drone)

The GNSS (Global Navigation Satellite System) provides accurate georeference for survey observation points, giving realtime positional information to the aerial drone, and

Event Notes:
Around 12pm on 10/25/2023, at some point during the initial sync, the rover fell over. We do not anticipate that this caused any damage or inaccuracy as the station was resynced successfully after, but there is some potential for error.

Total station - Leica TS02 (spec sheet)

Collected and resolved by:
Filiberto Chiabrando, with the assistance of Alessandra Spreafico and Beatrice Tanduo

The total station provides distance and angular observations of targeted features from multiple fixed locations. These observations are resolved against each other. to create a high accuracy network of control points, to which all other data can be aligned.

Data Acquisition:

Given the scale of Salvation Mountain, and the need to document individual sculptures, vehicles, complex interiors and exteriors, along with the landscape upon which it all sits, the team decided to employ a number of survey techniques to appropriately capture structures at varying scales and resolutions.

These tools and methods are outlined below:

Terrestrial LiDAR - Leica RTC 360

Collected by:
Alessandra Spreafico, Beatrice Tanduo, Scott McAvoy, Loren Clark
47 scans (25 exterior, 22 interior), medium resolution (6 mm @10m) with HDR enabled, capturing most of the site, some horizontal surfaces lacking, two chambers missing, one in museum one in hogan, does not cover much of the clay back driveway, lacking some info in northern nook.

Mobile Mapping System - StoneX 120GO

Collected by:
Beatrice Tanduo

3 Scans, 15 minutes each. These cover missing chambers in the museum, but not in hogan.
Scan 1: overall exterior context, main slope (west), cross, interior chambers of the *hogan*
Scan 2: cars, trucks and tractor
Scan 3: indoor environment of the *museum*

Terrestrial photogrammetry

Collected by:
Scott McAvoy (Sony a7R3):
Special attention was given to the northern nook, where a north facing slope had collapsed.

Collected by:
Dominique Rissolo (Sony a7R4):

- Truck (west)
- Truck (east)
- Tractor on trailer
- Jeep Wagoneer
- Toyota Corolla
- Ford Pinto
- Airstream trailer
- Balloon Furnace
- Hogan (west/main)

Aerial SFM DJI Mavic 3

Collected by:
John Driscoll - AlertCalifornia

Images were georeferenced using noaa opus solution in conjunction with the DRTK base station then tagged in Emlid studio.

This dataset includes:

- 278 ortho images taken in a lawnmower at 38 meters over the area of interest
- 992 oblique images taken in a double grid with varying camera angles to provide oblique angles of the facade.
- 431 manual captures taken at various points perpendicular to the slope of the mountain to improve detail in the main focus area

Structured Light Scanning - Artec Leo

Collected by:
Dominique Rissolo

Structured light scans of mailbox ,
Maquette, and the
hogan main chamber.

Data Quality and Availability

The data provided by this project is not certified by a licensed surveyor. Measurements provided are subject to error. If an application requires a particularly high level of accuracy or precision (for example, a hydrological analysis) please contact the authors of this report.

All data is provided within the following coordinate schema, intended to maximize accuracy and re-usability across subsequent studies.

Horizontal datum	NAD83(2011)
Vertical datum	NAVD88, EPSG:5703
Geoid model	GEOID18
Map Projection	NAD83(2011)/UTM Zone 11, EPSG:6340
Units	meters
Epoch: 2010.0	2010.0

Raw and processed data products are available for download and realtime visualization at https://openheritage3d.org/project.php?id=7az2-3v68

The data is made available via a Creative Commons 4.0 BY license, meaning that any re-use of

this data must cite its original authors and source.

The preferred citation is:

> Filiberto Chiabrando, Loren Clark, John Driscoll, Scott McAvoy, Dominique Rissolo, Alessandra Spreafico, Beatrice Tanduo (2023): Salvation Mountain - Photogrammetry - Terrestrial, Photogrammetry - Aerial, LiDAR - Terrestrial, LiDAR - Mobile. Distributed by Open Heritage 3D. https://doi.org/10.26301/7az2-3v68

3D Visualization System

A web-based interactive visualization system is available at https://pointcloud.ucsd.edu/OH3D/7az2-3v68.html. This system enables users to browse the highly detailed models at full resolution, take measurements, and create useful renderings. Some examples are shown below.

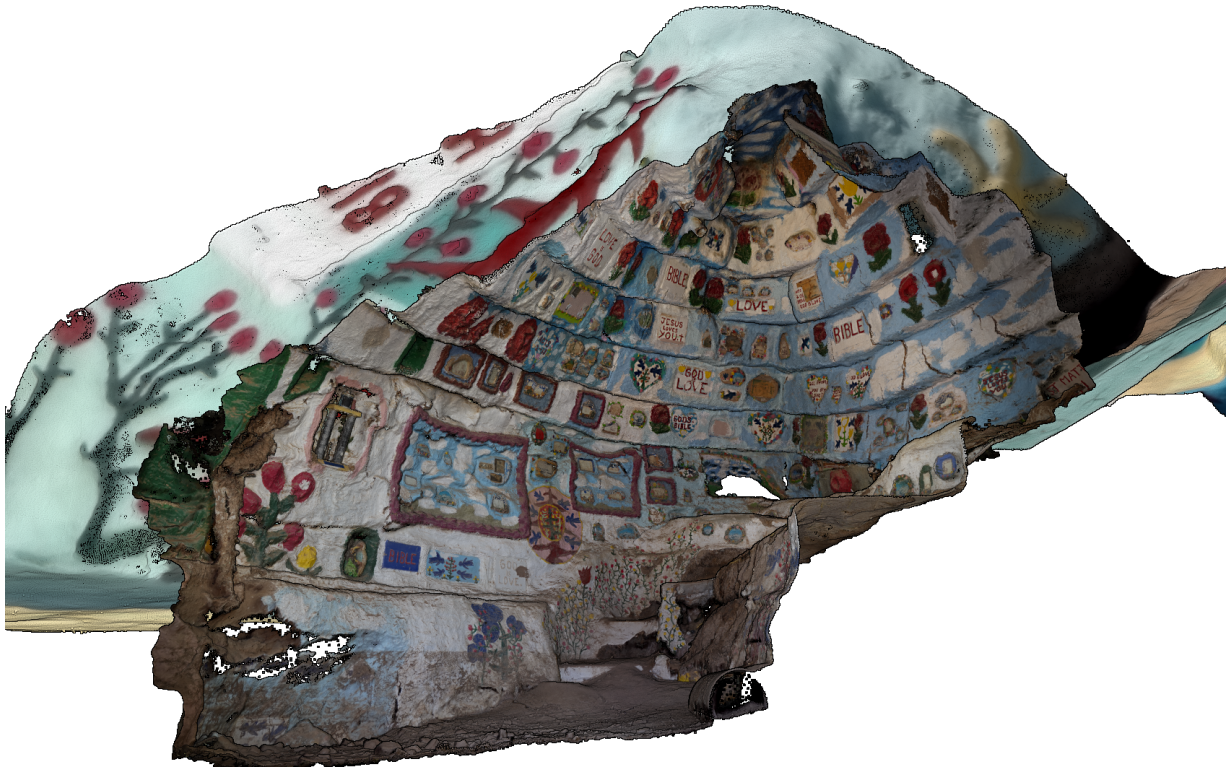


Fig. 1 - Interior cross-section view of hogan

Fig. 2 - Aerial orthophoto including significant structures

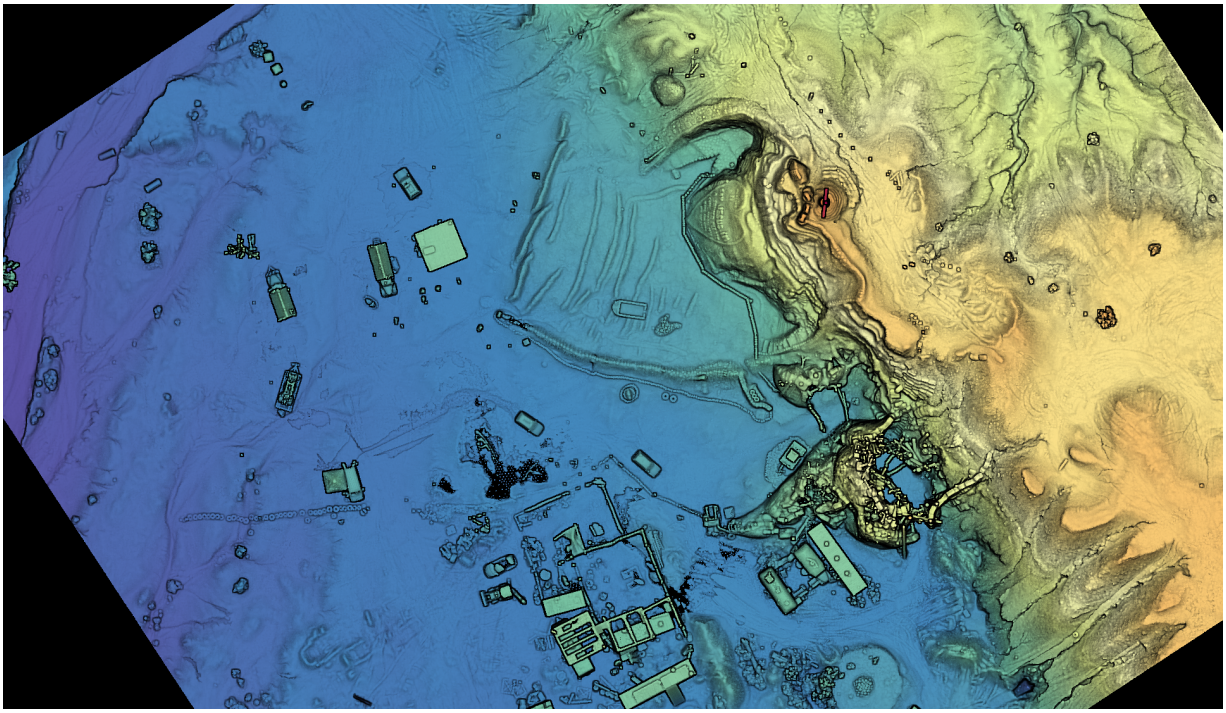


Fig.3 - Elevation view (6.46m minimum to 29.30m maximum)

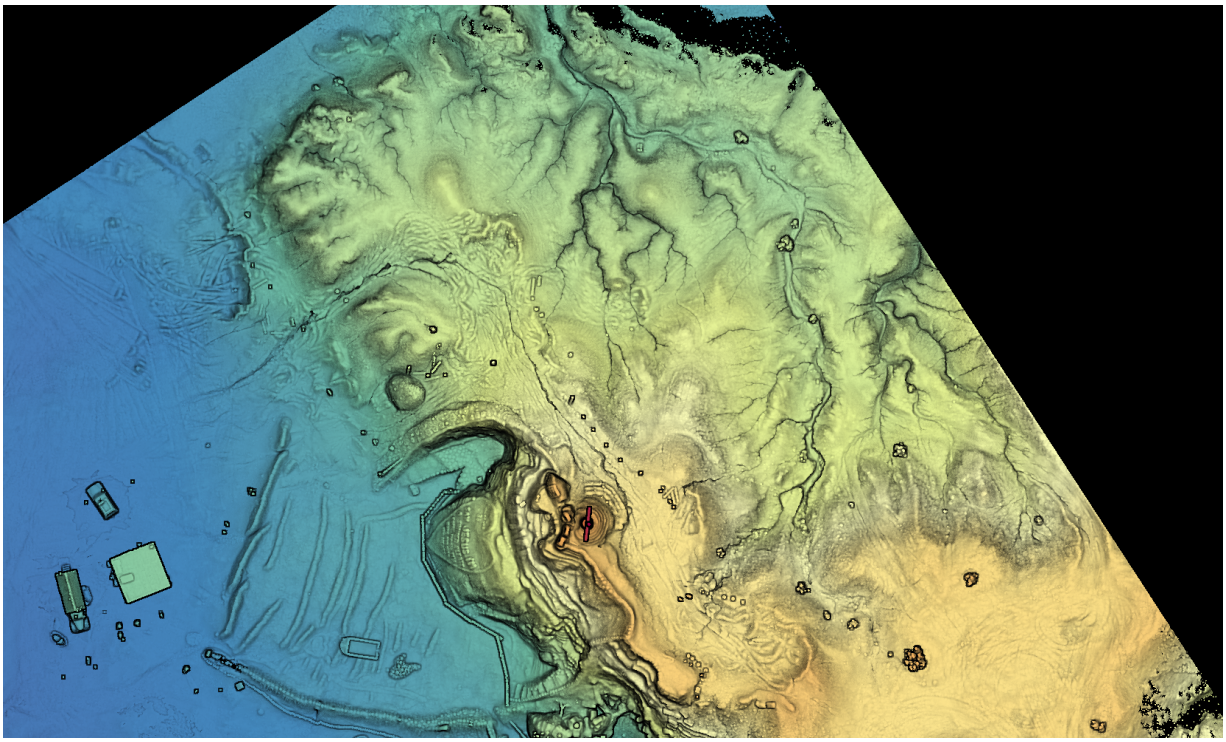


Fig. 4 - Northern slopes, impacted by rains

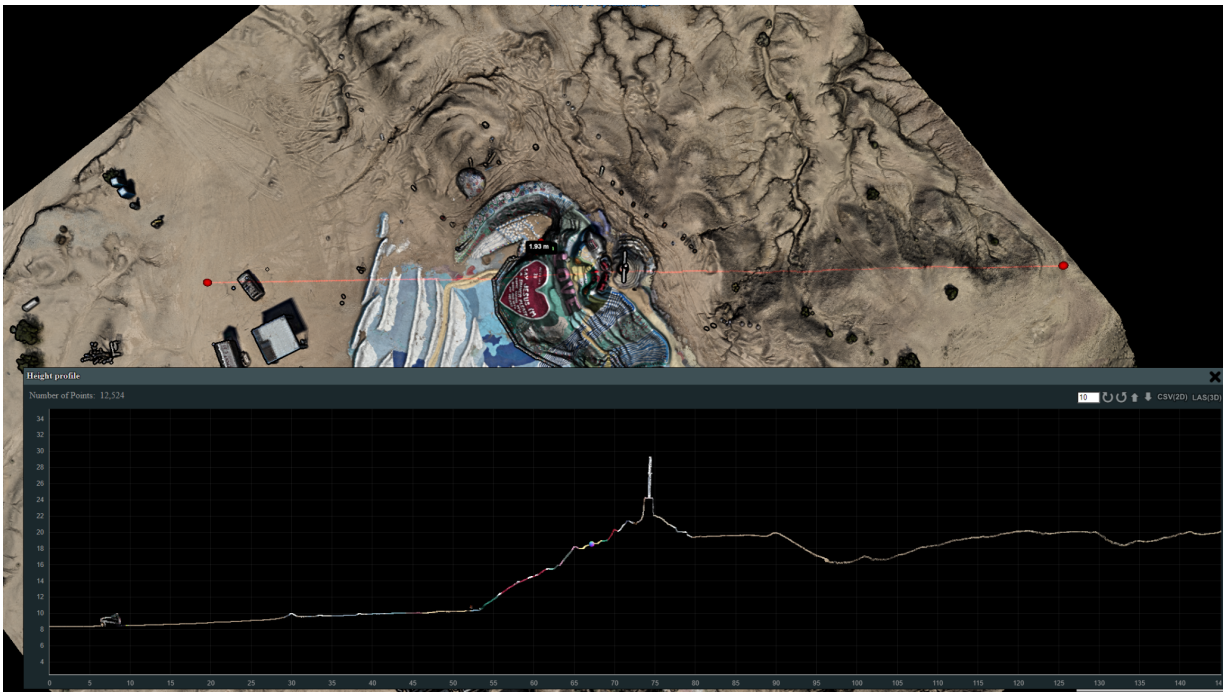


Fig. 5 - Cross section running east to west, showing height differentials

Fig. 6 - Color view of northern nook

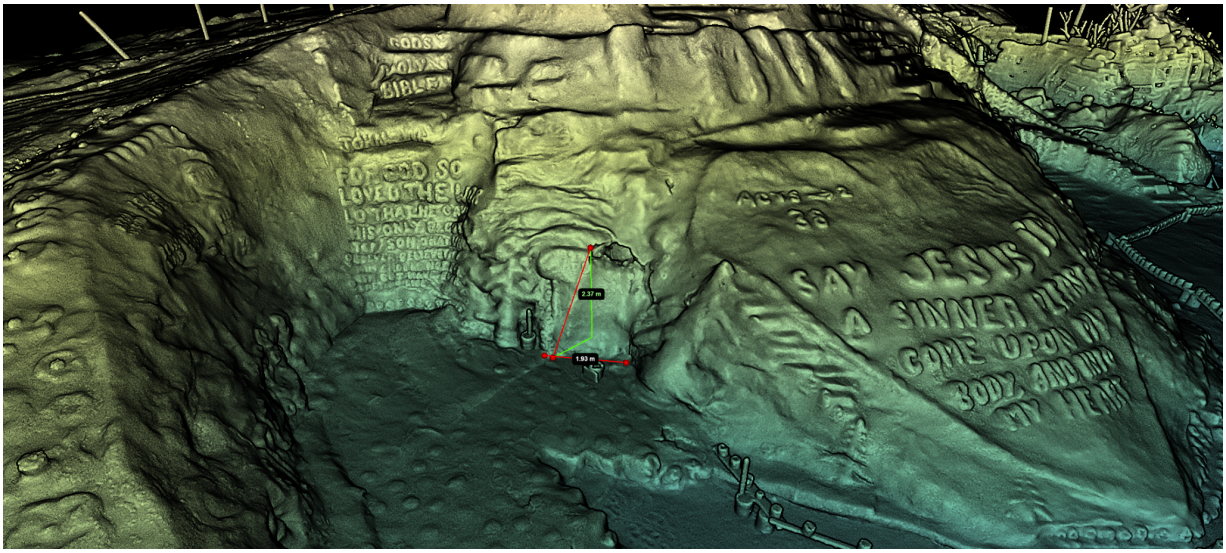


Fig. 7 - elevation view, with measurements describing the collapsed area.

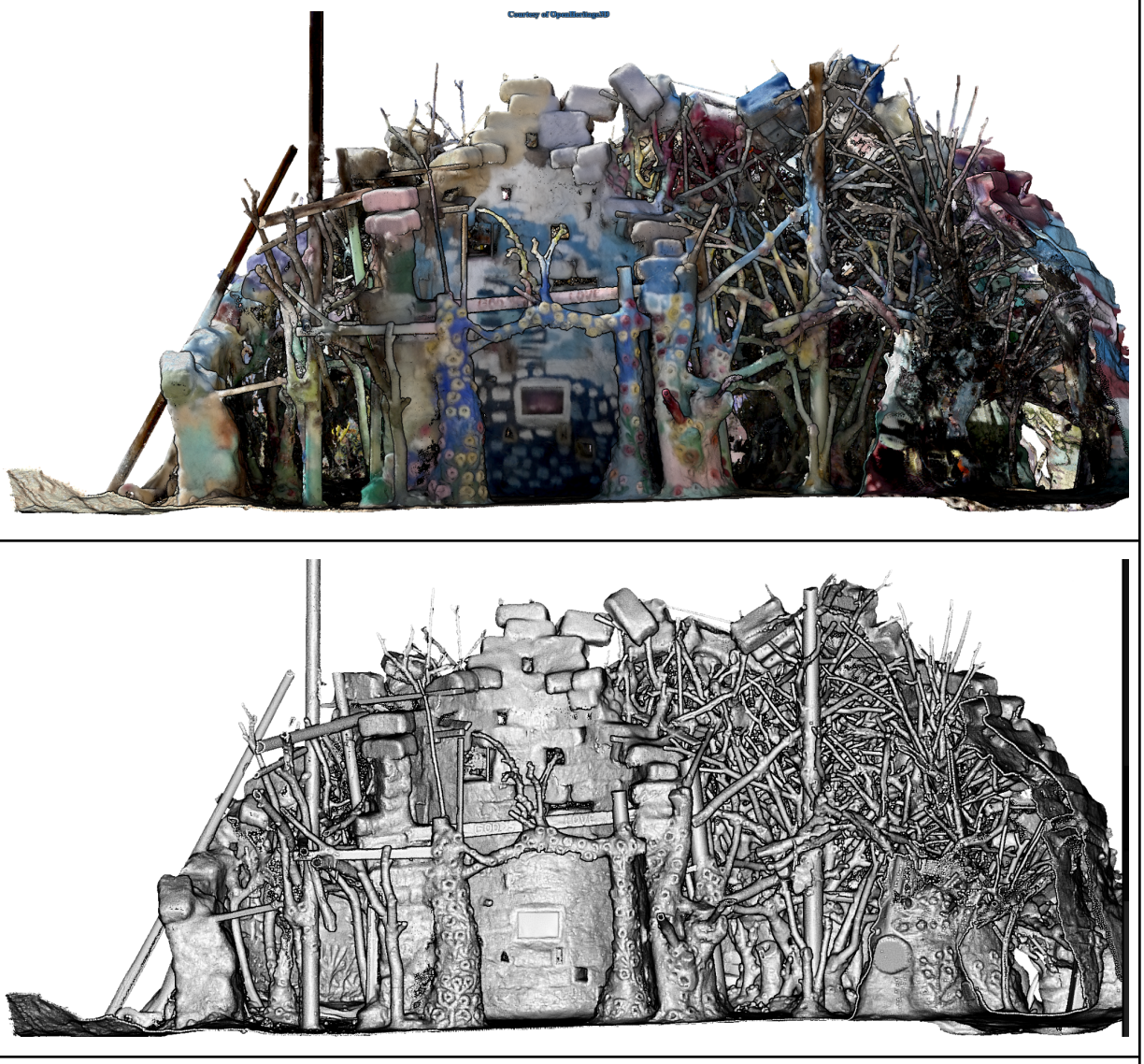


Fig. 8 - Museum interior cross section, east-facing view.

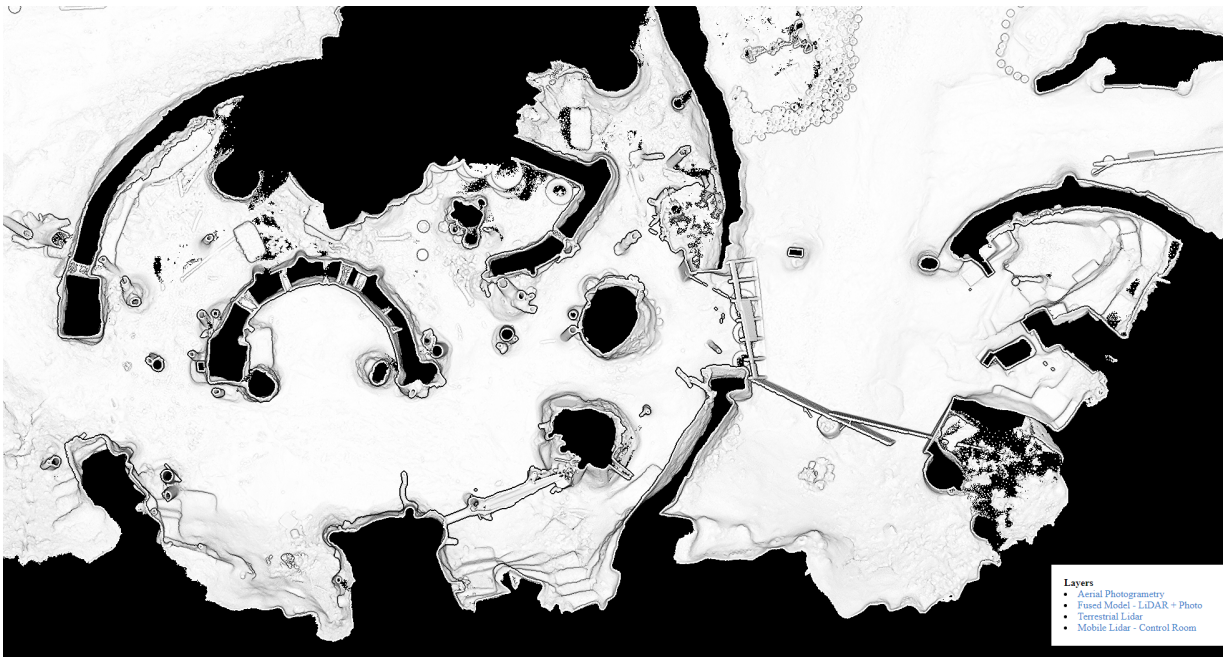


Fig. 8 - Horizontal cross section, showing interior chambers of the museum, and hogan.

Fig. 9 - 1949 White Motor Company truck, shown in color and geometry view

Fig. 10 - Isometric view of the Ford Pinto Cruising Wagon, with measurements