

Use of Laser Scanning Technology to Obtain As-Built Records of Historic Covered Bridges

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2nd National Covered Bridge Conference

June 6, 2013

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Covered bridges are part of the fabric of American history, and several hundred historic covered bridges still exist today.



The high cost of restoration, neglect and vandalism has resulted in the loss of many bridges. Hurricane Irene also reminded us of the power of natural disasters.





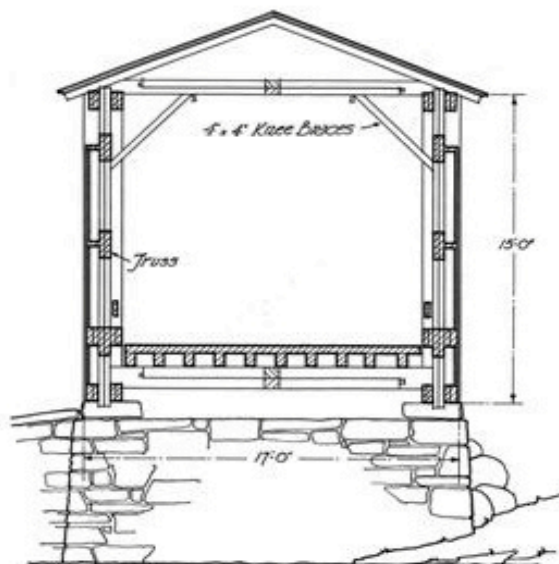
Historical Documentation

National Park Service

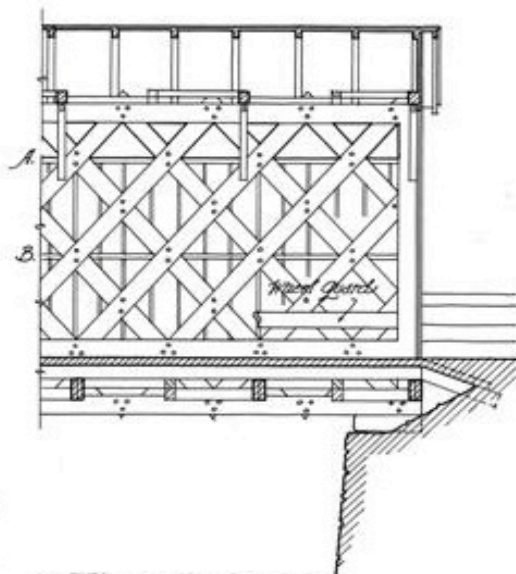
- Level I documentation:
 - Measured and interpretive drawings
 - Large-format photographs
 - Written historical reports



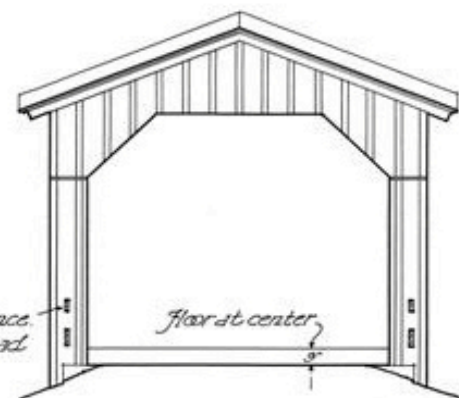




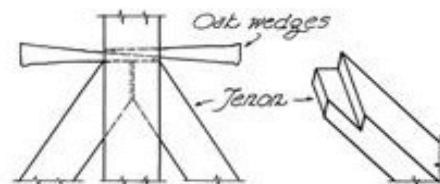
Transverse Section



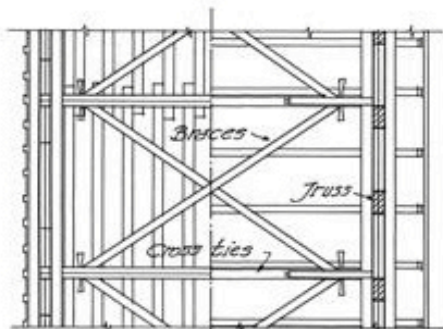
Longitudinal Section



End Elevation



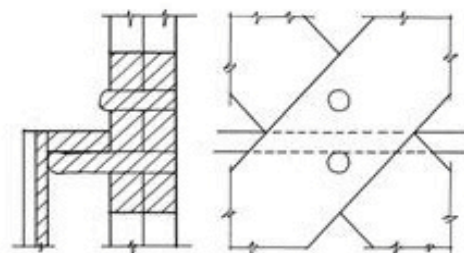
Intersection of Cross Ties & Diagonal Braces



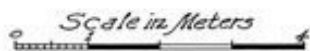
Floor & Roof
Plans of Construction

Legend

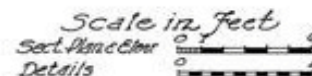
All parts of structure are of pine except as noted. Abutments are of stone. Boards at sides & ends are 1x12 with joints covered by 1x4 battens. Roof is of cedar shingles supported on 3x4 rafters spaced 30 to 36" o.c. Cross tie beams at floor are 2x12 notched & bolted at ends. Diagonal braces are 4x6 tenoned into cross tie beams & wedged with oak wedges 3x2 at but. Construction at ceiling same except cross ties 5x8 & braces 4x4 @ 3' o.c. Floor joists are 6x8 over which are laid 2x4s on edge forming floor of bridge. Truss members are 3x10 fastened at joints with 2" dia. oak pins with exterior ends rounded. At A each lower & at B every other lower pin projects to support 2x6s onto which are nailed tie boards & battens fastened to sides of truss at top, bottom & floor line are continuous members, each of 2x12s.



Section at A Elevation
Intersection of Truss Members



Clarence W. John Del. Hugo Logemann, Mens.



New technologies need to be developed, identified and implemented that quickly, accurately and cost-effectively capture the dimensions and physical condition of a bridge.

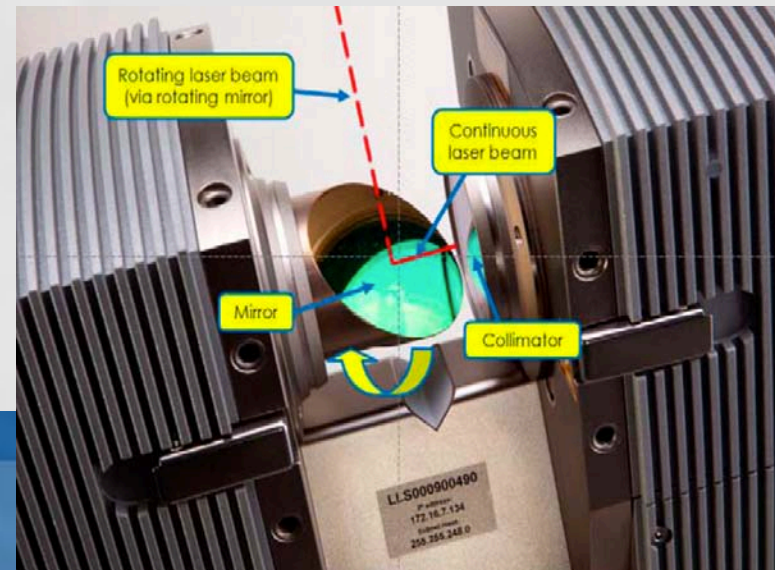
Laser Scanning

- Can create detailed 3D images.
- This image is an assembly of millions of 3D measurement points which provide an exact digital reproduction of existing conditions.



Technology Overview

- A laser beam is emitted from a rotating mirror out towards the area being scanned. The laser beam is then reflected back to the scanner by objects in its path. The distance to the objects defining an area is calculated as well as their relative vertical and horizontal angles (Faro 2011).



Objective

- To examine the technical feasibility of using laser scanning technologies for obtaining as-built records for historic, covered timber bridges and demonstrate its potential.

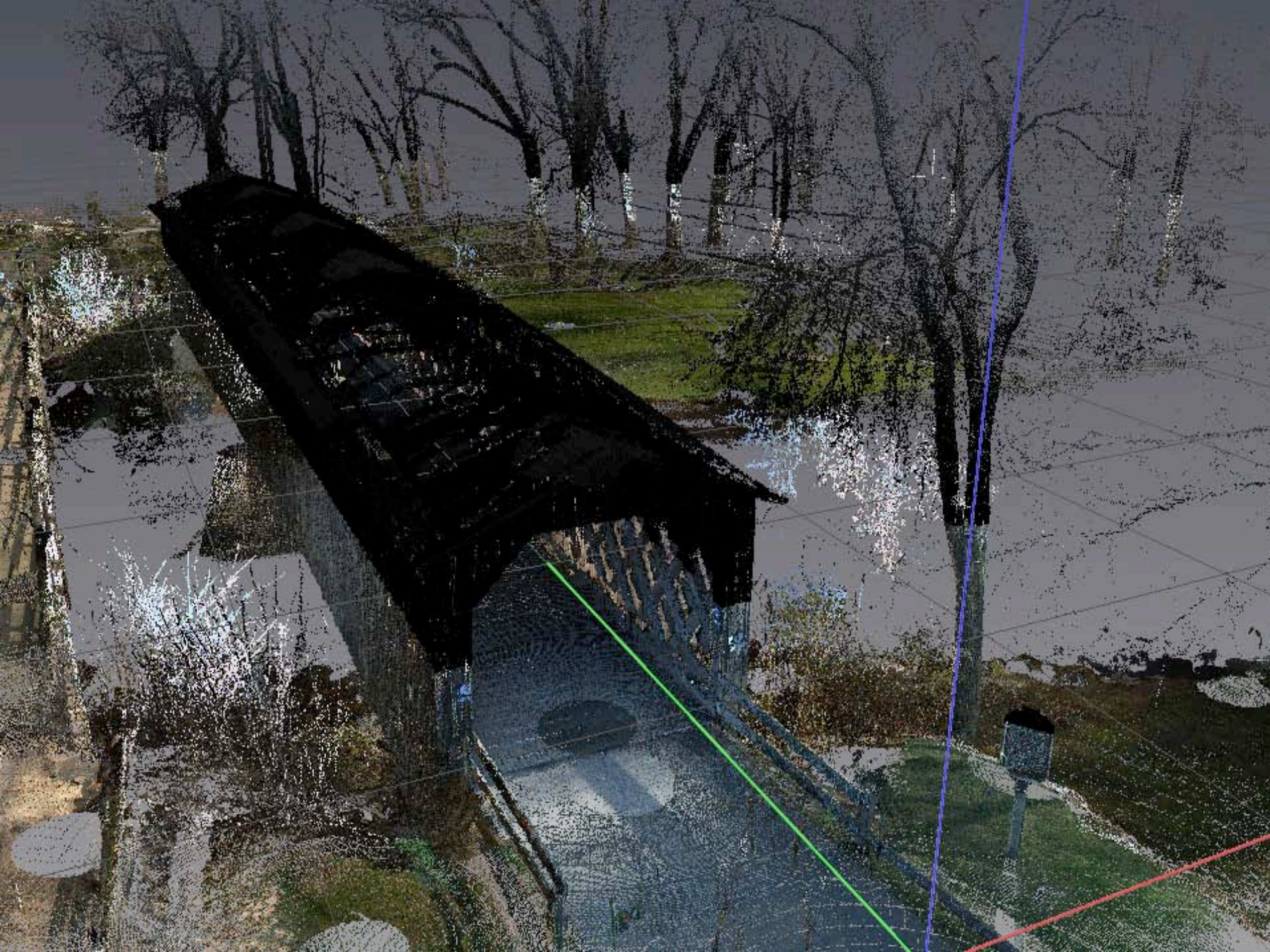
Work Plan

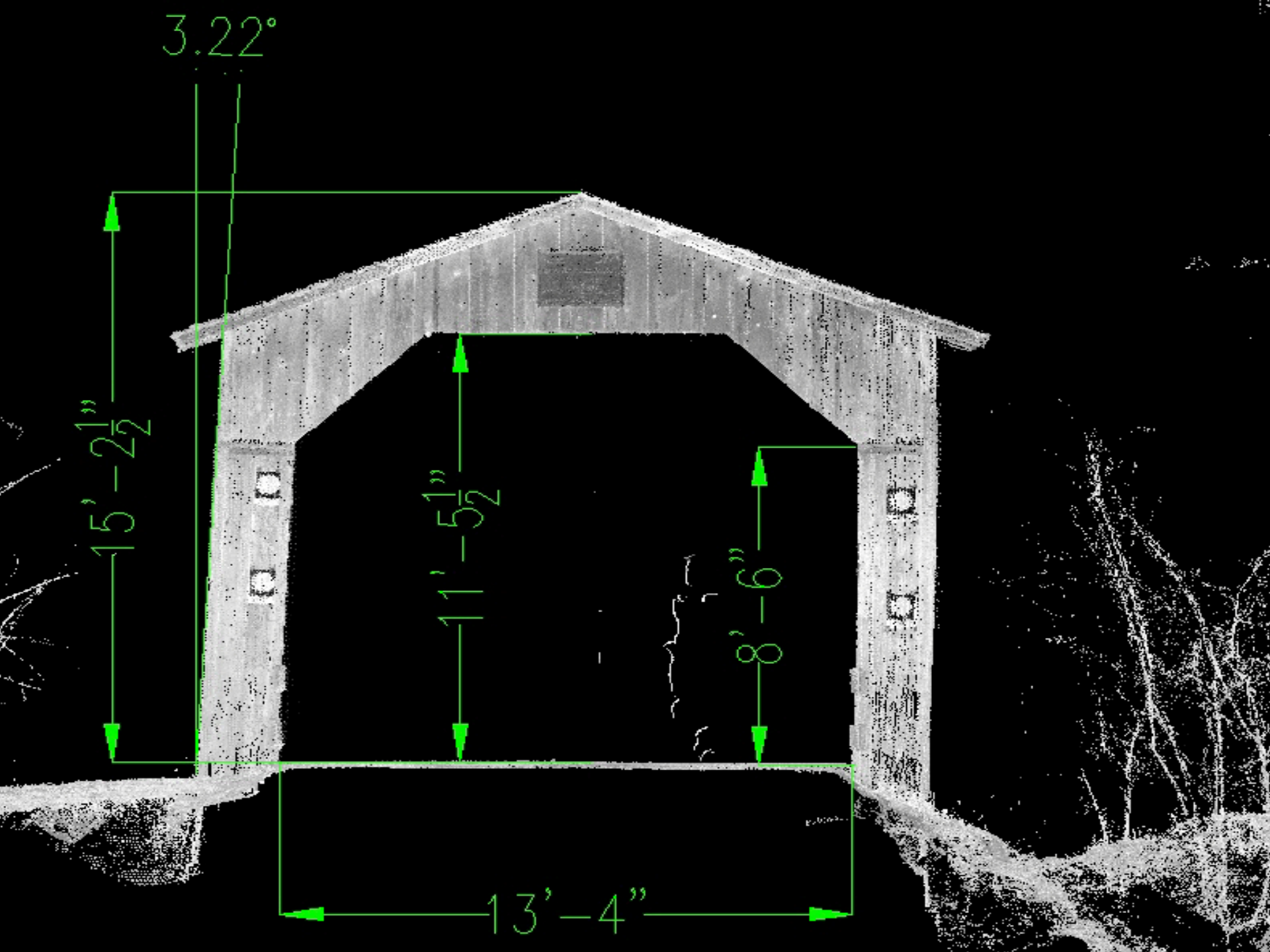
- 6 bridges selected in Minnesota, Wisconsin and Madison County, Iowa
- Faro 3D Scanner used by Sightline LLC and Faro
- Use software to connect the scans creating a 3D point cloud image
- Import the scans into AutoCAD® and create 2D and 3D drawings using kubitUSA software
- Create a 1/100th replica of the Zumbrota, Minnesota Bridge using rapid prototyping technology.

Red Bridge - Cedarburg, Wisconsin









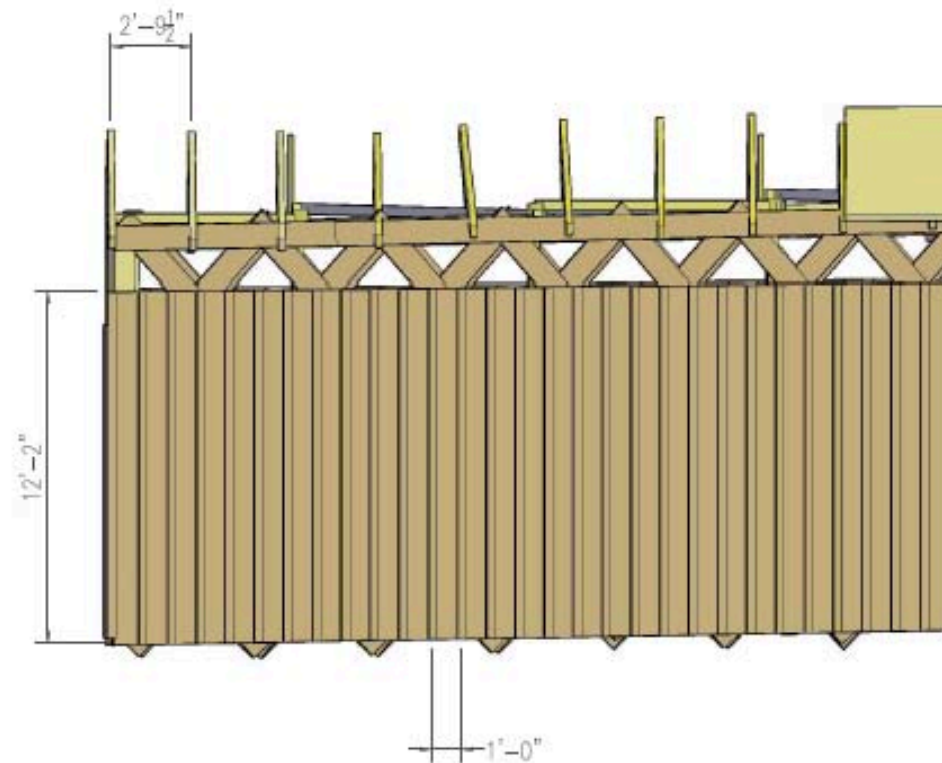
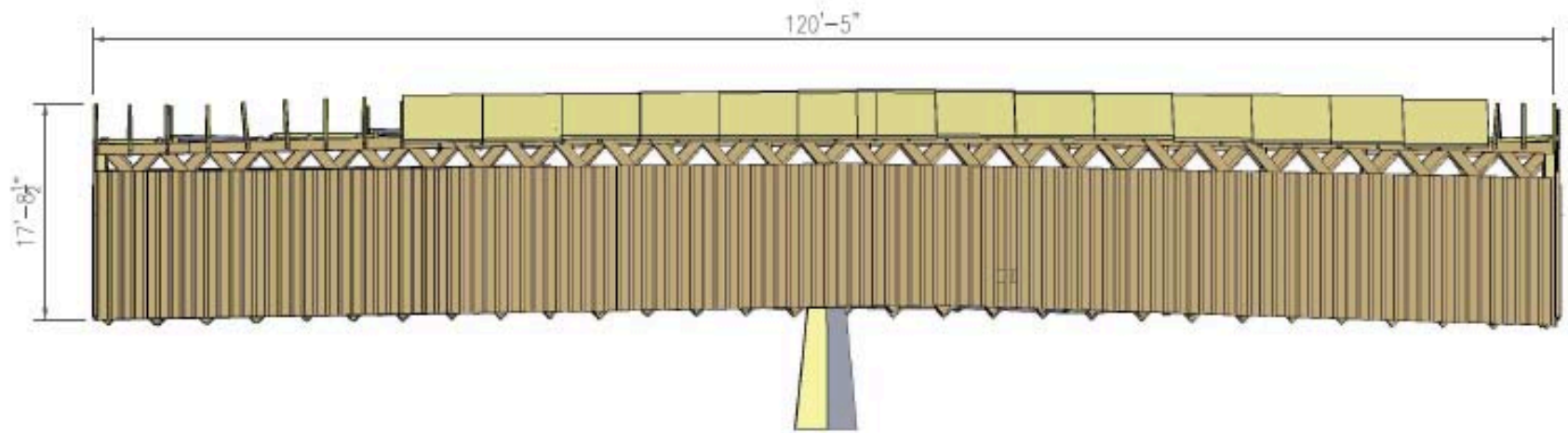
3.22°

15' - 2 1/2"

11' - 5 1/2"

8' - 6"

13' - 4"



Cedarburg

Side View

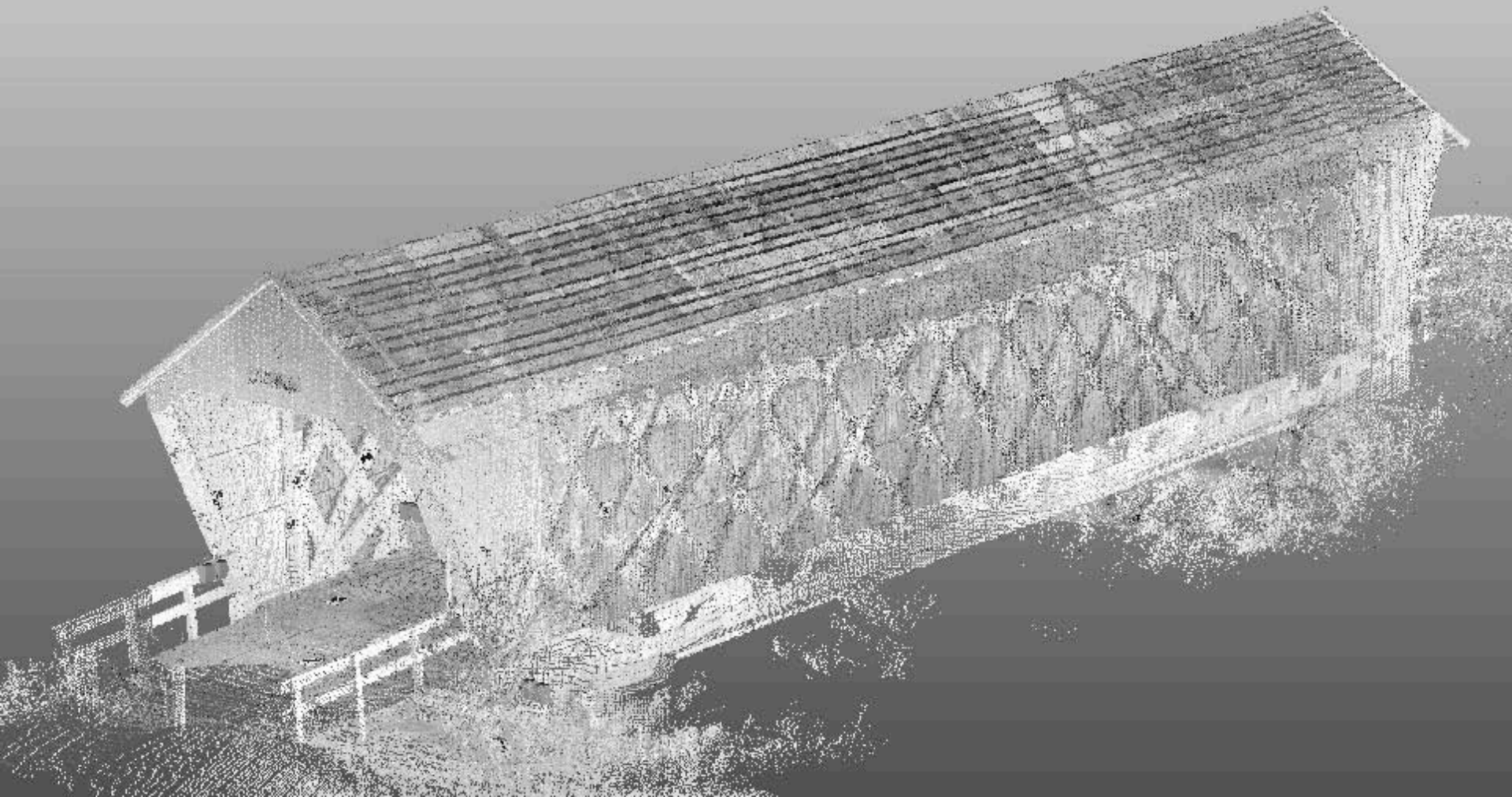
Natural Resources Research Institute

Imes Bridge, Madison County, Iowa, USA

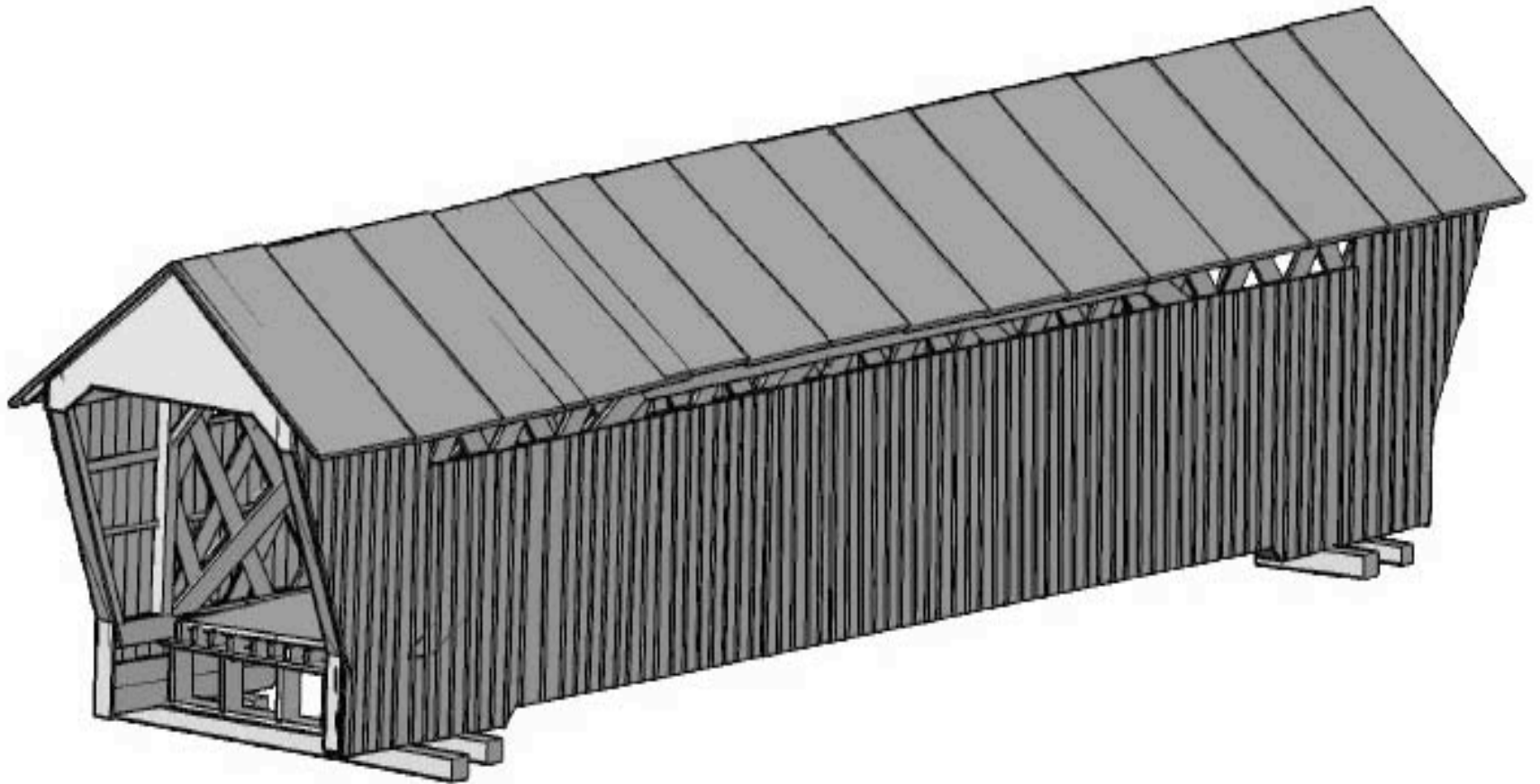


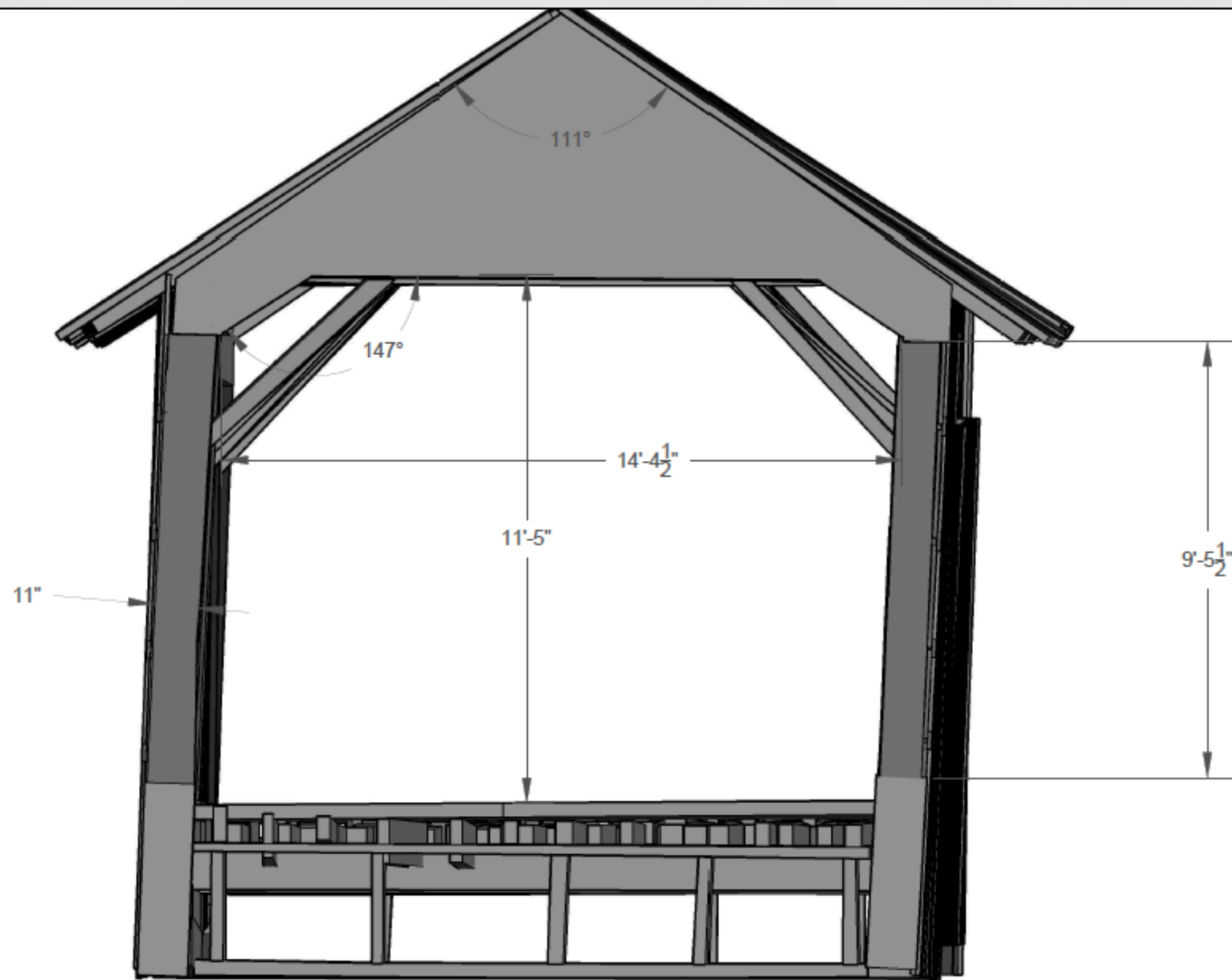


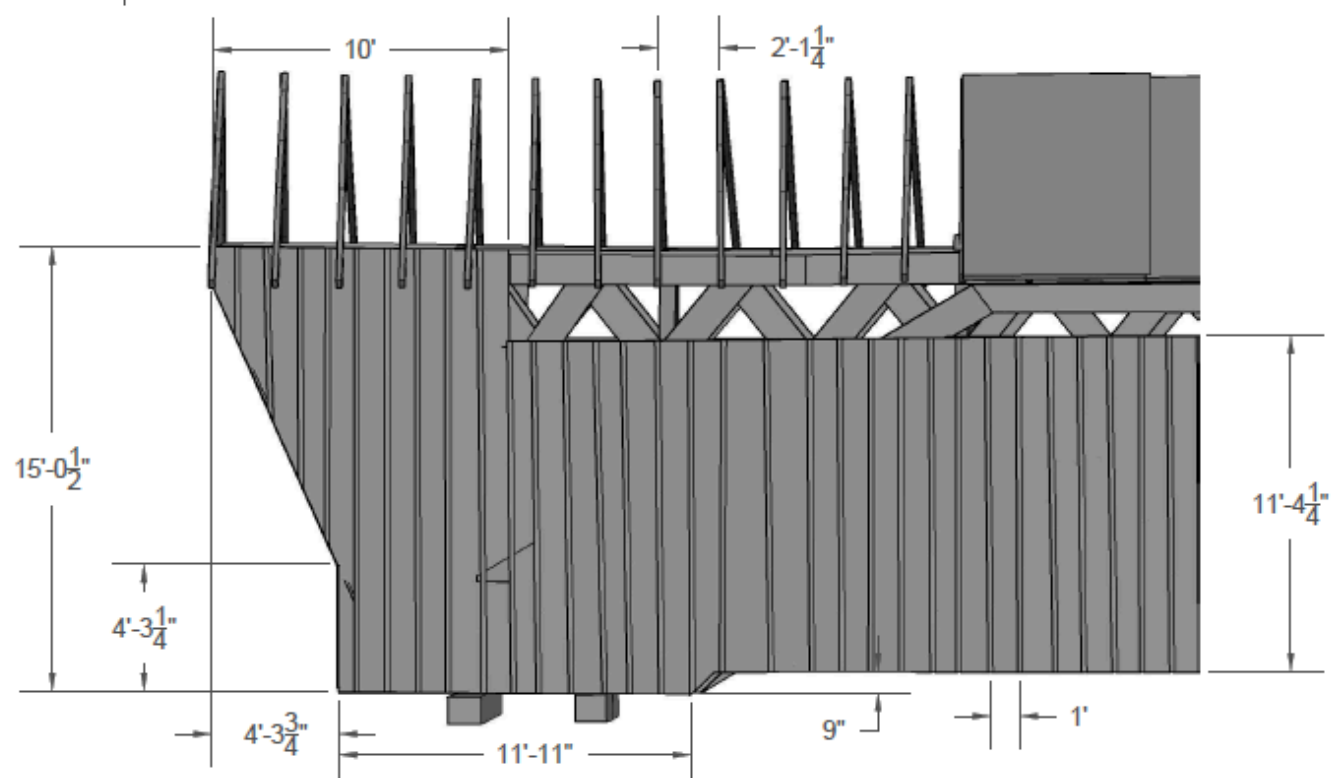
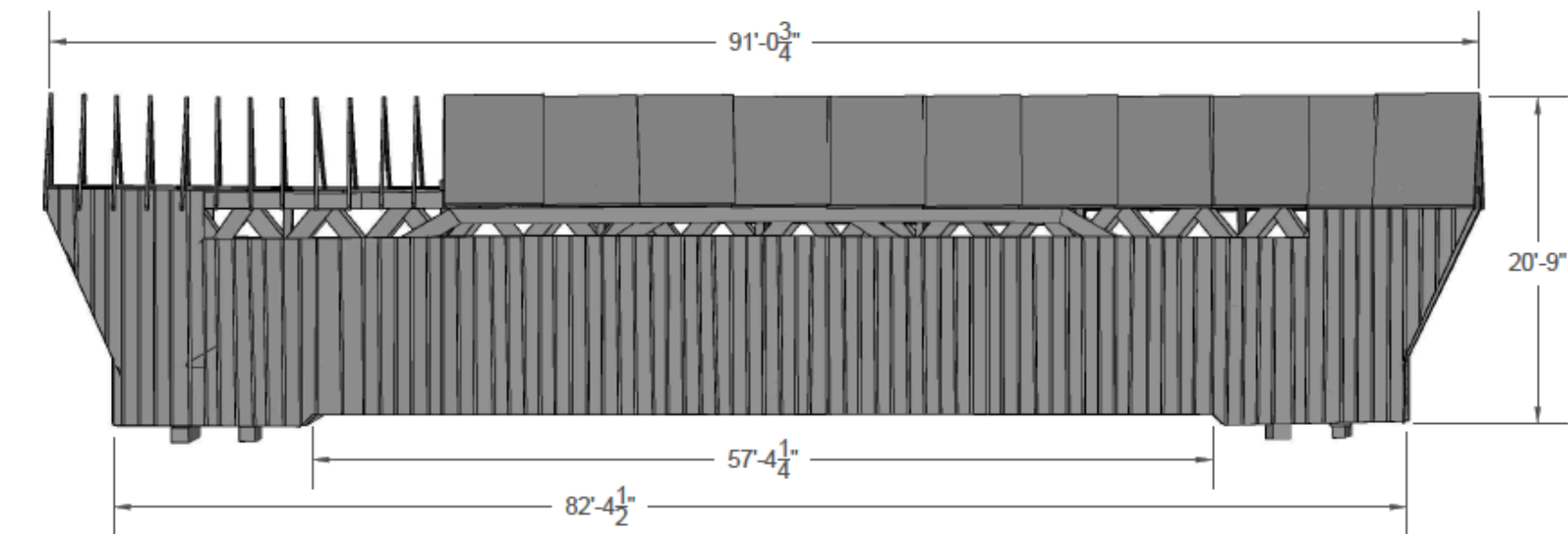
Imes Point Cloud



Imes 3D AutoCAD®







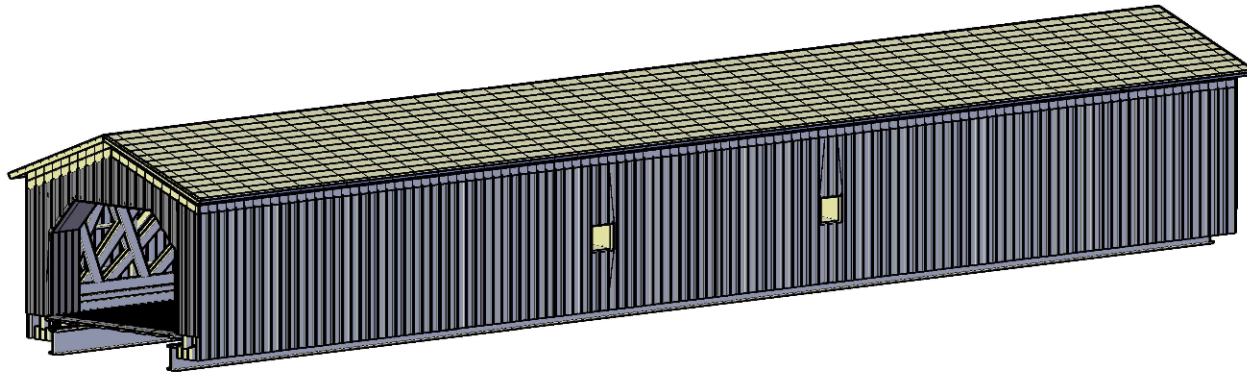
Zumbrota, Minnesota USA





Zumbrota Isometric 3D CAD View

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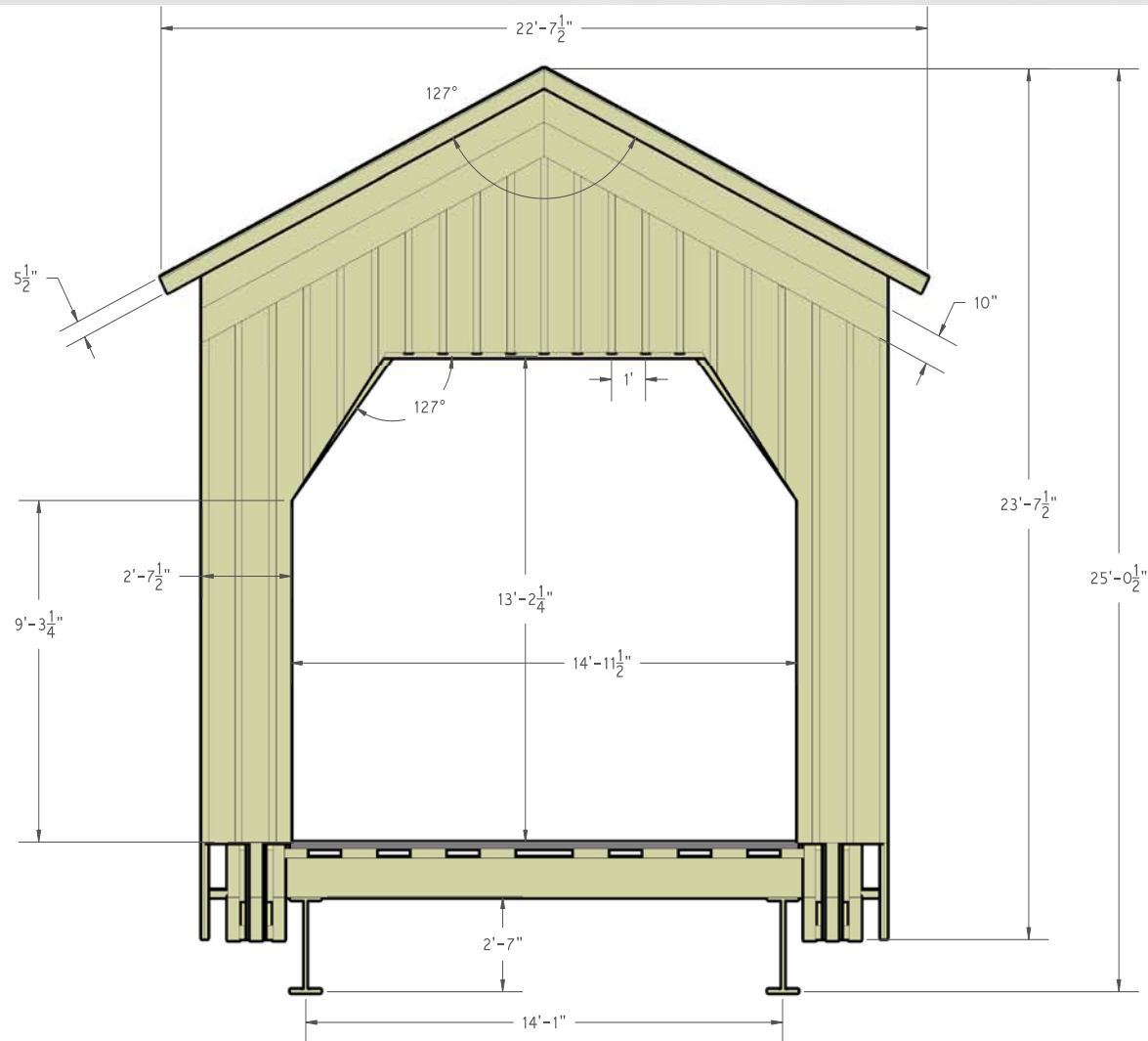
Zumbrota	Isometric View
Natural Resources Research Institute	

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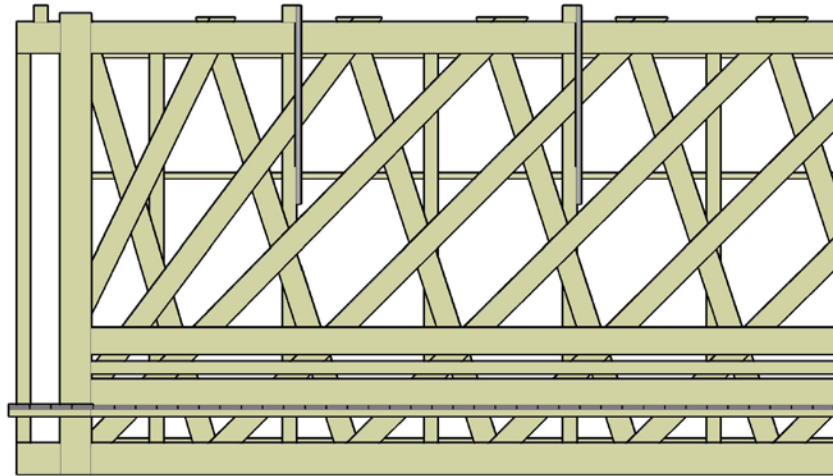
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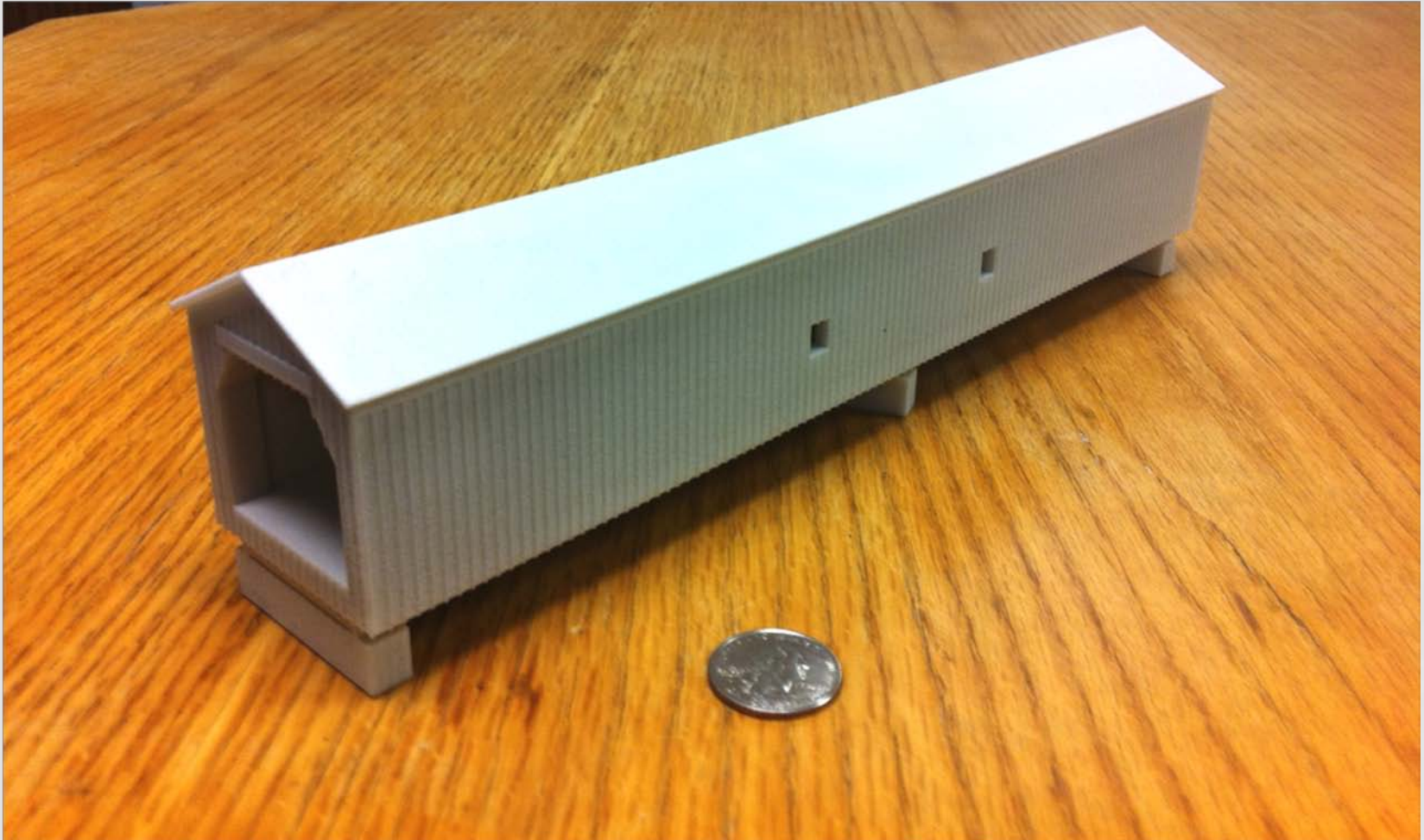
Autocad® Image Of The End Wall



Autocad® Image Of The Side Wall



Creation of a 1/100th Replica Using Rapid Prototyping Technology



Process Time

Step	Time Duration
Setup and place targets	2 person-hours
Conduct multiple scans (up to 20)	8 person-hours
Link scans	8 person-hours
Produce images	30-60 person-hours



Member Number	Method for Measurement			Difference Between Tape and Point Cloud	
	Tape Measurement (1/16 in.)	Point Cloud			
			3 Points (in.)	Mean (in.)	(in.)
1	2.88	2.68	2.73	0.15	3.77
		2.76			
		2.74			
2	2.88	2.84	2.77	0.10	2.58
		2.84			
		2.64			
3	11.25	11.40	11.21	0.04	0.93
		11.20			
		11.04			
4	5.50	5.24	5.43	0.07	1.86
		5.40			
		5.64			
5	11.50	11.32	11.30	0.20	5.08
		11.20			
		11.38			
13	11.63	11.34	11.60	0.03	0.64
		11.44			
		11.52			
14	11.75	11.88	11.80	0.05	1.27
		11.72			
		11.80			
15	12.00	11.96	11.95	0.05	1.35
		12.08			
		11.80			
16	1.88	1.80	1.83	0.05	1.23
		1.80			
		1.88			
		Average Difference		0.07	1.83

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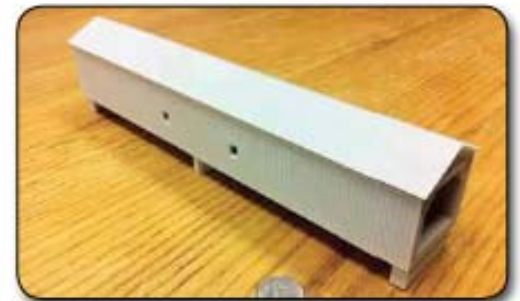
United States
Department of
Transportation

Federal
Highway
Administration



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Conclusions

- 3D laser scanning is an effective and accurate technique for documenting as-built conditions of historic covered bridges.
- Comparisons between digital scan data dimension and actual dimension showed that the scanner used in this study met the manufacturer reported accuracy of 5 mm at a distance of 75 meters.
- Post-processing of the scan data requires experience to cost-effectively create as-built documentation.
- A 3D scanner can be used to create a range of outputs such as point cloud scans, parametric images, and 2D and 3D AutoCAD® drawings.

Acknowledgements

This study is part of the Research, Technology and Education portion of the **National Historic Covered Bridge Preservation (NHCBP)** Program administered by the Federal Highway Administration. The NHCBP program includes preservation, rehabilitation and restoration of covered bridges that are listed or are eligible for listing on the National Register of Historic Places; research for better means of restoring, and protecting these bridges; development of educational aids; and technology transfer to disseminate information on covered bridges in order to preserve the Nation's cultural heritage.

This study is conducted under a joint agreement between the Federal Highway Administration – Turner Fairbank Highway Research Center, and the Forest Service – Forest Products Laboratory.

Federal Highway Administration Program Manager – Sheila Rimal Duwadi, P.E.

Forest Products Laboratory Program Manager – Michael A. Ritter, P.E.



U.S. Department of Transportation
Federal Highway Administration



Thank you!



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