

Robots in the Built Environment: Workflows for AEC at the Autodesk Technology Centers

Stefanie Pender

Senior Shop Supervisor, Autodesk Technology Center
Boston

CONNECT & CONSTRUCT SUMMIT





About the speaker

Stefanie Pender

Stefanie Pender is a Senior Shop Supervisor at the Autodesk Technology Center Boston, a research and development workspace where Autodesk invites startups, colleges and universities, and industry experts to explore ways to advance the building industry. The center focuses on industrialized construction, digital fabrication, automation and robotics in construction, and other ideas that are transforming the built world. Stefanie supports residents utilizing robotics at the technology center in applications that range from milling, welding, 3D printing, cutting, and material handling.

Agenda

- Introduce Autodesk Technology Centers
- 4 case studies of how residents from the technology centers have utilized construction robotics
 - Apis Cor
 - Perkins & Will
 - AI SpaceFactory
 - MADWORKSHOP





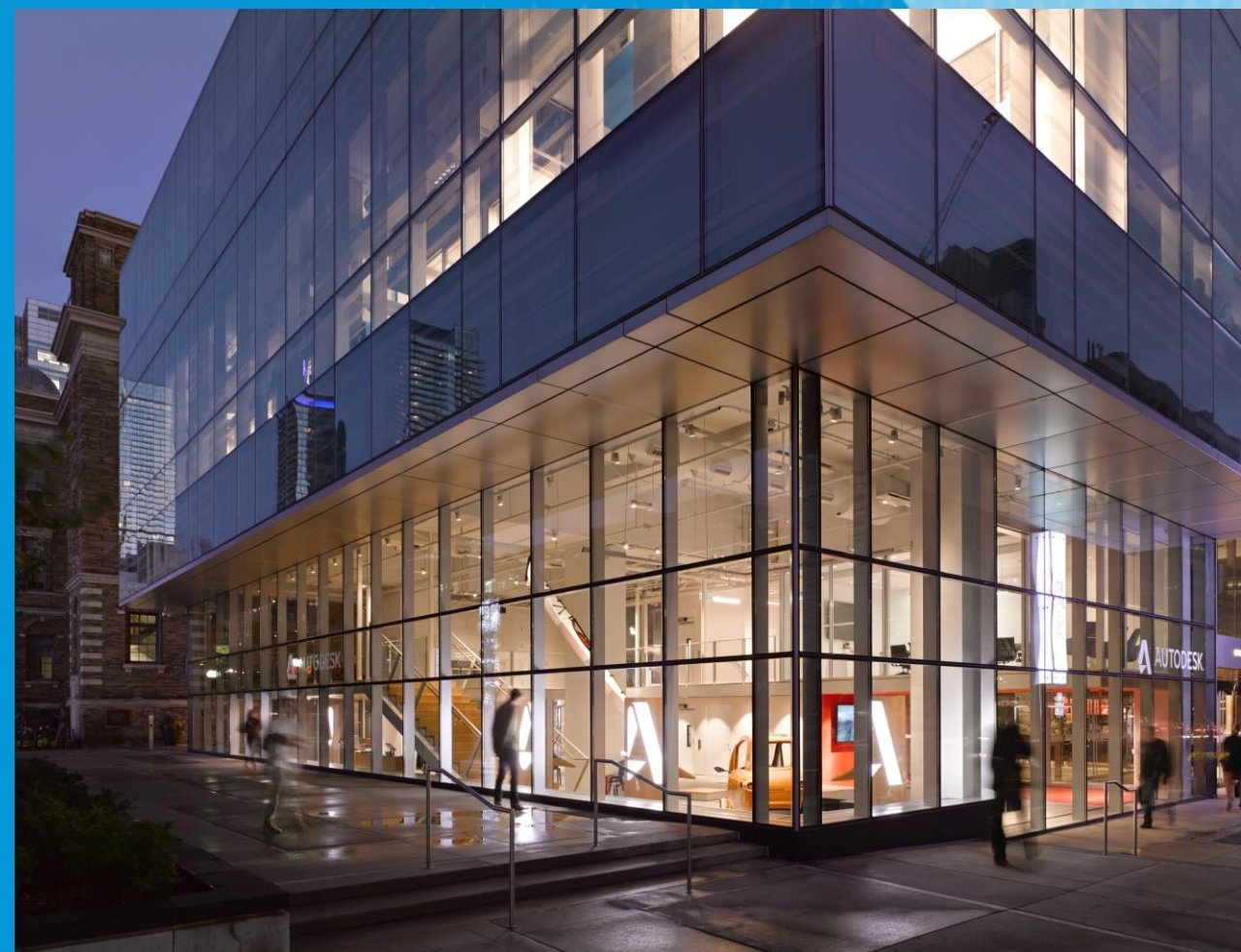
Autodesk Technology Center
Boston

Residency Locations

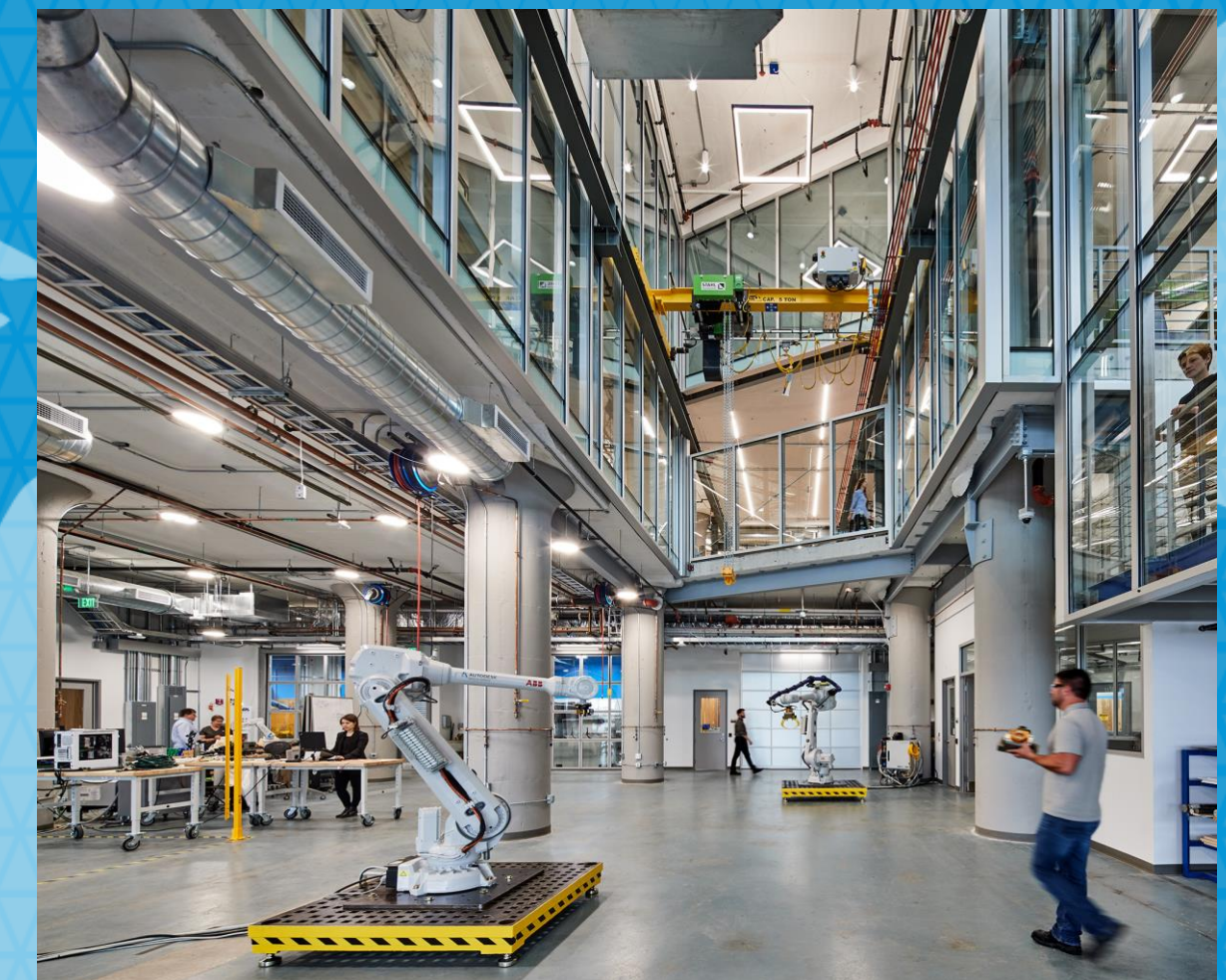
The residency program is offered in the Technology Centers in San Francisco, Toronto and Boston, each providing unique equipment and expertise tailored to specific thematic needs.



San Francisco, California



Toronto, Ontario Canada



Boston, Massachusetts

Residency Themes



Manufacturing

The Technology Center in San Francisco focuses on the development and demonstration of new manufacturing technologies relating to the concept of configurable microfactories.



Construction

The Technology Center in Boston supports innovation in areas related to the built environment with a focus on the architecture, engineering and construction industries.



Design

The Technology Center in Toronto supports the research and development of emerging technologies, including machine learning, generative design and artificial intelligence.

Autodesk Technology Centers
Residency Program



Autodesk Technology Centers Residency Program offers:



Dedicated team of subject matter experts



Inspiring workspaces



Training and access to advanced machinery



Cutting edge community

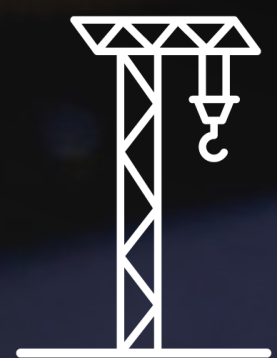


Varying duration (2 weeks to 1 year) with rolling admission



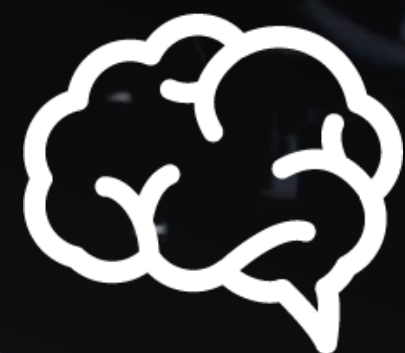
No cost to participate

Autodesk Technology Centers Resident Community



Industry

The resident community includes teams from industry and design practice. Often, the industry engagement team can facilitate collaboration between academic and industry groups to enhance the potential of the residency.



Academic

Academic residents include groups or individual faculty and students who are working on applied research in aligned thematic areas. Technology Centers host courses, special projects, and independent researchers from global universities.



Entrepreneurial

Startup residents have access to a unique co-working environment along with access to equipment, technical expertise, and connections to industry specific companies that allow the teams to focus on developing their business.



Network

In addition to residencies, the Technology Centers engage with accelerators, incubators, innovation centers, and members of our local community to allow residents to benefit from professional connections to build their networks.

Join the Resident Community



Connect

The Industry Engagement team is available to assist in proposal development and to answer any questions about the program.

technology.centers@autodesk.com



Apply

Complete the form linked at the bottom of the page to submit your proposal to provide background on your team and/or your proposed project.



Become a Resident

Once accepted, the Technology Center community team will serve as your liaison to schedule safety training, activate site access, and ensure your team is well positioned for success.

autodesktechnologycenters.com/apply-now/



For more information:

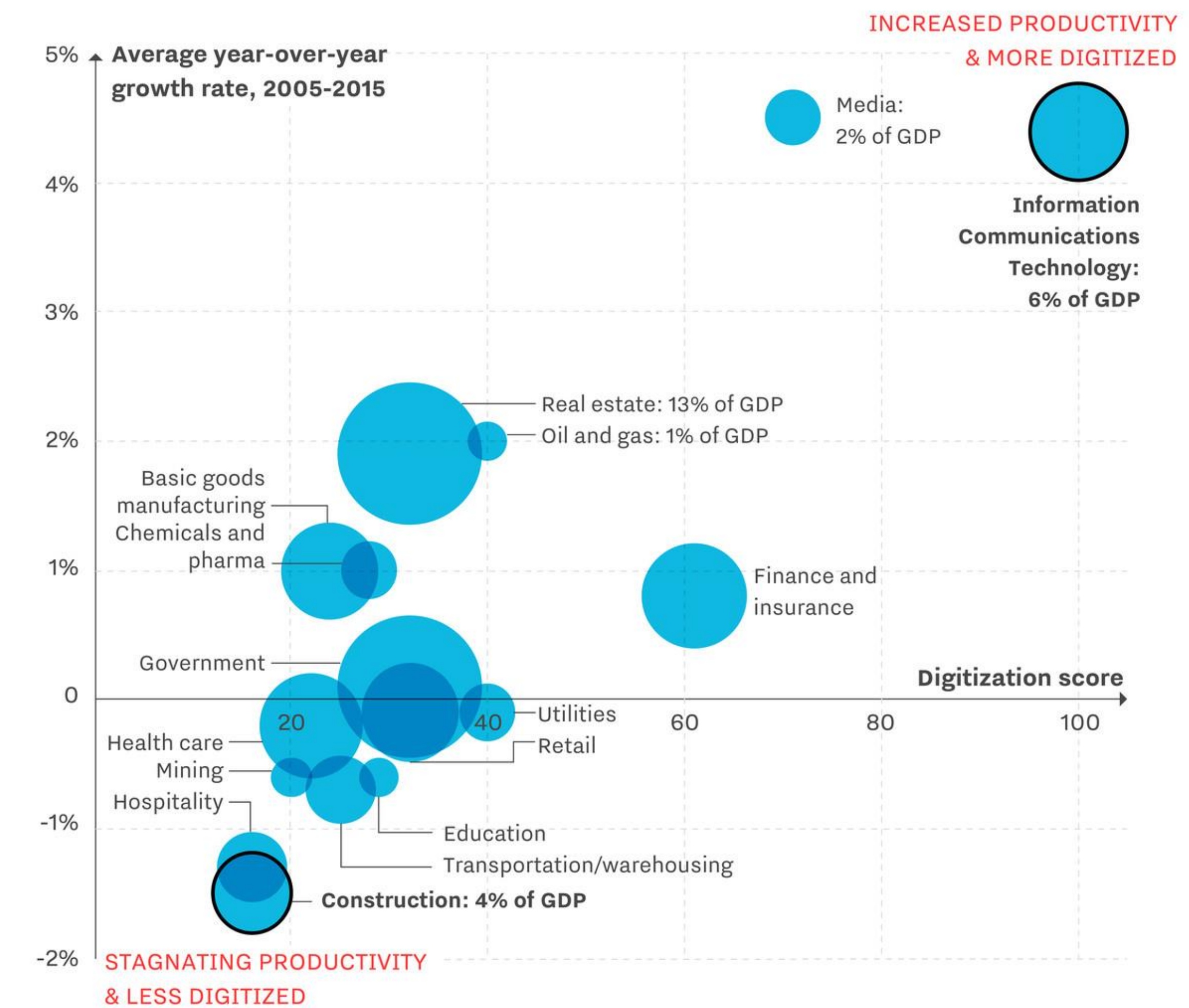
technology.centers@autodesk.com

Construction is a \$10 trillion global industry.
It's also mired by waste, severe worker shortages and weak productivity growth – all of which mean the business of building is ripe for a robotic takeover.

“The construction industry is short on human workers and ripe for a robotic takeover”

<https://www.vox.com/2017/6/6/15701186/robots-construction-homes-technology-drones-building-automation-productivity>

Industries like ICT and media have seen the most digitization and productivity growth. Construction is at the opposite end of the spectrum.



Source: McKinsey Global Institute

Note: Circles sized by share of GDP





Perkins&Will

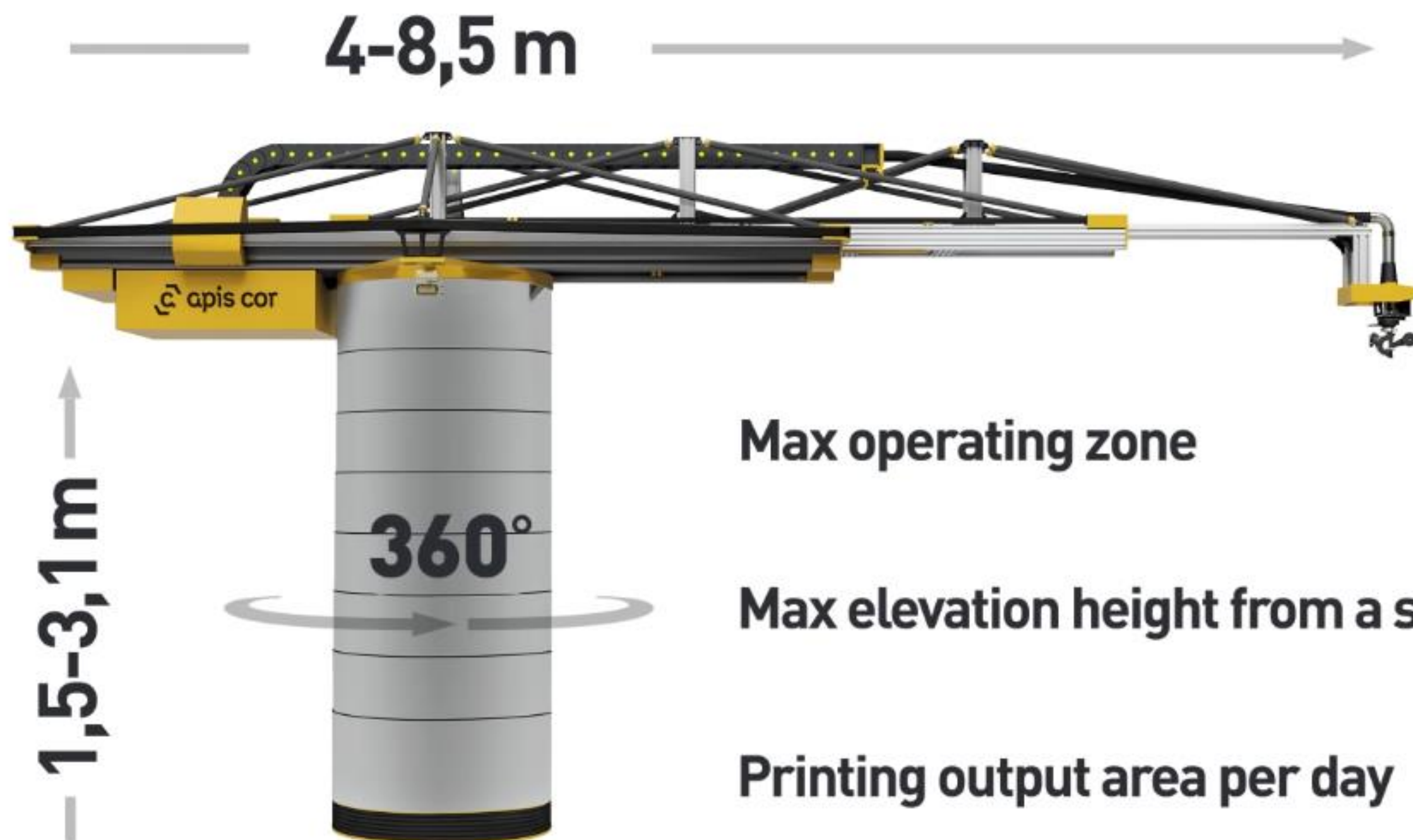
MADWORKSHOP
MADWORKSHOP
MADWORKSHOP
MADWORKSHOP
MADWORKSHOP

Apis Cor

3D printed concrete structures

<https://www.apis-cor.com/>

 **AUTODESK**. TECHNOLOGY CENTERS



Max operating zone

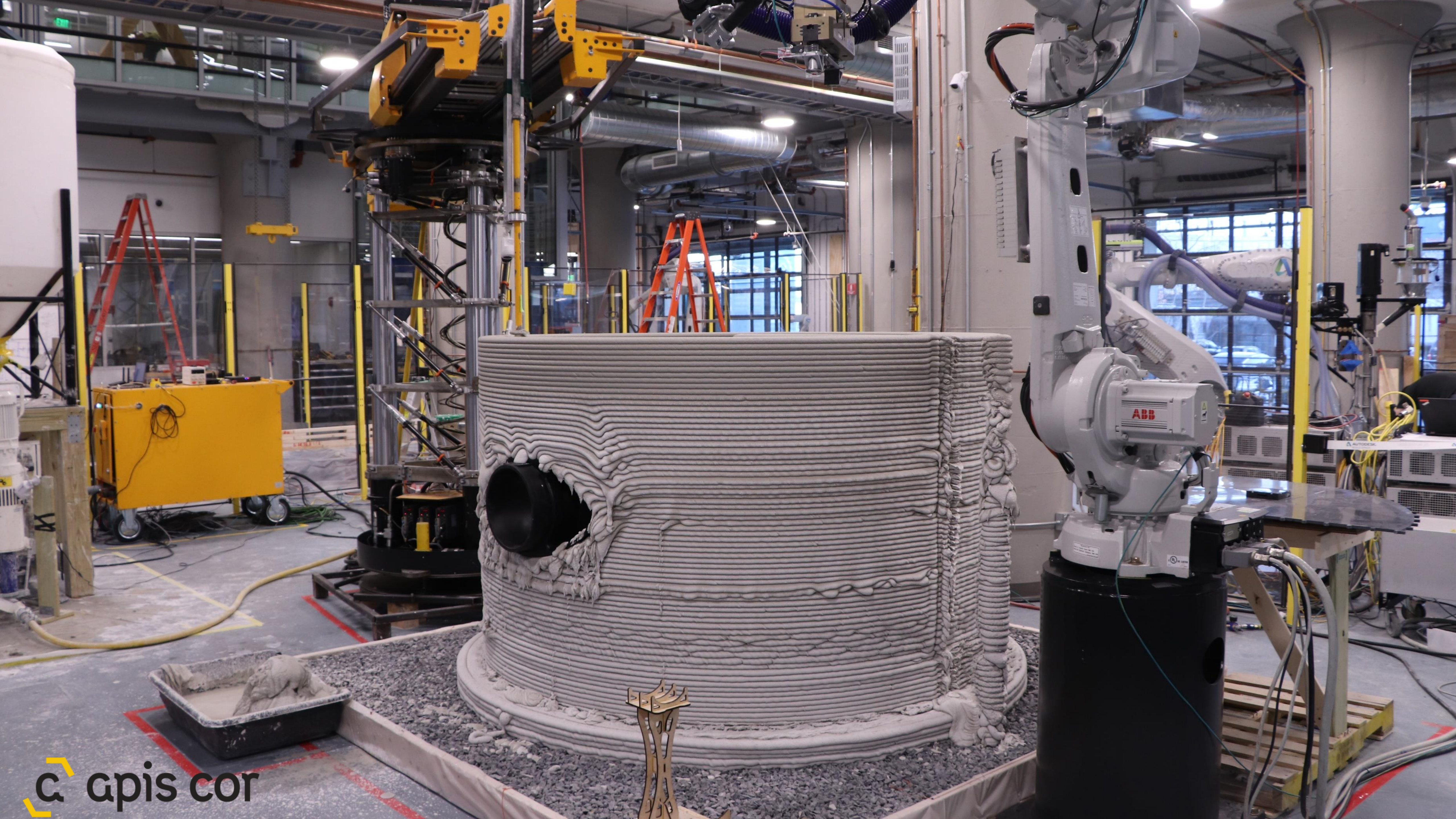
132 m²

Max elevation height from a single point

3300 mm

Printing output area per day

100 m²



Supported by



<https://www.youtube.com/watch?v=SLHAj8cl3R4>







 **apis cor**







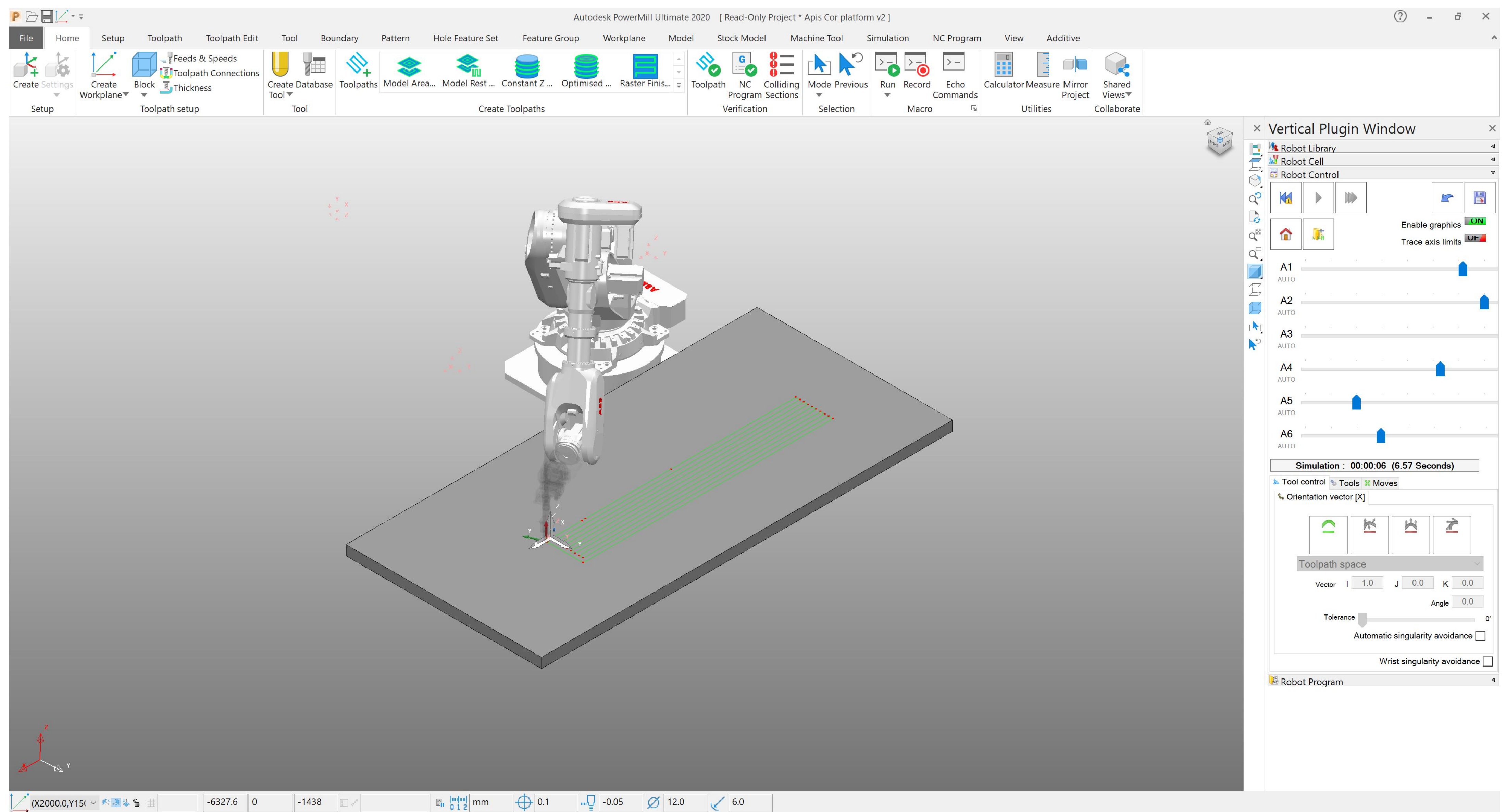
640 SQ. METERS



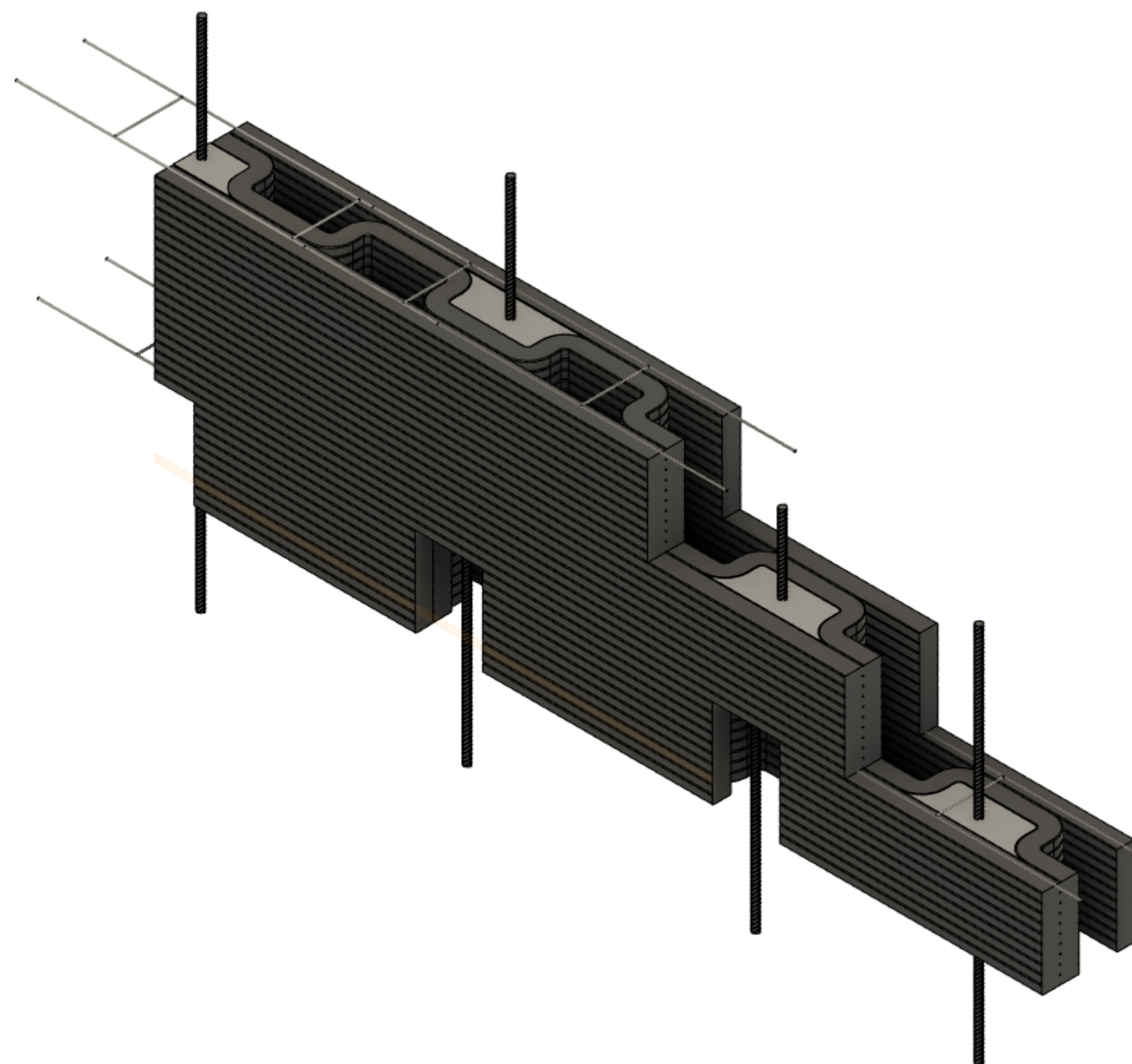
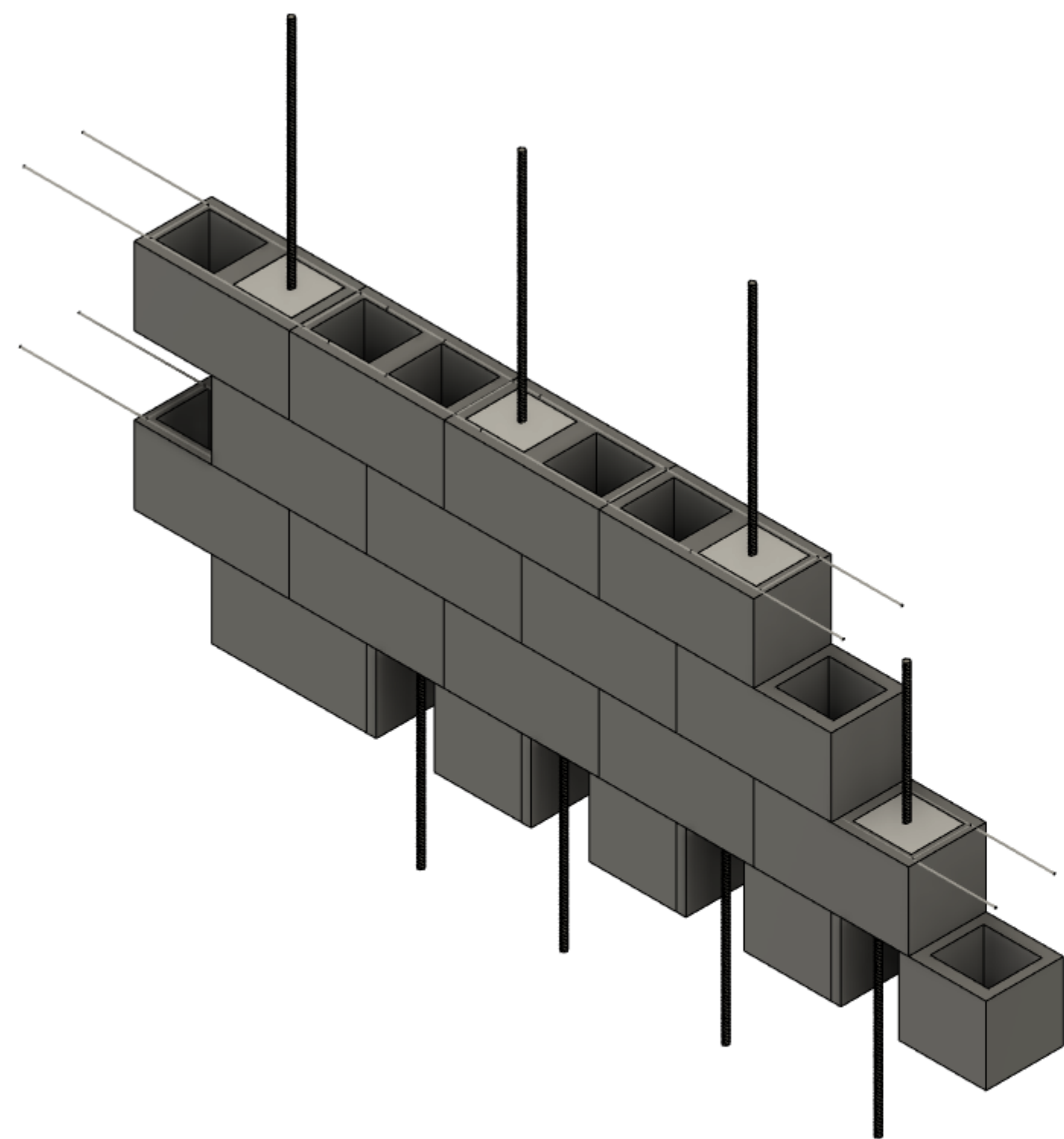


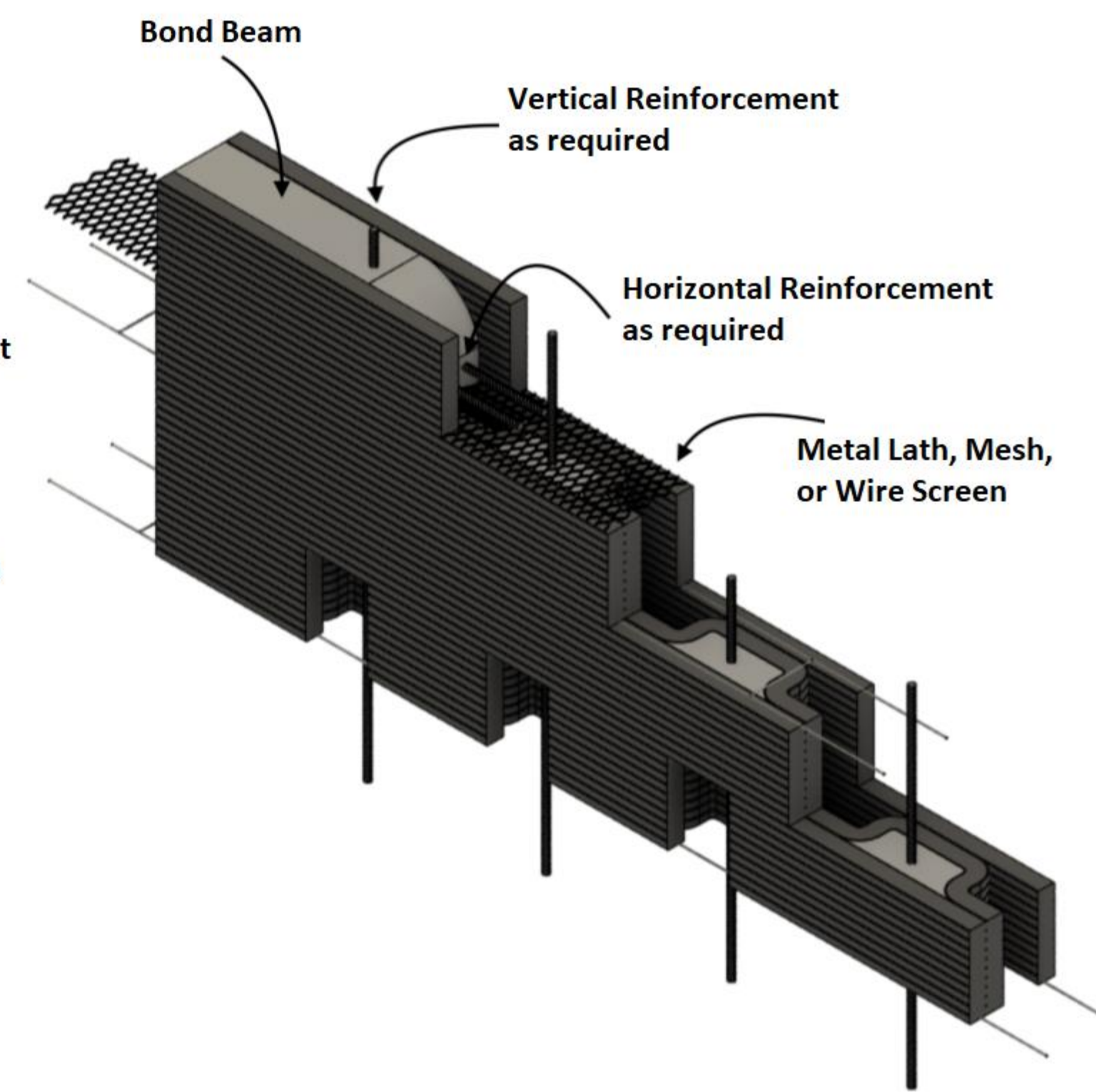
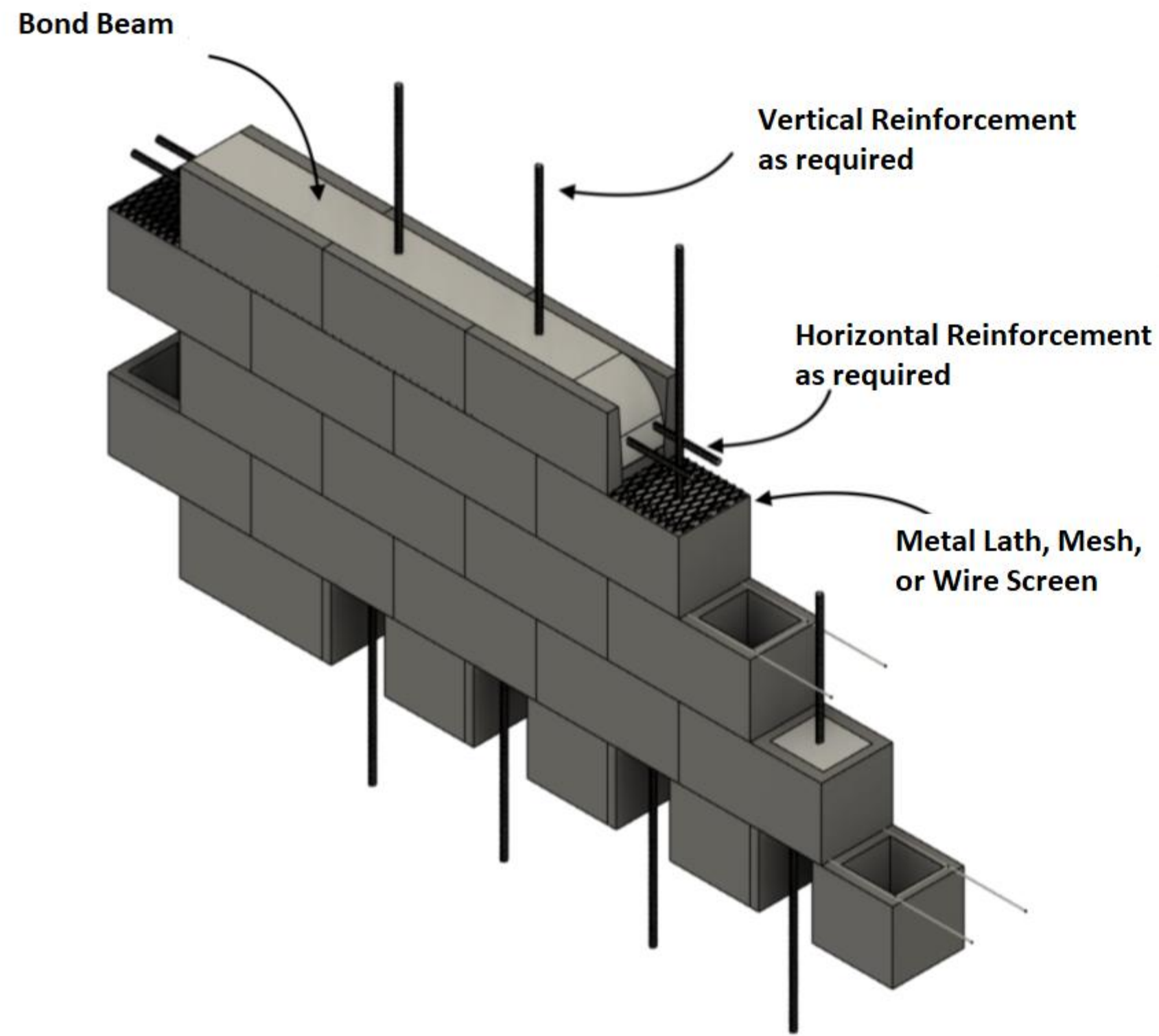




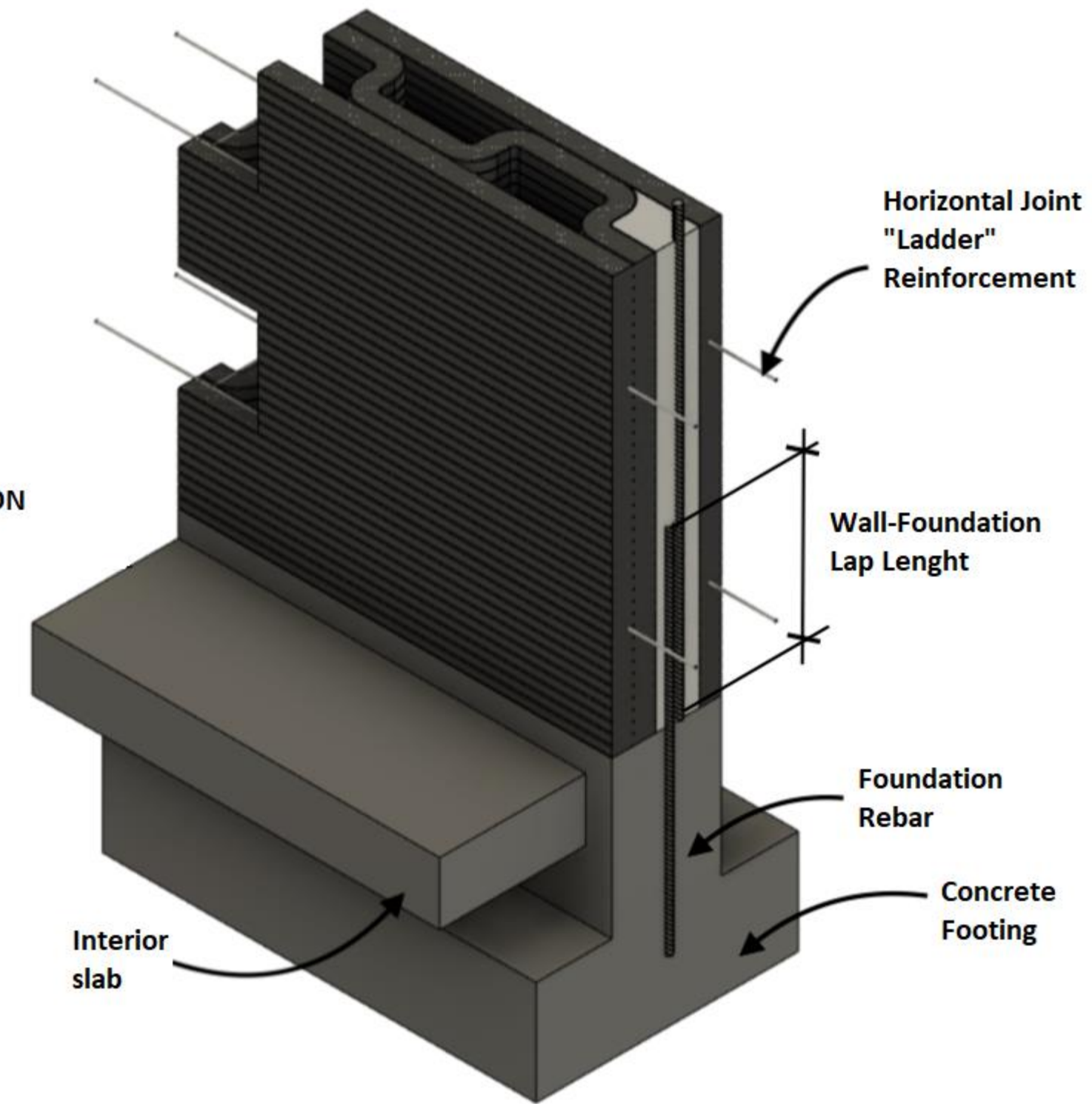
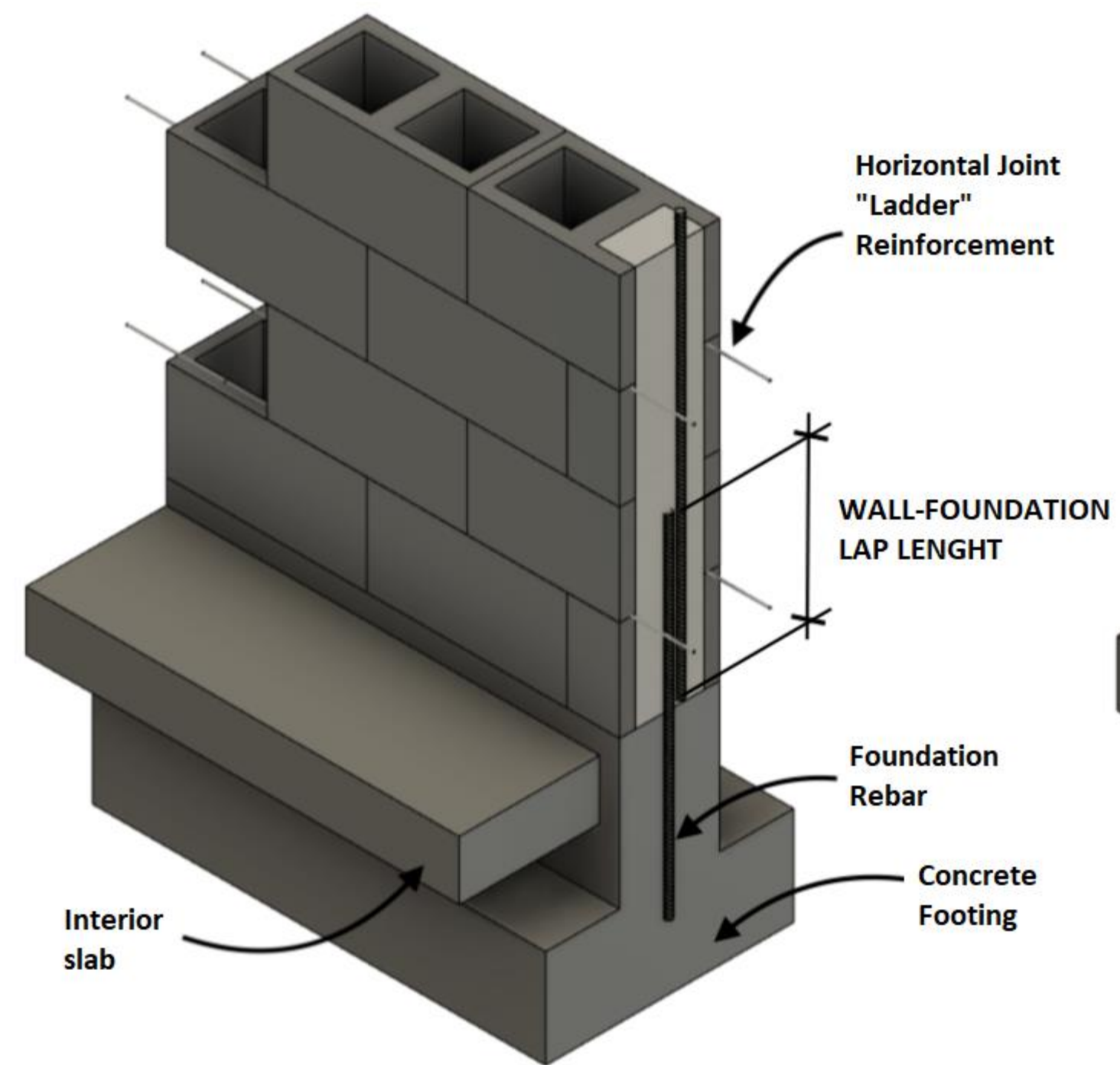


<https://manufacturing.autodesk.com/solutions/robotics/>

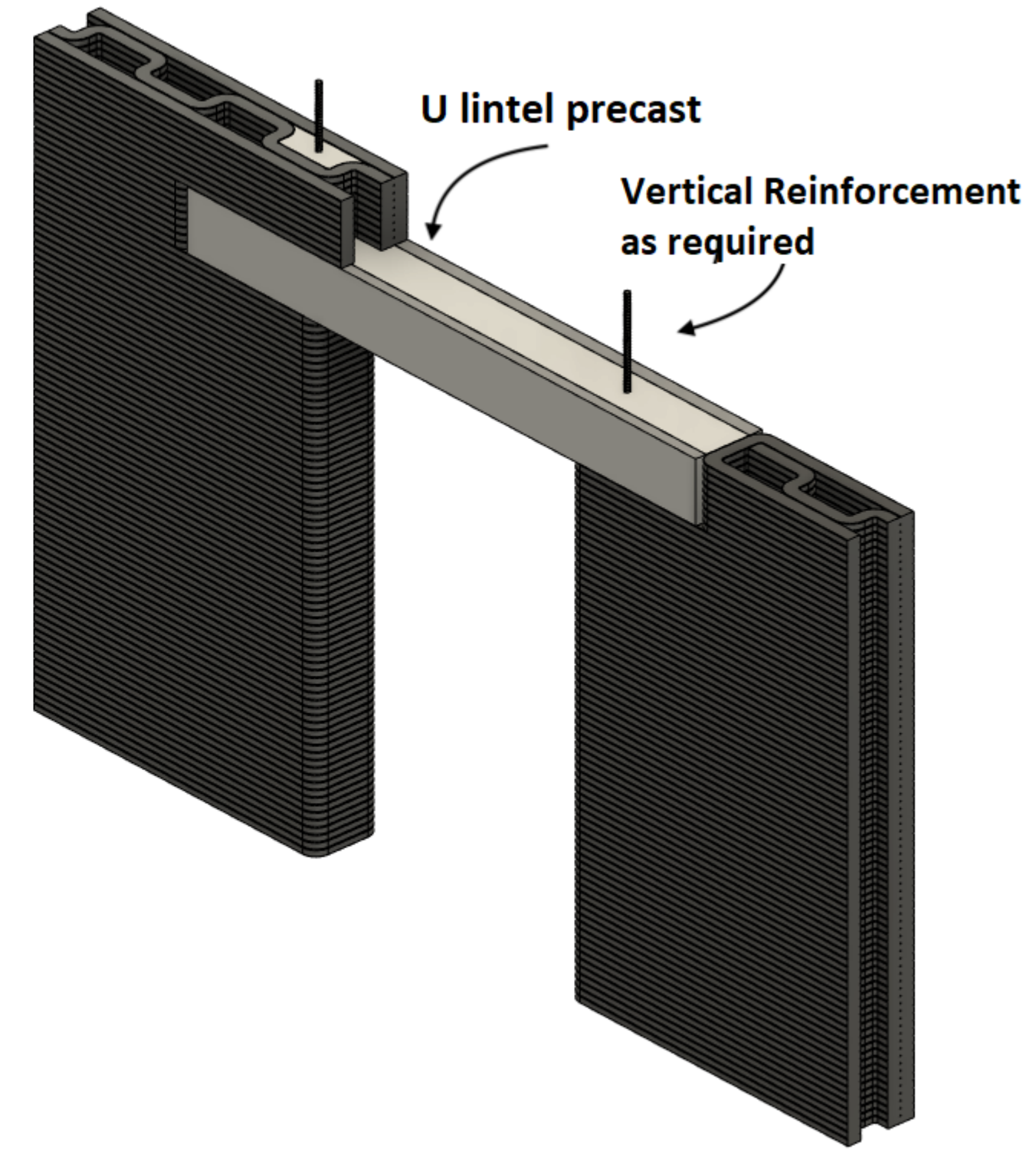
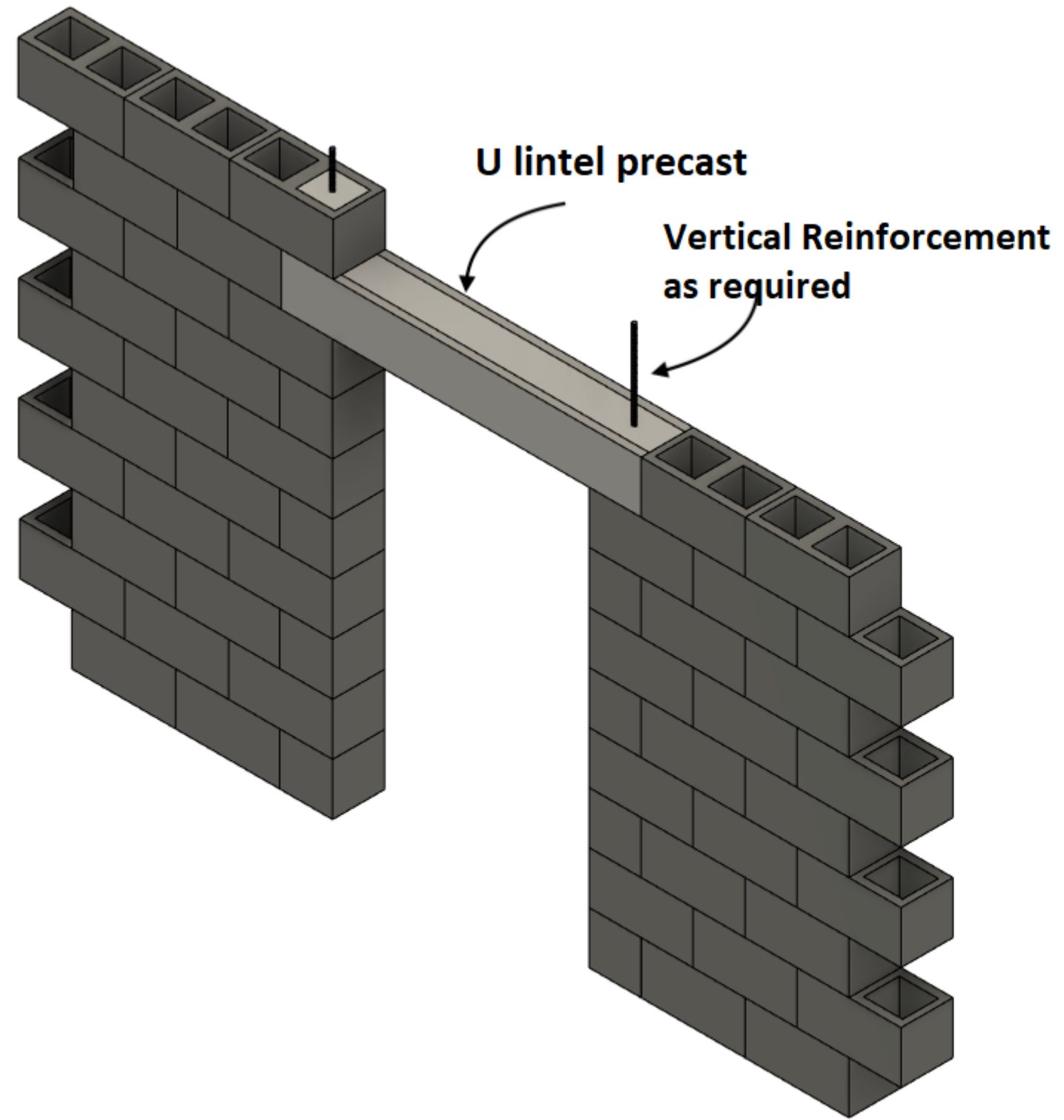




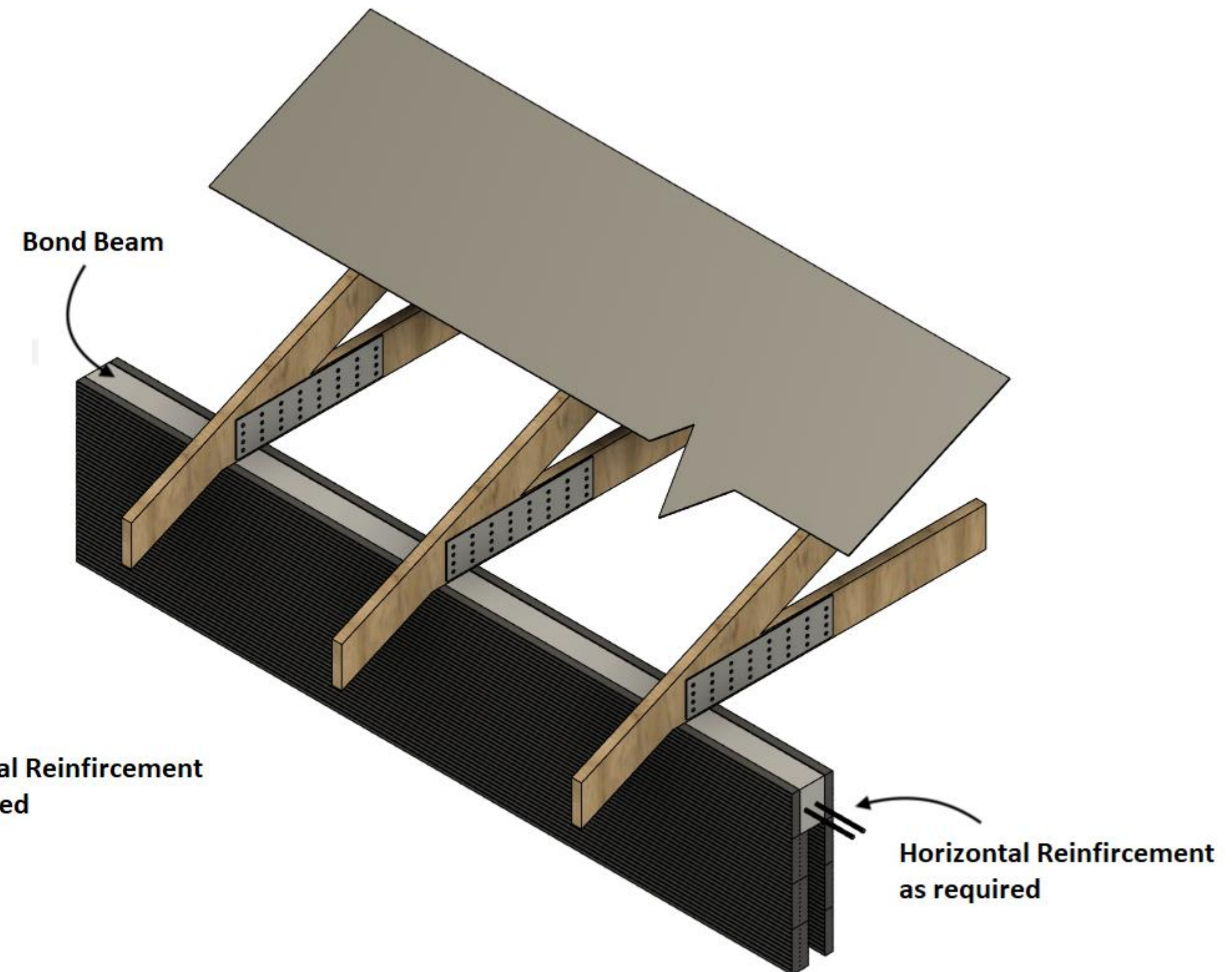
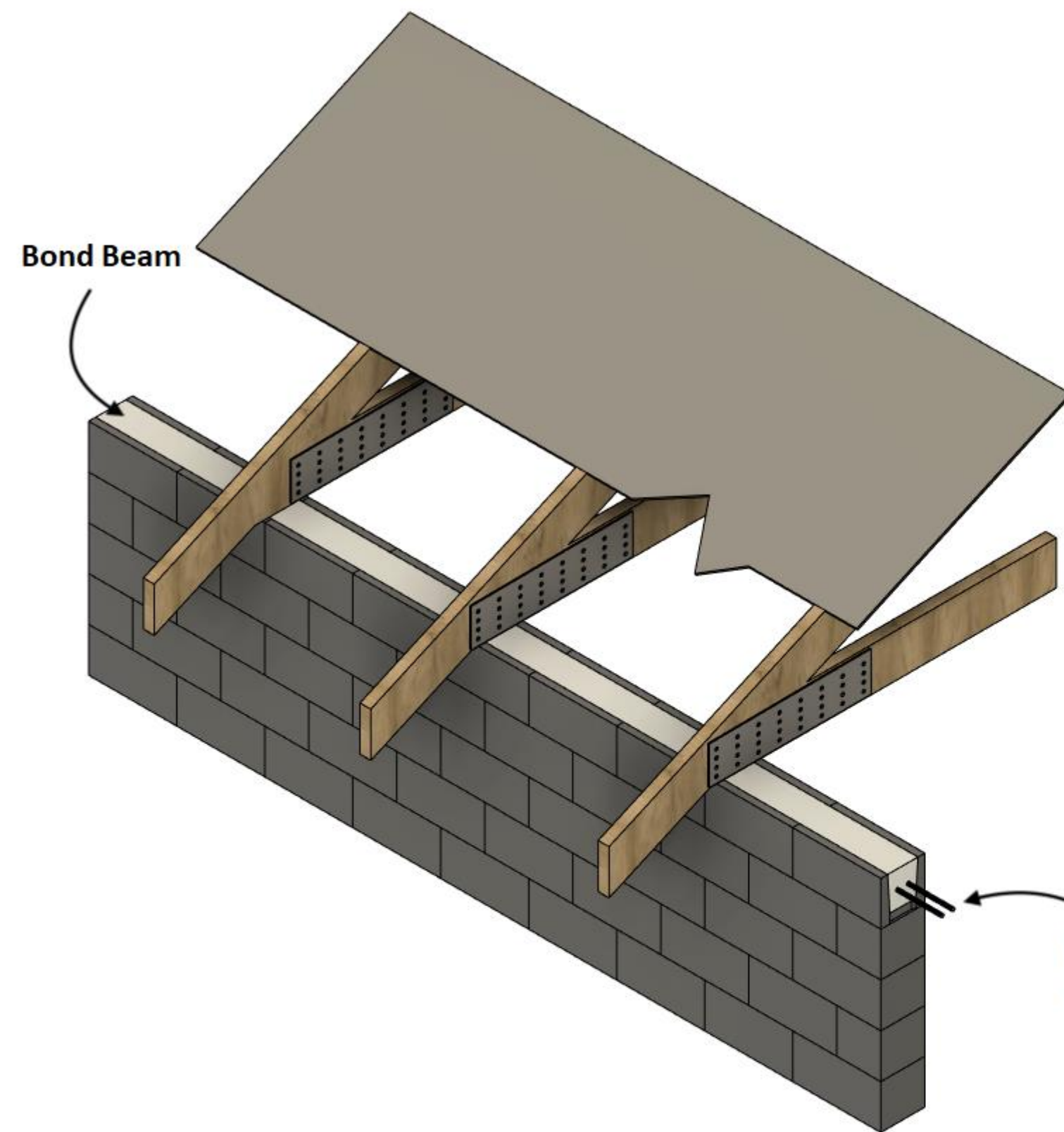
Apis Cor
2019



Apis Cor
2019



Apis Cor
2019



Apis Cor
2019

Perkins and Will

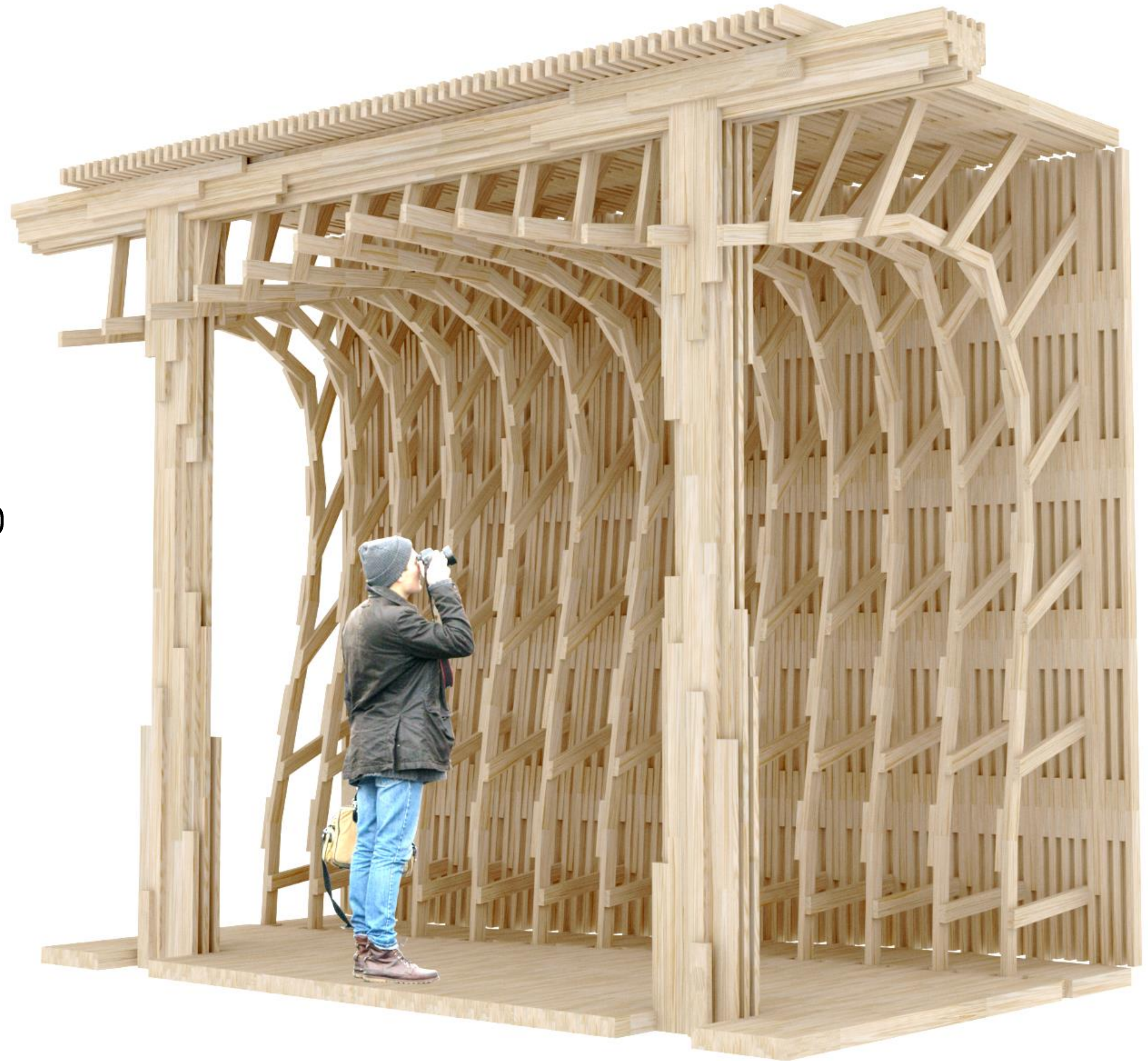
Robotic fabrication of Nail Laminated Timber Pavilion

<https://perkinswill.com/news/turning-imagined-designs-into-constructed-reality-with-robots/>

 **AUTODESK** TECHNOLOGY CENTERS

GOALS:

1. ROBOTIC FABRICATION OF WOOD STRUCTURE
2. SCALABLE SYSTEM APPLICABLE TO MULTI-STORY CONSTRUCTION
3. FIRE-RESISTIVE ASSEMBLY



NAIL LAMINATED
TIMBER (NLT)



OFF THE SHELF LUMBER



WOOD NAILS



FIRE RESISTANCE

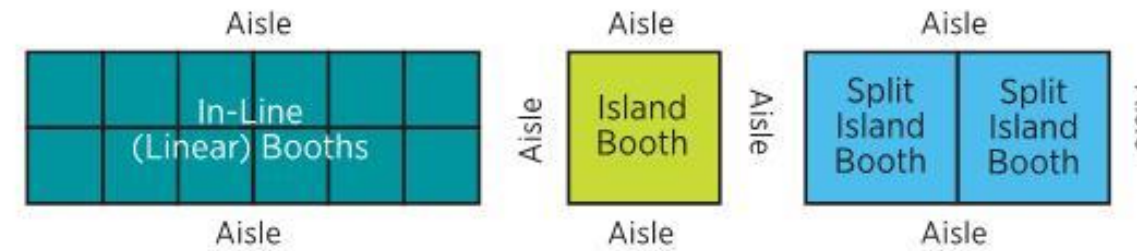


Please review the following to ensure that your display meets the Booth Specifications. If your booth does not meet these specifications, you must submit a rendering of your display to Show Management for review. All booths, regardless of size, are required to follow these guidelines.

To avoid additional costs (i.e. design cost or tear down of an unapproved structure), please obtain written approval before beginning production or construction of display. All requests must be in writing; e-mail karen.young@informa.com for approval or with any questions.

Booth Configurations:

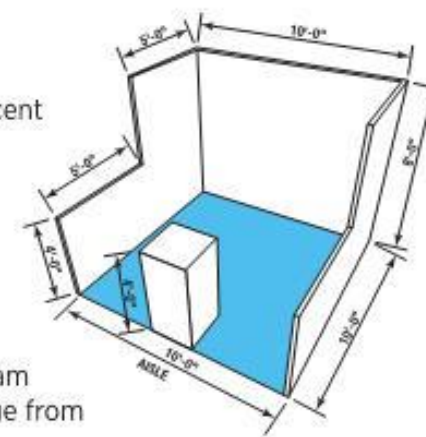
Carpeting is NOT required in your booth



In-Line (Linear) Booth (Booths 10' x 10')

Definition: In-Line Booths have only one side exposed to an aisle and have at least one adjacent neighbor on either side of the booth.

Booths are most commonly 10' wide by 10' deep. No booth construction or signage may exceed 8' in overall height. The maximum height of 8' is permitted on the back 5' section and a maximum height of 4' is permitted on the front 5' section. Please reference the diagram of allowable configurations. No hanging signage from the ceiling is allowed in an In-Line Booth.



Note: When three or more In-Line Booths are used as a single booth space, the 4' height limitation is applied only to that portion of booth space which is within 10' of an adjoining booth.

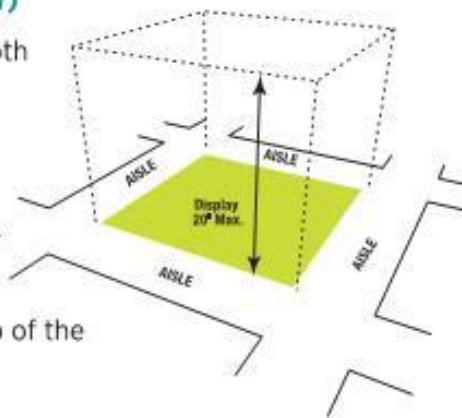
A Corner Booth is an In-Line Booth exposed to aisles on two sides. The same rules for In-Lines apply for Corner Booths.

Booth Equipment: Standard 10' x 10' In-Line Booths will be set with 8' high back drape and 3' high side drape.

Island Booths (Booths 20' x 20' or greater)

Definition: An Island Booth is any size booth exposed to aisles on all four sides of the booth with no adjacent neighbors.

Booth fixtures, components and signage will be permitted up to a maximum height of 20'. Hanging signs from the ceiling are permitted in Island Booths that are 400 square feet and larger, but the top of the sign may not exceed 20' in overall height.



Multi-Level Booths

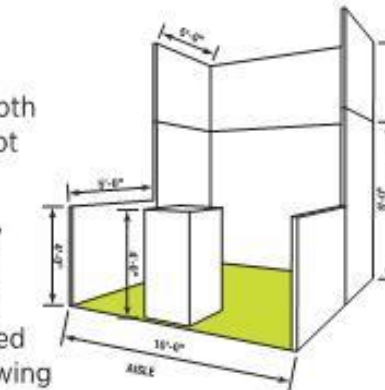
Definition: An island booth with a second level, not to exceed 20'.

You MUST receive approval from Show Management and the Fire Marshal when building a multi-level booth to insure that your display meets the necessary fire safety precautions involving smoke alarms, fire extinguishers, sprinkler systems, etc. You must have drawings available for inspection by Show Management, the installation and dismantling contractor, the exhibitor and governmental authority during the time the exhibit is being erected, exhibited and dismantled at the show site that include a signature or stamp of a reviewing structural engineer indicating that the structure designed is properly engineered for its proposed use, and a signature of an authorized official of the exhibit building company indicating that the structure is built in compliance with the details and specifications set forth on the drawings. Signs must also be posted indicating the maximum number of people that the structure will accommodate.

Perimeter In-Line Booth (Booths 10' x 10')

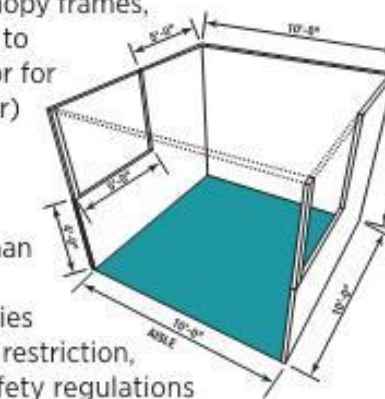
Definition: A Perimeter Booth is an In-Line Booth that is the outermost aisle of booths that do not back up to another booth.

All guidelines for In-Line (Linear) Booths apply to Perimeter Booths except that the maximum backwall height allowed on the back 5' section is 12'. No hanging signage from ceiling is allowed in a Perimeter Booth. Please reference the drawing for a diagram of the allowable configurations.



In-Line (Linear) Booth with Canopies and Ceilings

Canopies, including ceilings, umbrellas and canopy frames, can be either decorative or functional (such as to shade computer monitors from ambient light or for hanging products). Canopies for In-Line (Linear) or Perimeter Booths should comply with line of sight requirements.



The base of the Canopy should not be lower than 7' from the floor within 5' of any aisle. Canopy supports should be no wider than 3". This applies to any booth configuration that has a sightline restriction, such as an In-Line (Linear) Booth. Fire and safety regulations in many facilities strictly govern the use of canopies, ceilings and other similar coverings.

Hanging Signs

Hanging signs will be permitted in Island and Split Island Booths ONLY (minimum of 400 sq. ft.) at a 20' maximum from floor to top of sign.

Signs may be hung from the ceiling (where permitted), trusswork or equipment. Signs that will be hung from the ceiling or trusswork must be installed and dismantled by the Rigging Crew.

Unfinished Walls

Any unfinished walls are subject to review by Show Management. Should Show Management deem the backside of the booth "unsightly" and/or does not conform to the overall quality of the show, the exhibitor may be required to drape the backside of the booth at the exhibitor's expense.

NOTE: Regulations for products being featured in booths differ from the booth display regulations. If your product does not meet booth specifications, send detailed specs and available photos to karen.young@informa.com.

GREENBUILD BOOTH DESIGN GUIDELINES

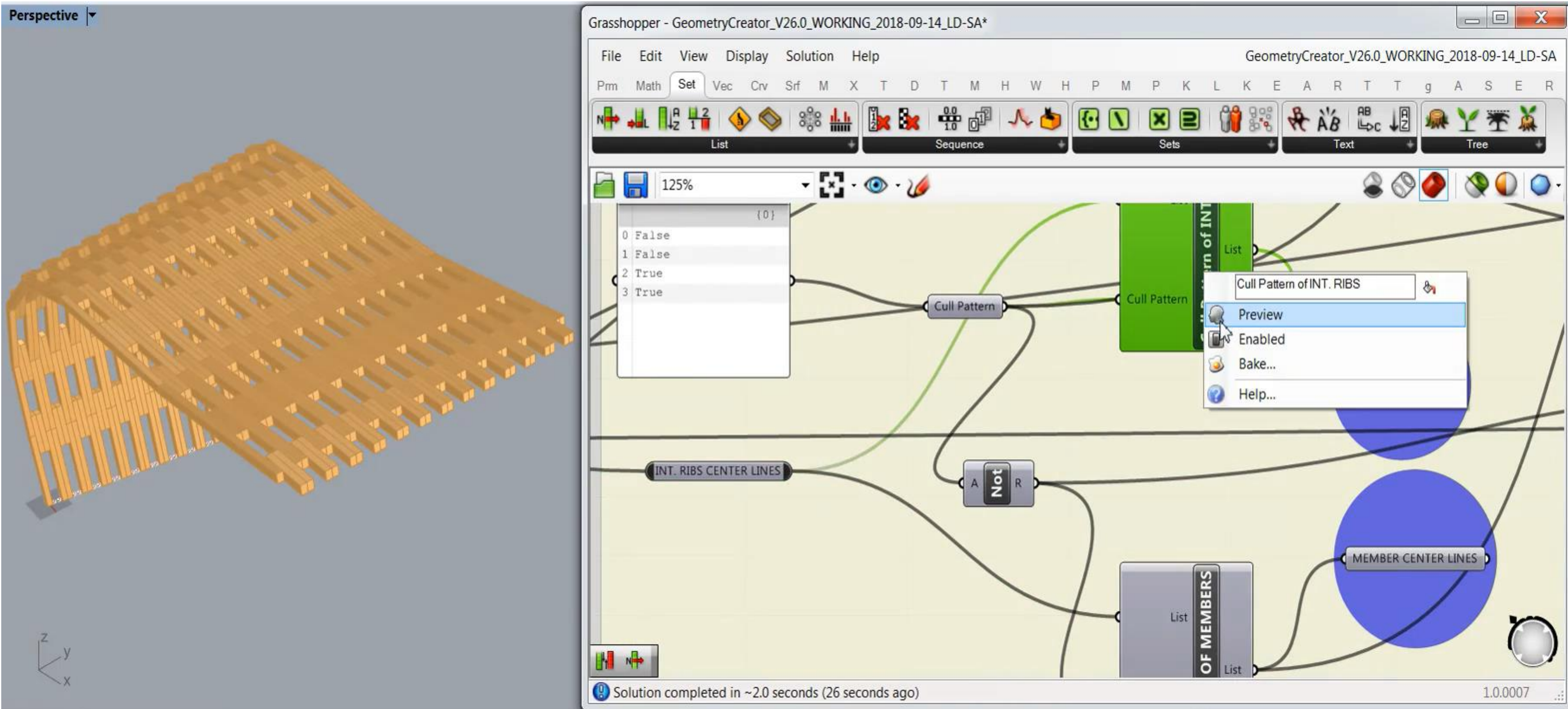
ROBOTIC FABRICATION OF NAIL LAMINATED TIMBER

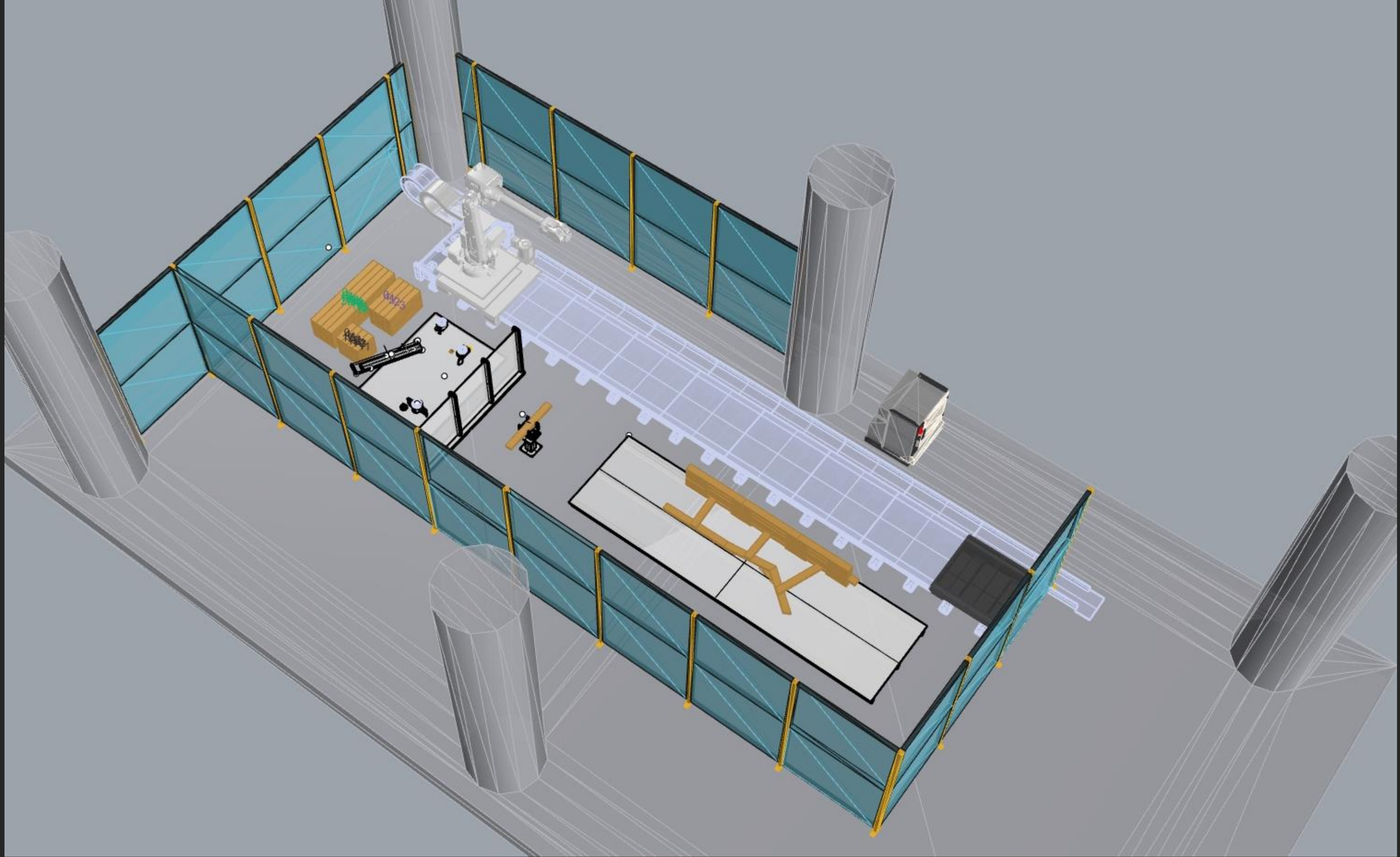
GREENBUILD 2018



<https://youtu.be/awd3qwTV6uc>

DESIGN FLEXIBILITY





MACHINA

ROBOT

NAME

ROBOTEXMACHINA

BRAND

ABB

CONNECTION

MANAGER

MACHINA

IP

127.0.0.1

PORT

7000

CONNECT

BRIDGE

SERVER

ws://127.0.0.1:6999/Bridge

CLIENTS

Machina GBP

RESET BRIDGE

STATUS

POSITION	-
ORIENTATION	-
AXES	-
EXT.AXES	-
SPEED/ACCELERATION	-
PRECISION	-
MOTION MODE	-
TOOL	-

QUEUE

INSTRUCTION

[x] #1 SpeedTo(600);

[>] #2 DefineTool("SuctionGRIPPER1",-6.27760940160413,2.82027152863479,304.806216

[.] #3 DefineTool("MillingSPINDLE1",307.590543131765,2.13641310085247,213.1584690

[.] #4 DefineTool("CircSAW1",-56.358023966162,-63.1468186879592,367.217,0.8638751

[.] #5 DefineTool("WoodNAILER1",0.4855175,6.00388,453.3118,0,-1,0,1,0,0,5.8,0.242

[x] #7 ExternalAxisTo(1,1950);

[x] #8 SpeedTo(1990);

[x] #9 TransformTo(987.69,-2004.62,713.45,-0.018,1,0.015,1,0.018,-0.009);

[x] #10 TransformTo(987.69,-2004.62,-236.55,-0.018,1,0.015,1,0.018,-0.009);

[x] #11 WriteDigital("Do_ToolChange",True);

[x] #12 Wait(500);

[x] #13 WriteDigital("Do_1_ToolAttach",False);

[x] #14 SpeedTo(50);

[x] #15 TransformTo(987.69,-2004.62,-286.55,-0.018,1,0.015,1,0.018,-0.009);

[x] #16 SpeedTo(1990);

[x] #17 Wait(500);

[x] #18 WriteDigital("Do_ToolChange",False);

[x] #19 Wait(500);

[x] #20 WriteDigital("Do_1_ToolAttach",True);

[x] #21 Wait(500);

[x] #22 TransformTo(987.69,-2004.62,713.45,-0.018,1,0.015,1,0.018,-0.009);

[x] #23 AttachTool("SuctionGRIPPER1");

[x] #24 ExternalAxisTo(1,500);

[x] #25 SpeedTo(1000);

[x] #26 WriteDigital("Do_9",True);

[x] #27 TransformTo(-378.921,-992.712,949.12,0,1,0,1,0,0);

[x] #28 TransformTo(-378.921,-992.712,49.12,0,1,0,1,0,0);

[x] #29 SpeedTo(100);

[x] #30 TransformTo(-378.921,-992.712,-50.88,0,1,0,1,0,0);

[x] #31 Wait(1500);

CONSOLE

CLEAR4 - VERBOSE

VERBOSE: Action from "Machina GBP": WriteDigital("Do_5",False);

VERBOSE: Action from "Machina GBP": WriteDigital("Do_9",True);

VERBOSE: Action from "Machina GBP": SpeedTo(600);

VERBOSE: Action from "Machina GBP": TransformTo(465.804,-1706.346,-11.487,-0.004,0.821,-0.57,0.83,-0.316,-0.46);

VERBOSE: Action from "Machina GBP": SpeedTo(300);

VERBOSE: Action from "Machina GBP": TransformTo(409.959,-1753.849,-79.492,-0.004,0.821,-0.57,0.83,-0.316,-0.46);

VERBOSE: Action from "Machina GBP": Wait(1500);

VERBOSE: Action from "Machina GBP": SpeedTo(500);

VERBOSE: Action from "Machina GBP": TransformTo(521.65,-1658.843,56.518,-0.004,0.821,-0.57,0.83,-0.316,-0.46);

VERBOSE: Action from "Machina GBP": SpeedTo(600);

VERBOSE: Action from "Machina GBP": TransformTo(557.461,-1687.548,467.375,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": SpeedTo(1000);

VERBOSE: Action from "Machina GBP": ExternalAxisTo(1,3000);

VERBOSE: Action from "Machina GBP": PrecisionTo(200);

VERBOSE: Action from "Machina GBP": TransformTo(1212.896,-1472.999,420.481,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": TransformTo(2011.896,-1472.999,420.481,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": PrecisionTo(3);

VERBOSE: Action from "Machina GBP": WriteDigital("Do_3",True);

VERBOSE: Action from "Machina GBP": TransformTo(2428,-1498.63,-20.4,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": SpeedTo(300);

VERBOSE: Action from "Machina GBP": TransformTo(2428,-1498.63,-120.4,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": Wait(300);

VERBOSE: Action from "Machina GBP": WriteDigital("Do_3",False);

VERBOSE: Action from "Machina GBP": WriteDigital("Do_9",False);

VERBOSE: Action from "Machina GBP": Wait(300);

VERBOSE: Action from "Machina GBP": WriteDigital("Do_5",True);

VERBOSE: Action from "Machina GBP": Wait(1500);

VERBOSE: Action from "Machina GBP": SpeedTo(500);

VERBOSE: Action from "Machina GBP": TransformTo(2428,-1498.63,-20.4,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": WriteDigital("Do_5",False);

VERBOSE: Action from "Machina GBP": PrecisionTo(200);

VERBOSE: Action from "Machina GBP": SpeedTo(1990);

VERBOSE: Action from "Machina GBP": TransformTo(2011.896,-1472.999,420.481,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": TransformTo(1212.896,-1472.999,420.481,0,1,0,1,0,0);

VERBOSE: Action from "Machina GBP": PrecisionTo(5);

VERBOSE: Action from "Machina GBP": Message("Tool Should Be Detached Here");

VERBOSE: Action from "Machina GBP": DetachTool();

VERBOSE: Action from "Machina GBP": ExternalAxisTo(1,1950);

☒ Send on EnterSEND

FileHomeModelingSimulationControllerRAPIDAdd-Ins

Add Controller

Request Write Access

Release Write Access

Authenticate

Restart Backup

Inputs/Outputs

Events

File Transfer

FlexPendant

Online Monitor

Signal Analyzer Online

Jobs

Configuration

Load Parameters

Save Parameters

Properties

Installation Manager

Conveyor Tracking

Integrated Vision

Collision Avoidance

Controller

IRBT 4600_GB_1:View1

Virtual Controllers

4600-800107-IRBT

HOME

Configuration

Event Log

I/O System

RAPID

T_ROB1 (Program 'Pinocchio')

Program Modules

Machina_Driver

CursorsInitialize

CustomAction

GetExternalJointsData

GetJointTarget

GetRobTarget

GetSpeedData

GetToolData

GetZoneData

LogAction

Main

MainLoop

ParseBuffer

ParseLongStatement

ParseStatement

ParseStream

ReadStream

SendAcknowledgement

SendExtAx

SendInformation

SendJoints

SendPose

SendVersion

ServerFinalize

ServerInitialize

ServerRecover

StoreAction

StoreBuffer

IRBT 4600_GB_1:View1

Manual

4600-800107-IR.. (BOSPF15J..)

Motors On

Running (Speed 100%)

Production Window : Pinocchio in T_ROB1/Machina_Driver/ServerRecover

```
345 SocketAccept serverSocket, clientSocket \Client
346
347
348 TPWrite "Machina Driver: Connected to client:
349 TPWrite "Machina Driver: Listening to remote
350
351 ! Update the client with some data
352 SendVersion;
353 SendPose;
354 SendJoints;
355 SendExtAx;
356
357 ERROR
358 IF ERRNO = ERR SOCK_TIMEOUT THEN
```

Load Program... PP to Main Debug

Production Window

ROB_1 1/3

Controller Status

Output

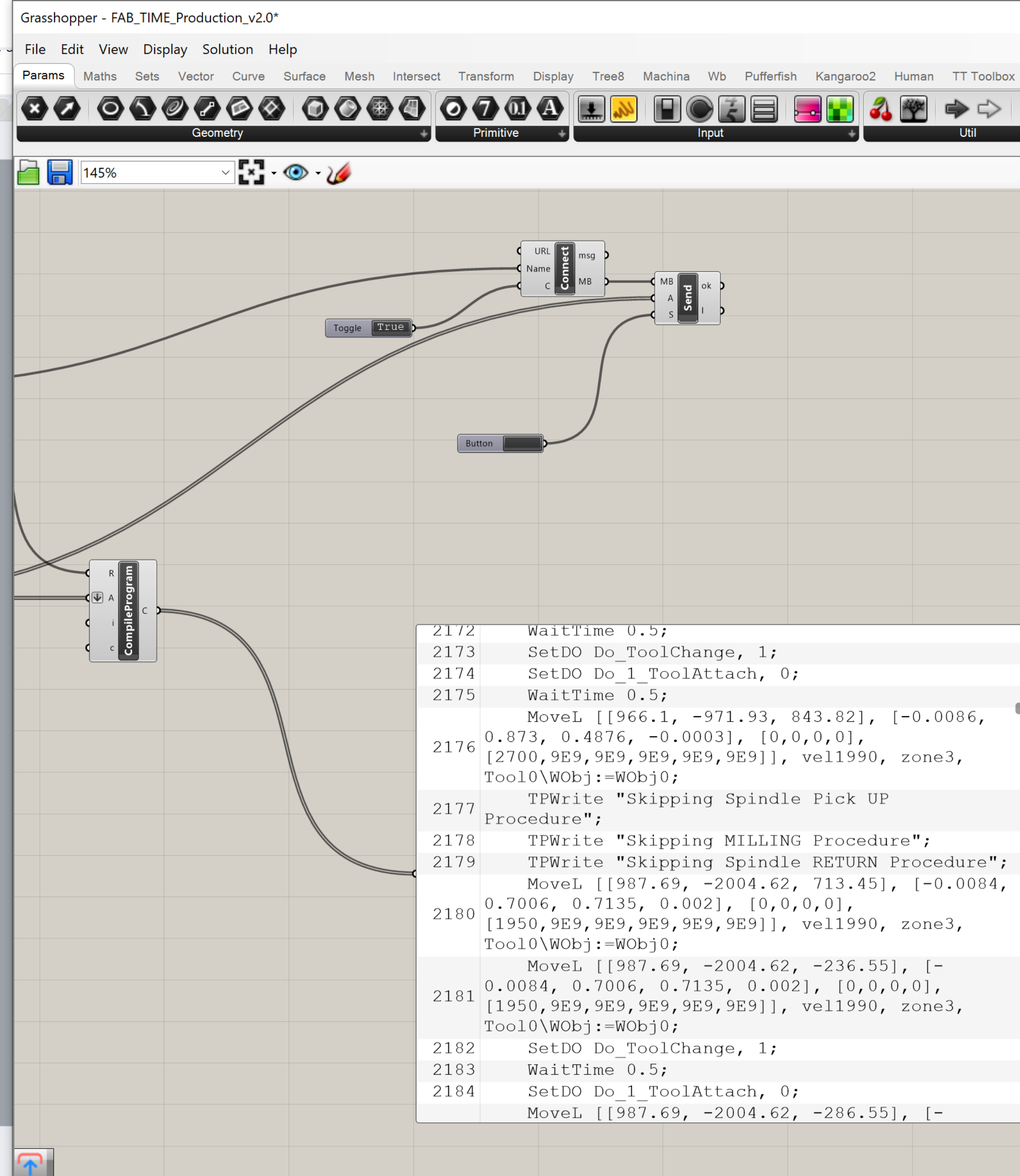
Search Results

Show messages from: All messages

4600-800107-IRBT (Local): 10053 - Regain ready	11/11/2019 7:52:36 AM	Event Log
4600-800107-IRBT (Local): 10151 - Program started	11/11/2019 7:52:36 AM	Event Log
4600-800107-IRBT (Local): 50024 - Corner path failure [8]	11/11/2019 7:56:30 AM	Event Log
4600-800107-IRBT (Local): 10125 - Program stopped	11/11/2019 7:56:52 AM	Event Log
4600-800107-IRBT (Local): 10002 - Program pointer has been reset [3]	11/11/2019 8:08:43 AM	Event Log
4600-800107-IRBT (Local): 10052 - Regain start	11/11/2019 8:08:47 AM	Event Log
4600-800107-IRBT (Local): 10053 - Regain ready	11/11/2019 8:08:47 AM	Event Log
4600-800107-IRBT (Local): 10151 - Program started	11/11/2019 8:08:47 AM	Event Log

4600-800107-IRBT (Local): 10151 - Program started

<https://new.abb.com/products/robotics/robotstudio>



<https://github.com/RobotExMachina/Machina-Grasshopper>

Autodesk Dynamo Studio

File Edit View Packages Settings Help

Library 07_3DPrinting.dyn

Search

MachinaDynamo

Actions

- Attach
- Axes
- AxesTo
- Comment
- Detach
- Extrude
- ExtrusionRate
- ExtrusionRateTo
- Message
- MotionMode
- Move
- MoveTo
- PopSettings
- Precision
- PrecisionTo
- PushSettings
- Rotate
- RotateTo
- Speed
- SpeedTo
- Temperature
- TemperatureTo
- Transform
- TransformTo
- Wait

A program where the robot 3D prints a surface.

Performs a compound absolute transformation to target Plane. The device's new absolute position and orientation will be those of the Plane.

INPUT

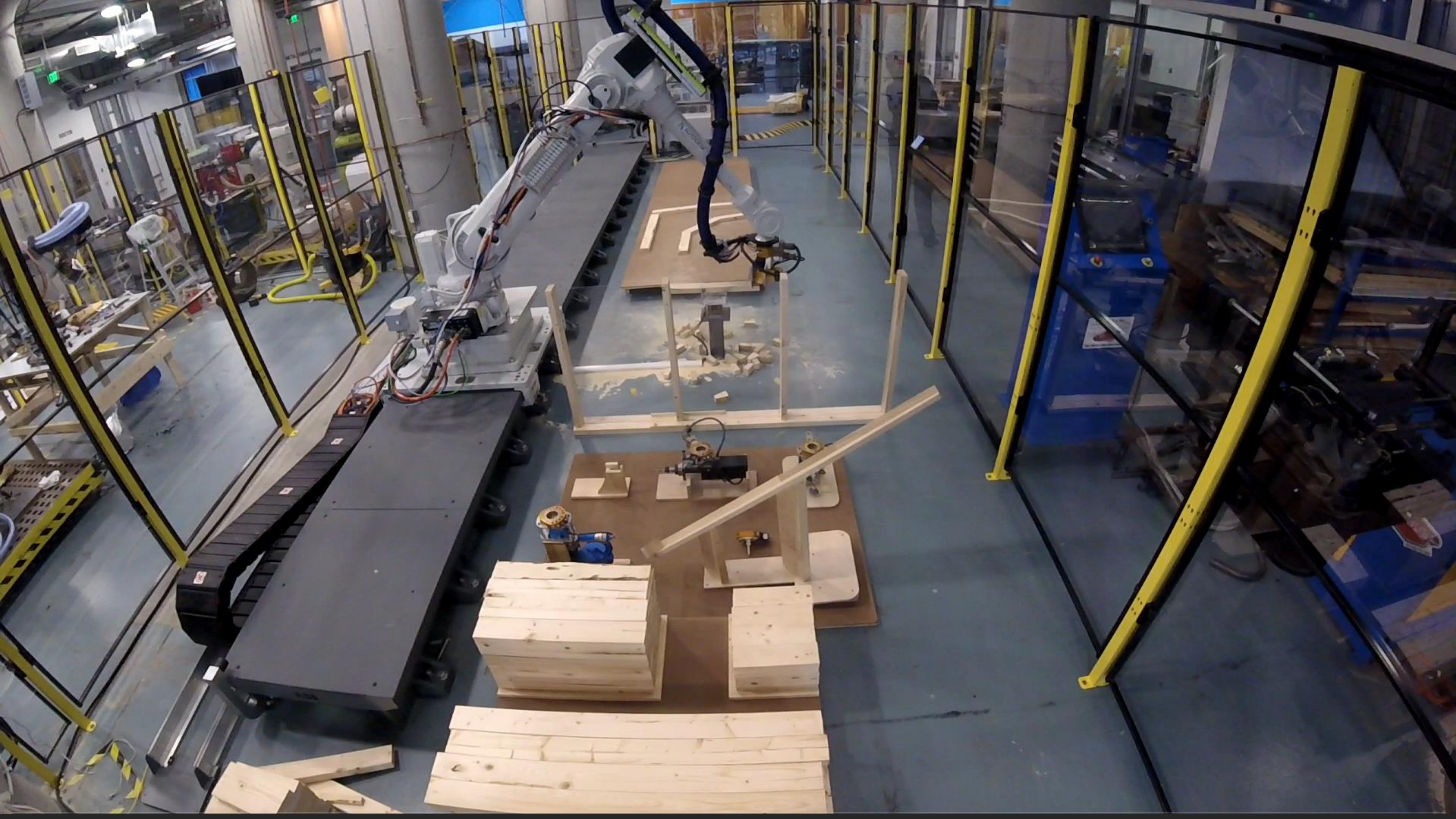
plane : Plane

OUTPUT

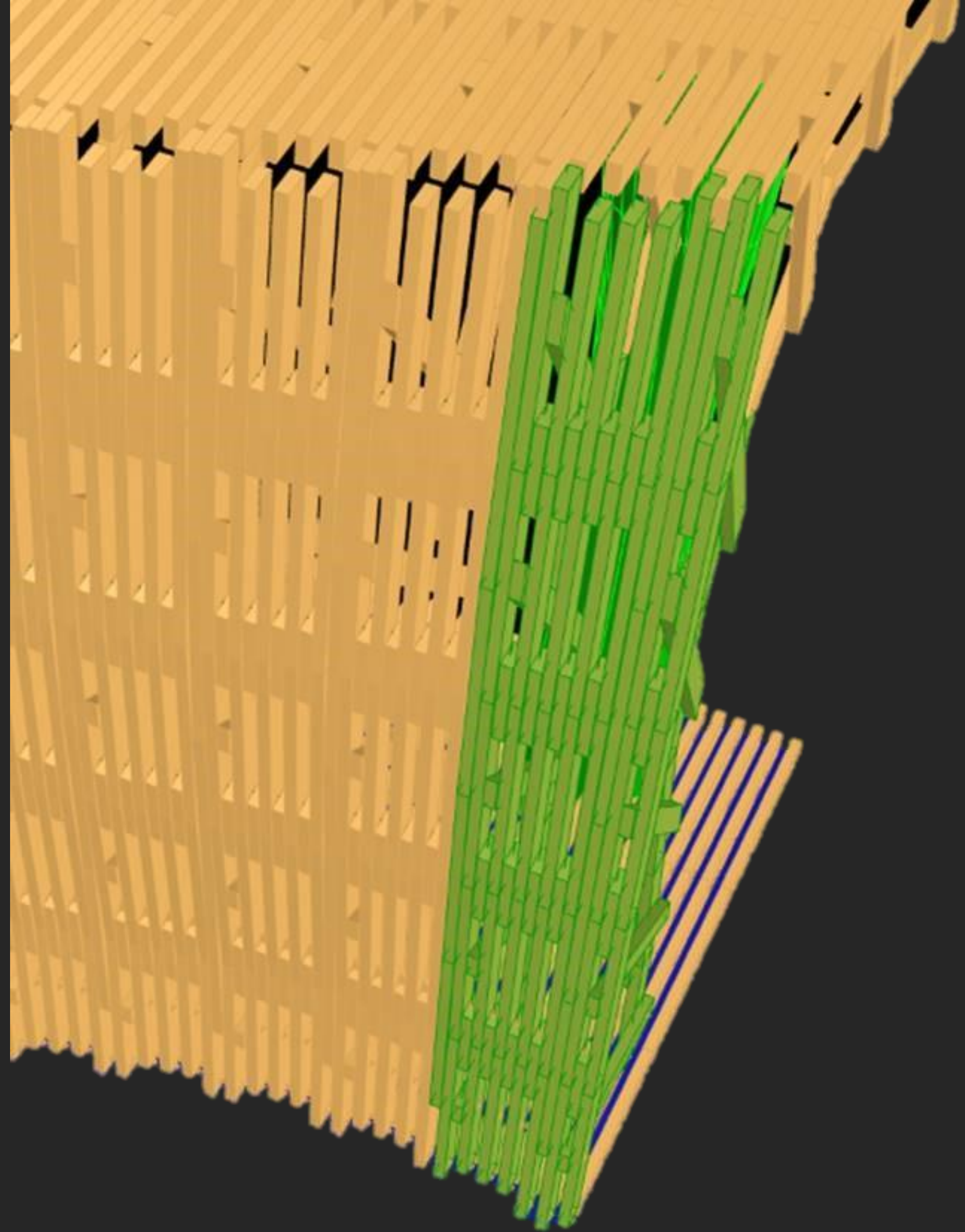
var

Automatic Run completed.

<https://github.com/RobotExMachina/Machina-Dynamo>

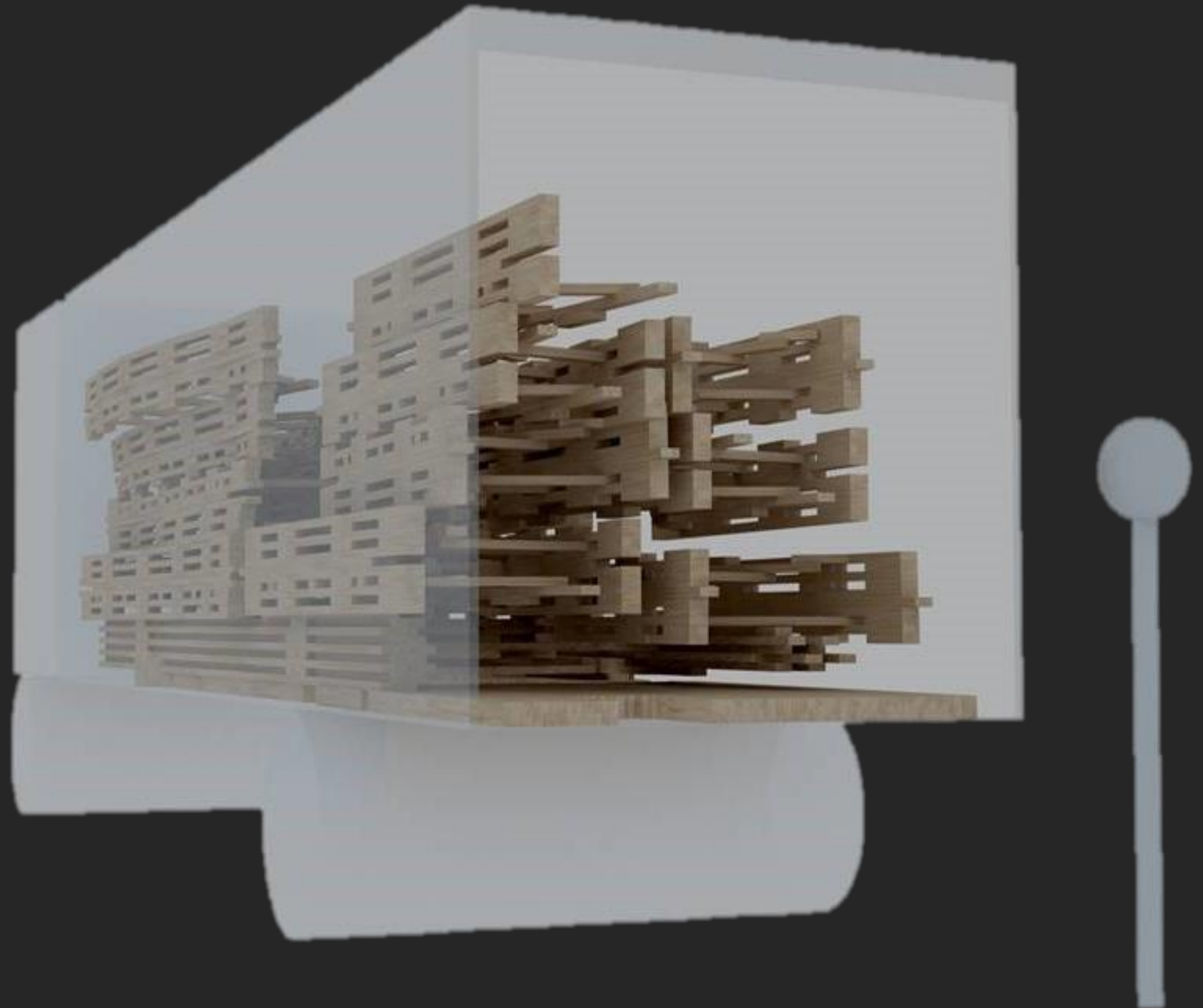


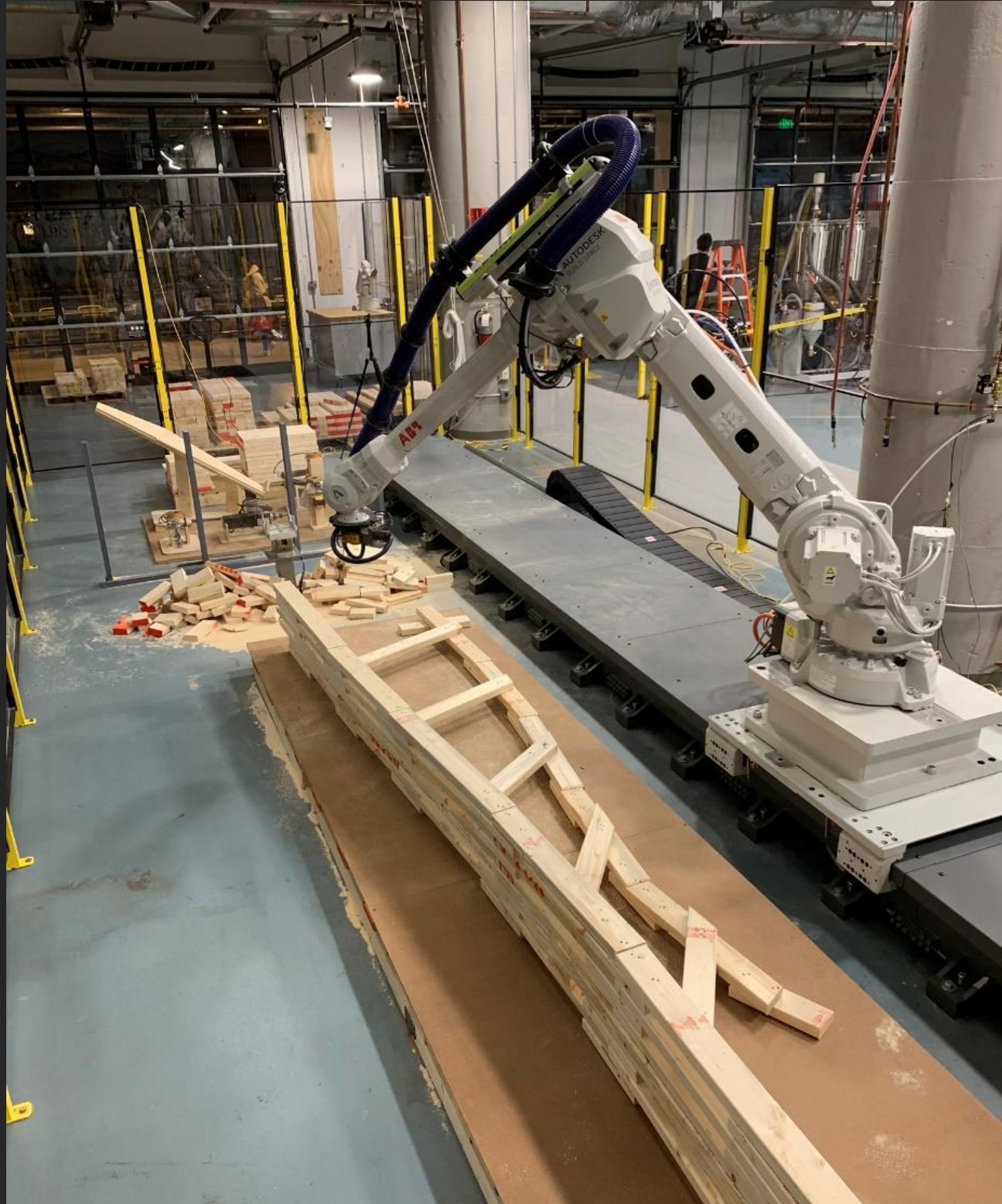
SUBDIVIDING STRUCTURE INTO
PANELS FOR FABRICATION

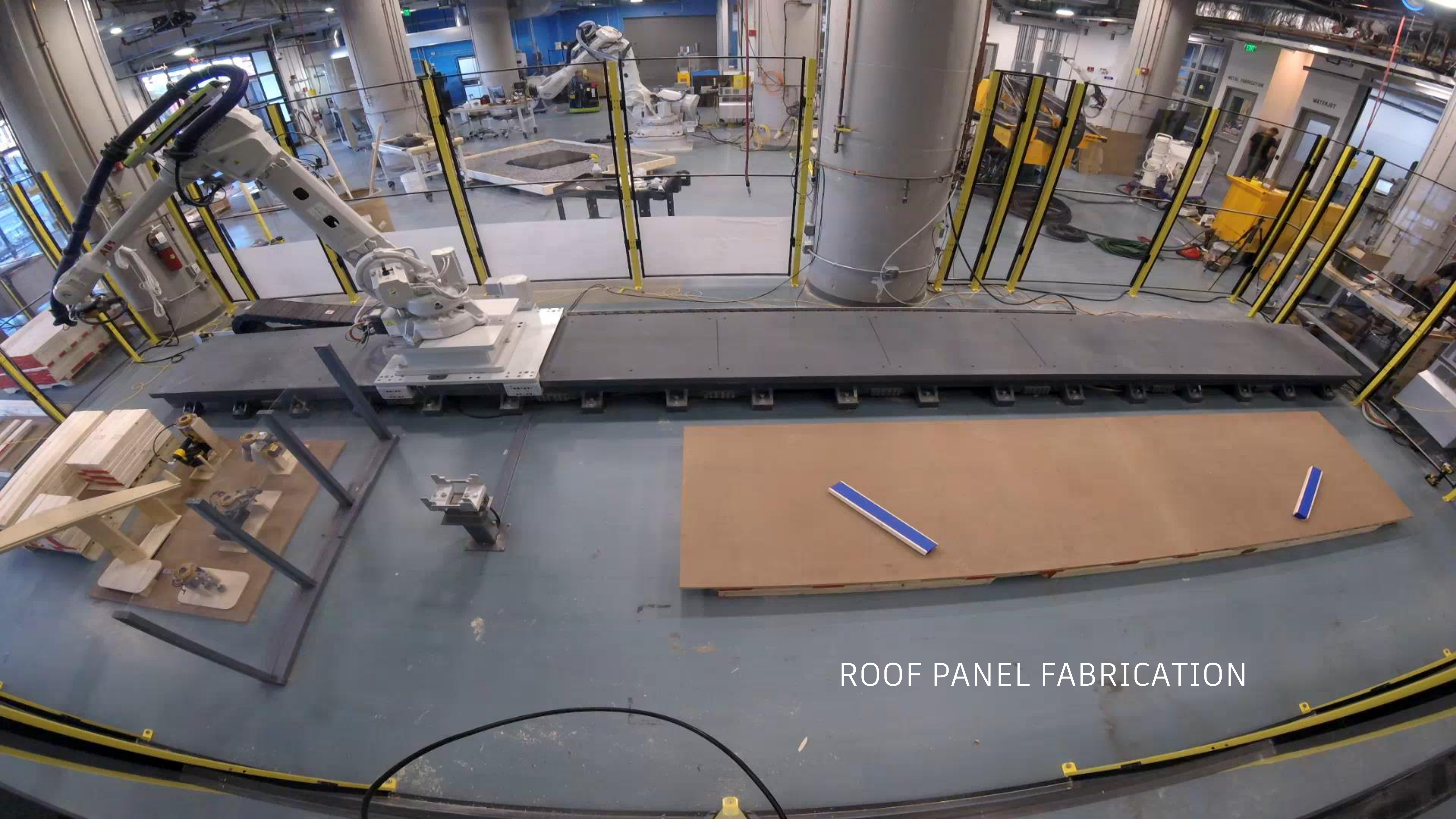


PANEL SIZE AND DESIGN

- BRAWN
- STORAGE
- TRUCK SIZE/QUANTITY
- STACKING
- LOADING DOCK







ROOF PANEL FABRICATION



COLUMN ASSEMBLY





PERKINS+WILL
Building Technology Lab

KESTREL: A FABRICATED WOOD LAMINATE TOWER
Perkins+Will is proud to announce the completion of the Kestrel tower, a 10-story, 100,000-sq-ft, 100% wood building. The tower is a testament to the power of wood as a sustainable building material. It is a landmark project for Perkins+Will and a testament to the power of wood as a sustainable building material.

Project Details:

- Location: Chicago, IL
- Client: Perkins+Will
- Architect: Perkins+Will
- Structural Engineer: Perkins+Will
- Interior Designer: Perkins+Will
- Construction Manager: Perkins+Will

Logos: Autodesk, Thornton Tomasetti, FASCO, Perkins+Will









PERKINS+WILL

Building Technology Lab

ROBOTICALLY FABRICATED NAIL LAMINATED TIMBER PAVILION
Perkins+Will is researching applications of robotics in sustainable architecture and construction. Digital technologies allow us to both optimize form and to build what once was the site of fabrication itself. This pavilion is an exploration in combining new parametric workflows with classic nail laminated timber assemblies.

- 1. Form-finding process
- 2. Digital fabrication
- 3. On-site assembly
- 4. Construction
- 5. Material optimization



AUTODESK

Thomson Tomasetti

FASCO

DeWALT

KOMODO



Structure

Perkins+Will X

Perkins+Will

Scans

ScanManager

PW_000

PW_001

PW_002

PW_004

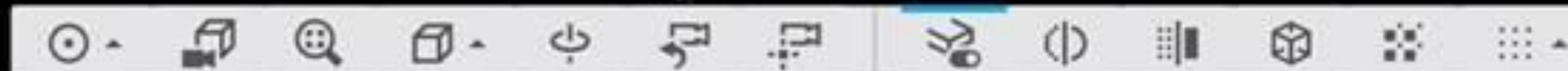
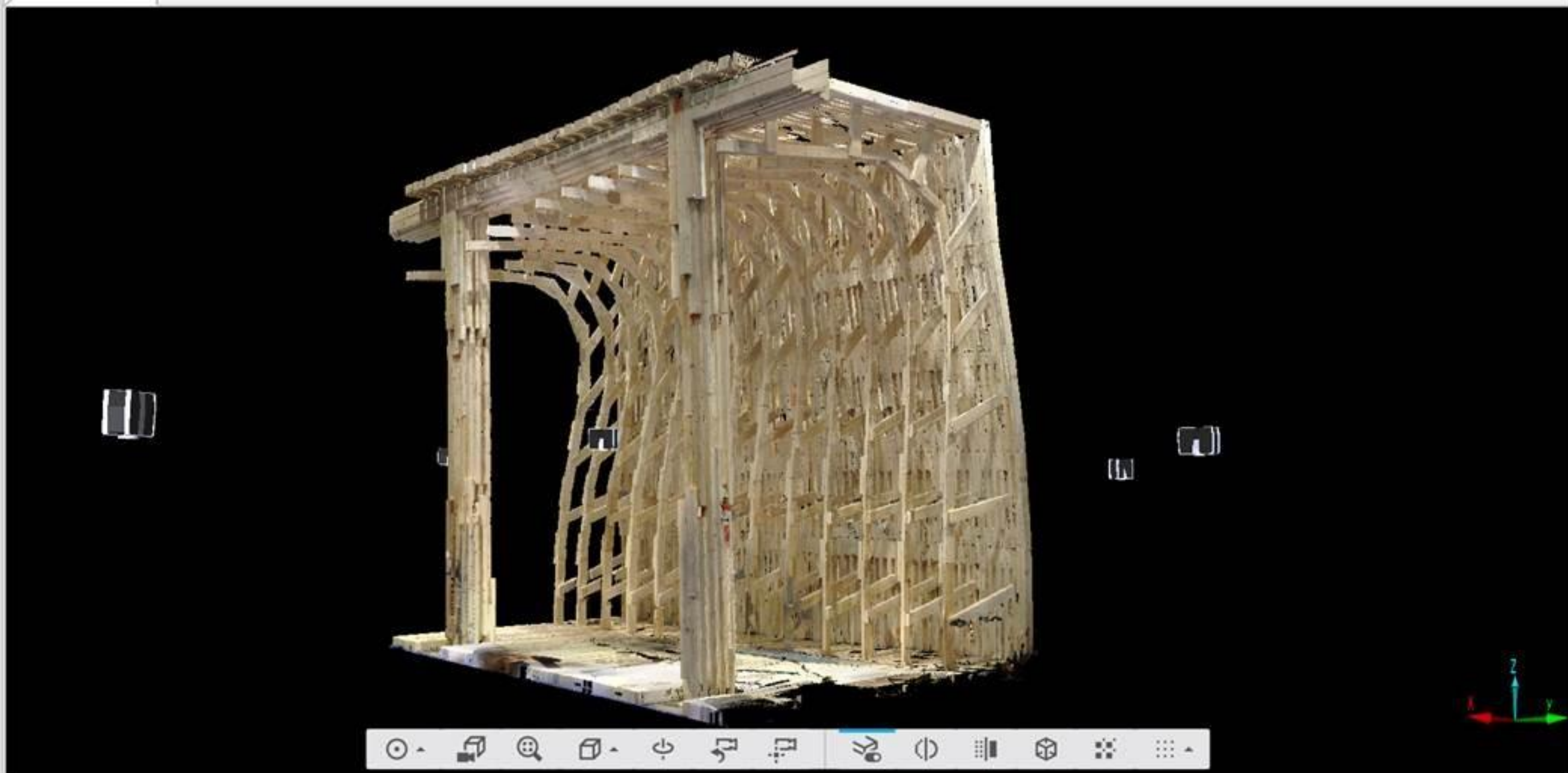
PW_005

PW_007

PW_008

ClippingBoxes

Models



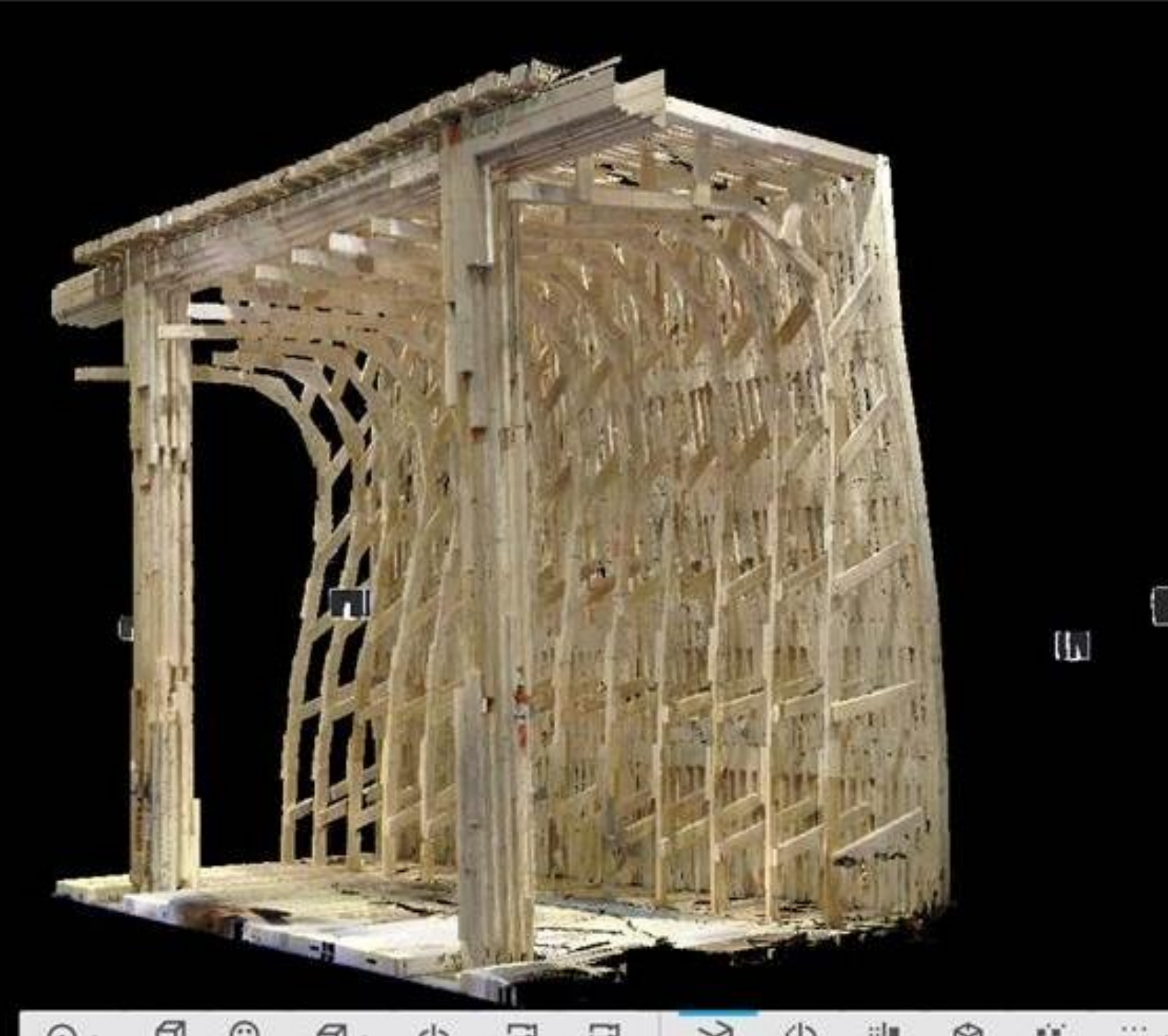
View: 233° 4' w: 65°

Pos: 38.13ft US 24.20ft US 16.20ft US

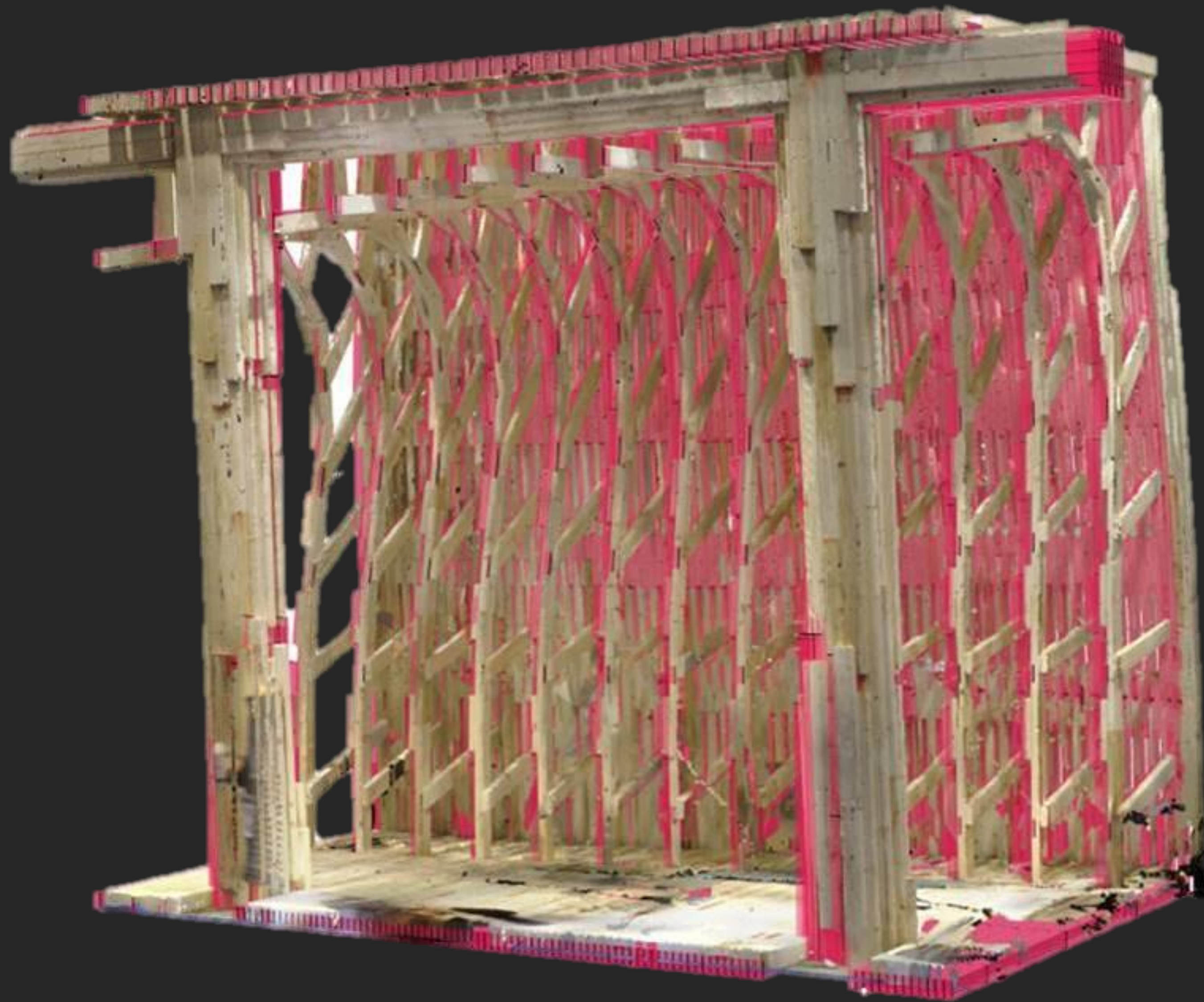
Loading Done

Detail: 100% Subsample: 1 Pts: 1M

DIGITAL - PHYSICAL - DIGITAL



DIGITAL VS. PHYSICAL



AI SpaceFactory

MARSHA – NASA Centennial 3D printed habitat winner

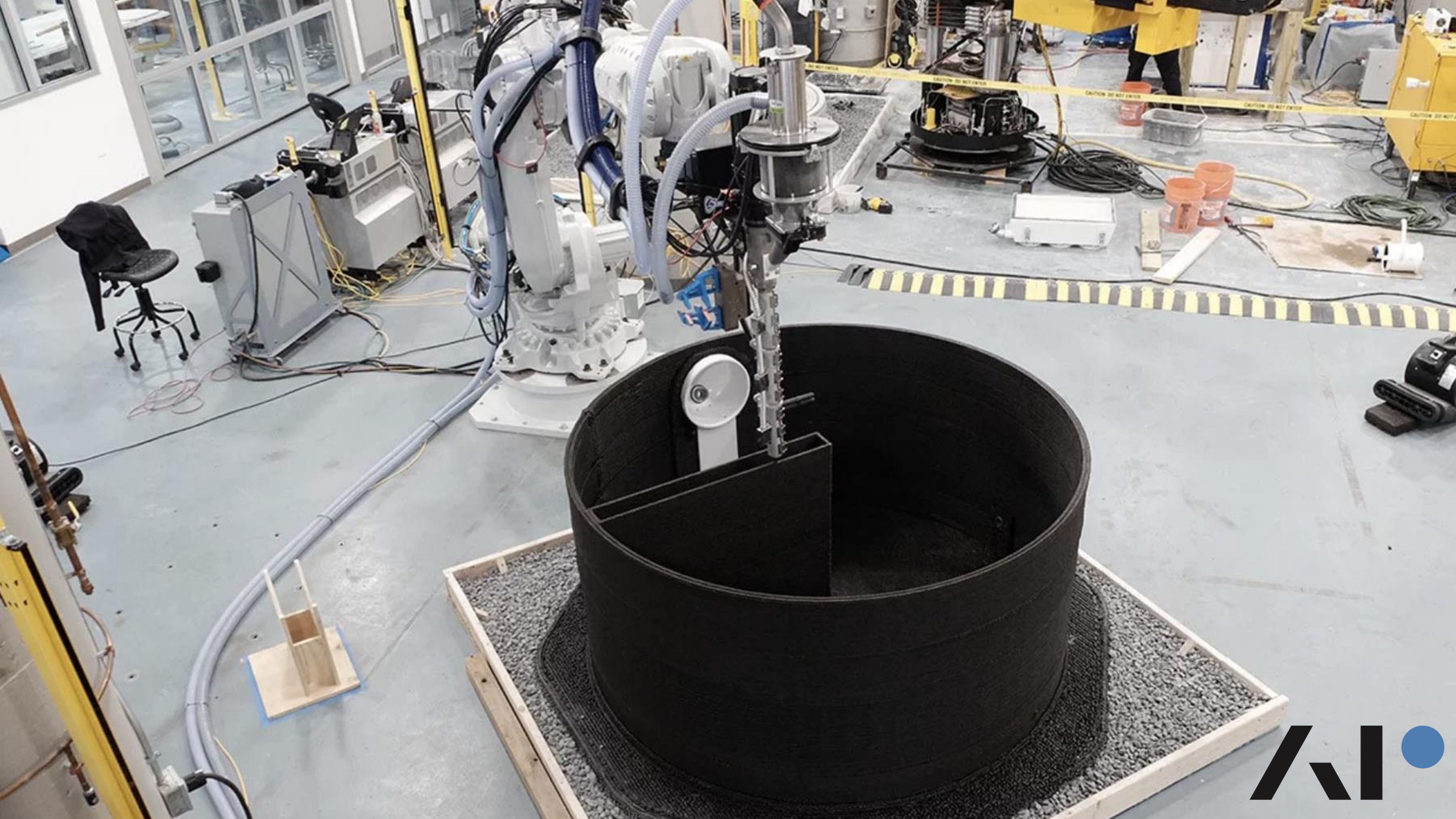
<https://www.aispacefactory.com/>

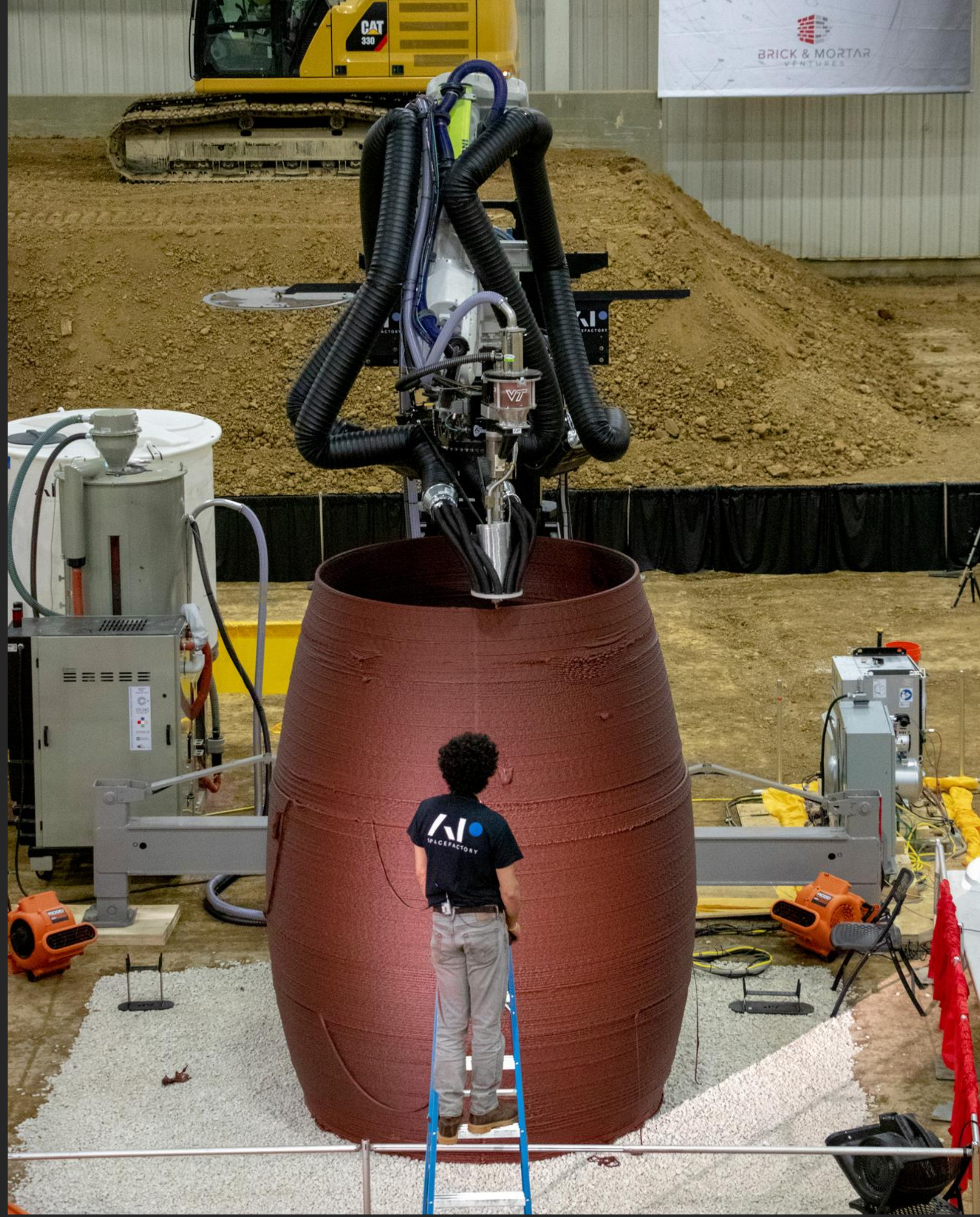
 **AUTODESK.** TECHNOLOGY CENTERS



AI SpaceFactory/plomp

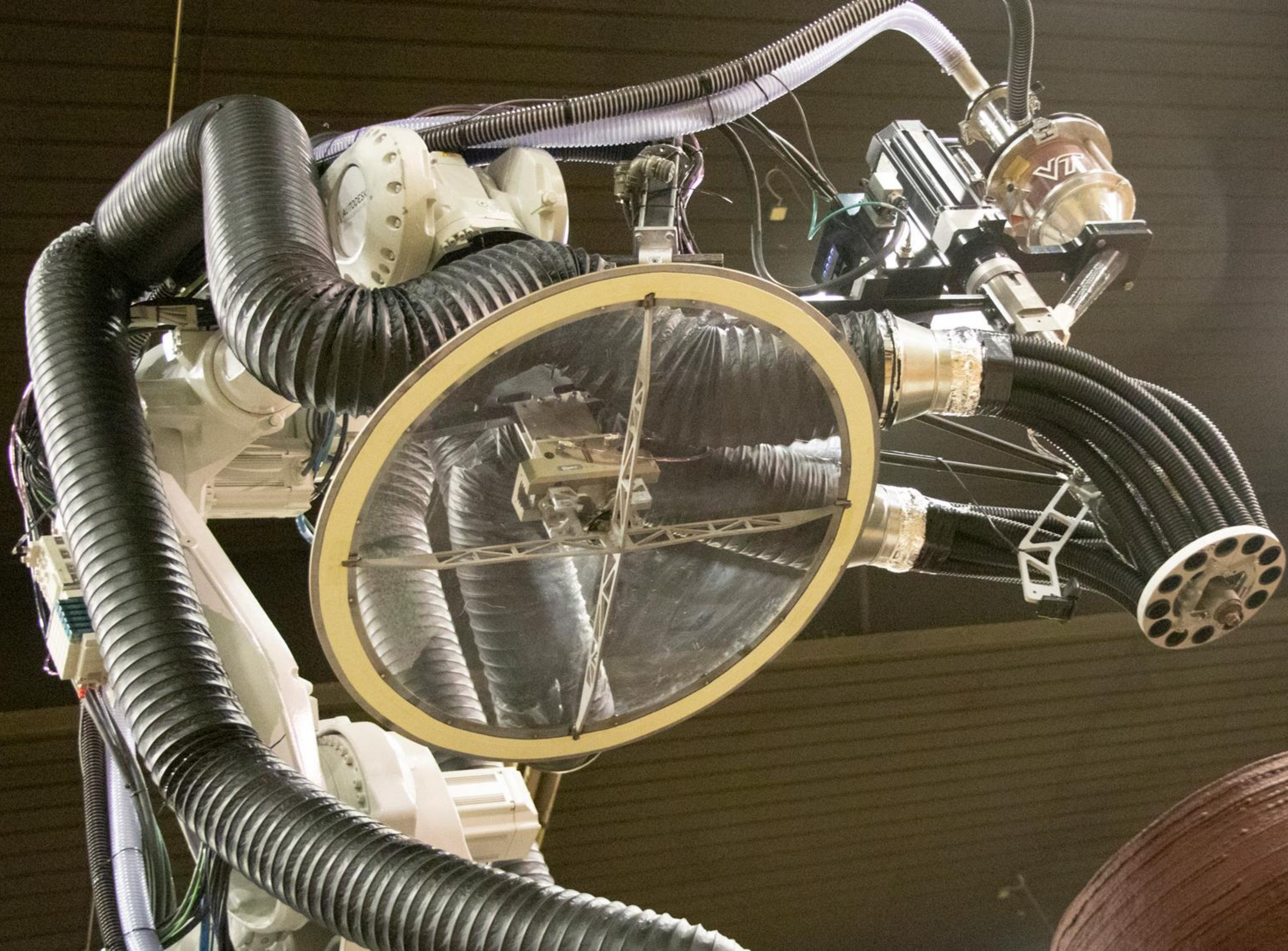








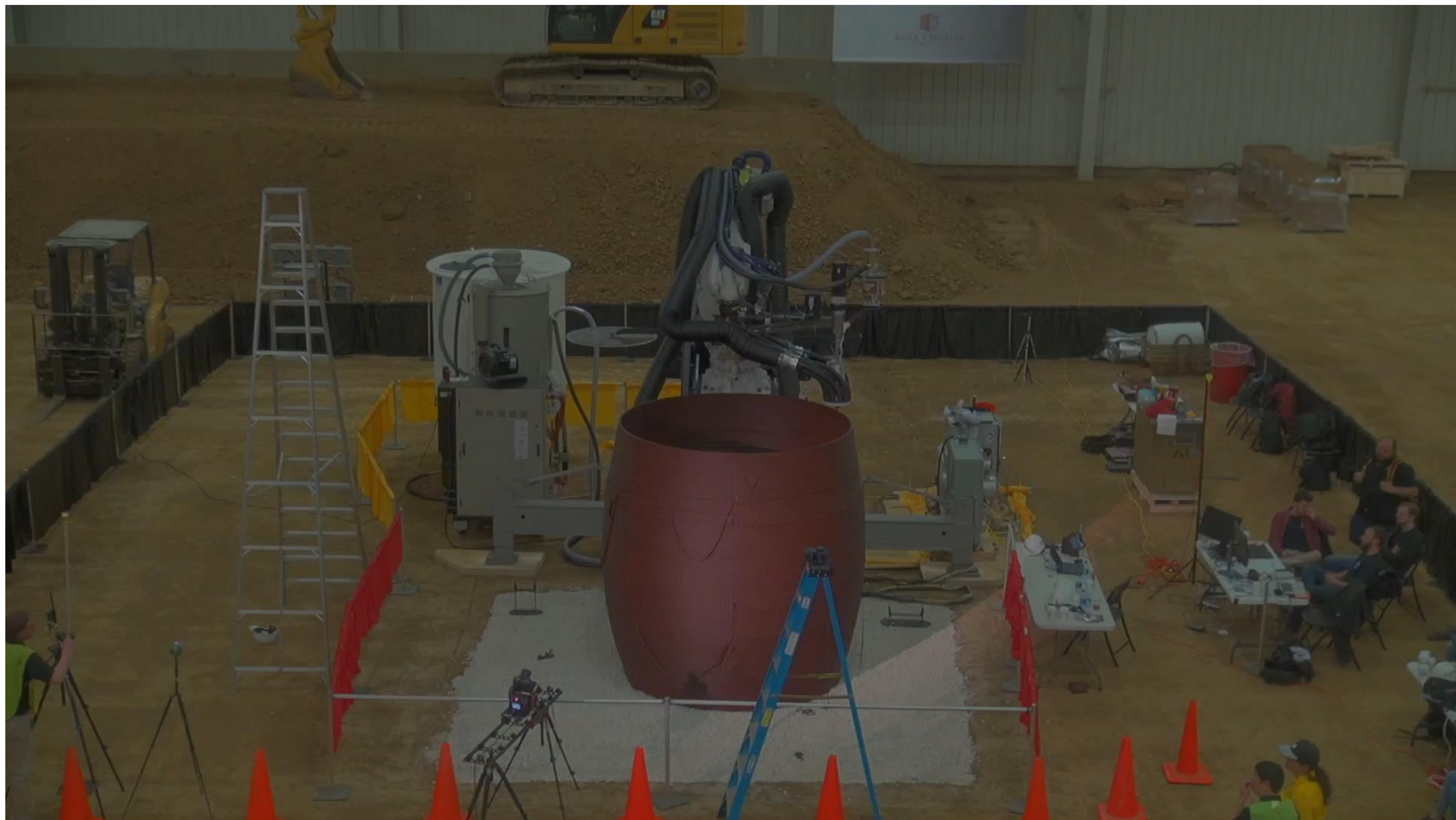








<https://youtu.be/axnuLepJufs>



Space_Factory_Day1 - RobotStudio

FileHomeModelingSimulationControllerRAPIDAdd-Ins

Request Write AccessRelease Write AccessSynchronize

Format OutliningSnippet Instruction

Find / ReplaceCompare

ApplyRAPID TasksRun ModeProgram

Adjust RobtargetsModify Position

Selected TasksStart

Step inStep outStep over

Stop

Check ProgramProgram Breakpoint

RAPID Path EditorWorkpieceToolOriginal PositionsPath Editor

ControllerFiles

Current Station

- MTD_5000
 - HOME
 - Configuration
 - Event Log
 - I/O System
 - RAPID
 - T_ROB1 (Program 'Al-MARSHA-Fina'
 - Program Modules
 - AlMarsha_Program
 - main
 - rFindHeight
 - TrapFaultExtruder
 - System Modules
 - BASE
 - SafetyVisu
 - TCBASE
 - TCDEFINE
 - TCDEVICE
 - TCSERVICE
 - TCUSER
 - user

Space_Factory_Final:View1

Controller StatusOutputRAPID WatchSimulation WatchRAPID Call StackRAPID BreakpointsSearch Results

Show messages from: All messages

MTD_5000 (Station): 10002 - Program pointer has been reset	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10150 - Program started	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10129 - Program stopped	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10016 - Automatic mode requested	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10017 - Automatic mode confirmed	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10140 - Speed adjusted	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10010 - Motors OFF state	11/11/2019 10:17:36 AM	Event Log
MTD_5000 (Station): 10011 - Motors ON state	11/11/2019 10:17:40 AM	Event Log

MTD_5000 (Station): 10011 - Motors ON stateController status: 1/1

<https://new.abb.com/products/robotics/robotstudio>



AI SpaceFactory/plomp

A dark, conical structure, possibly a modern shelter or a piece of art, stands on a grassy bank. It has a glowing, golden-yellow entrance at the base. The structure is adorned with several small, diamond-shaped lights. A pink rectangular logo with the word 'INDIEGOGO' in white capital letters is visible on its side. The background features a calm lake, dense evergreen forests, and misty mountains under a soft, overcast sky. The word 'TERA' is overlaid in large, white, sans-serif capital letters, followed by a stylized white symbol resembling a person or a stylized 'A'.

<https://youtu.be/3S57kpoQZcY>

MADWORKSHOP

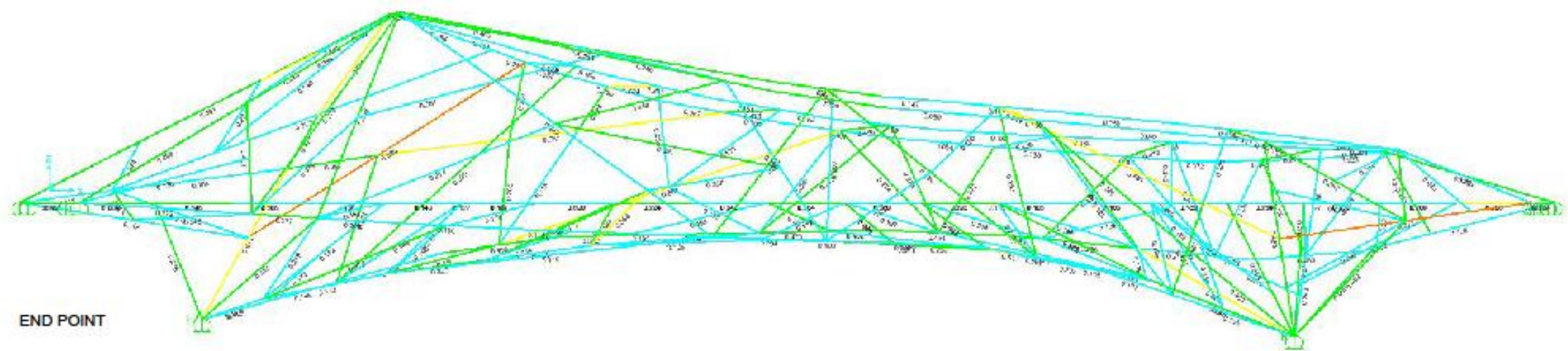
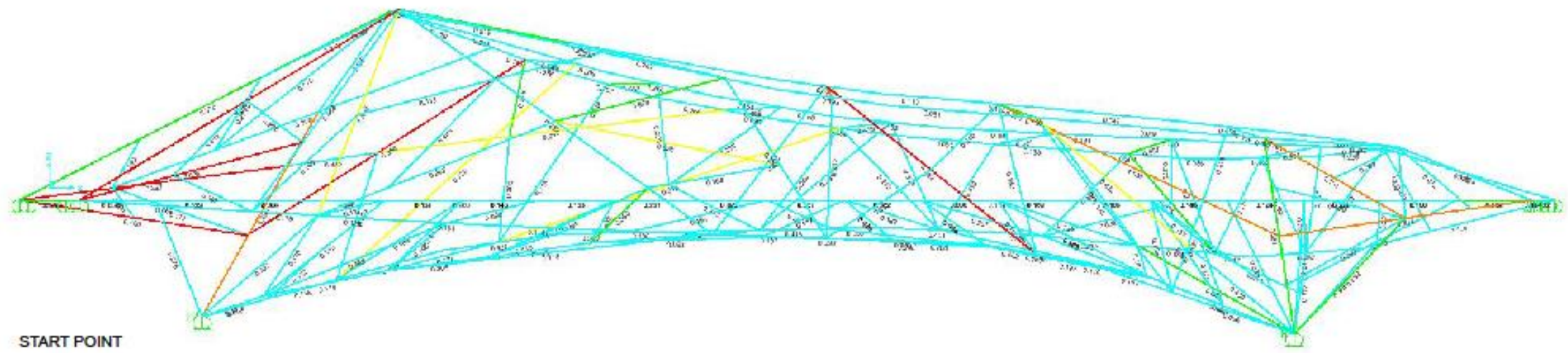
The Arroyo Bridge

<http://madworkshop.org/projects/the-arroyo-bridge-studio/>

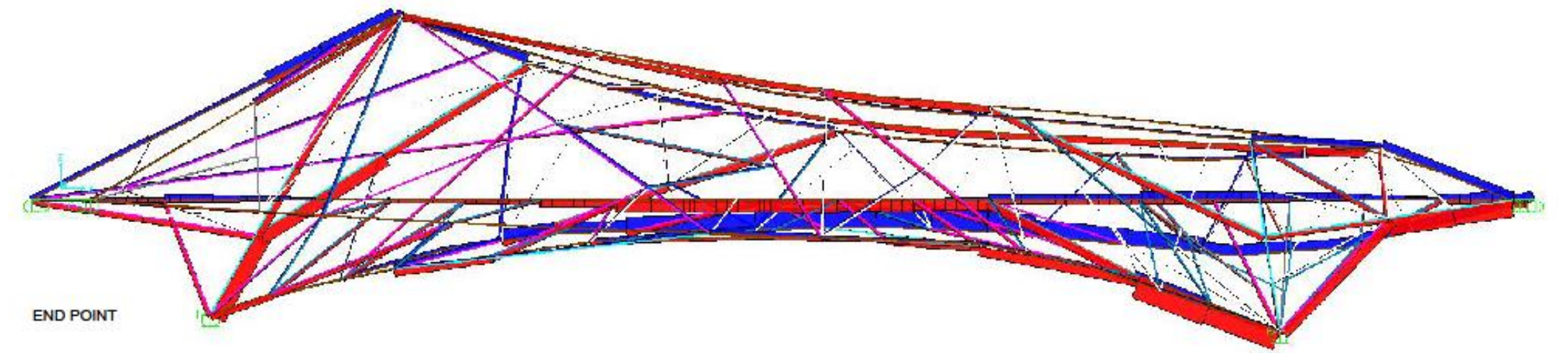
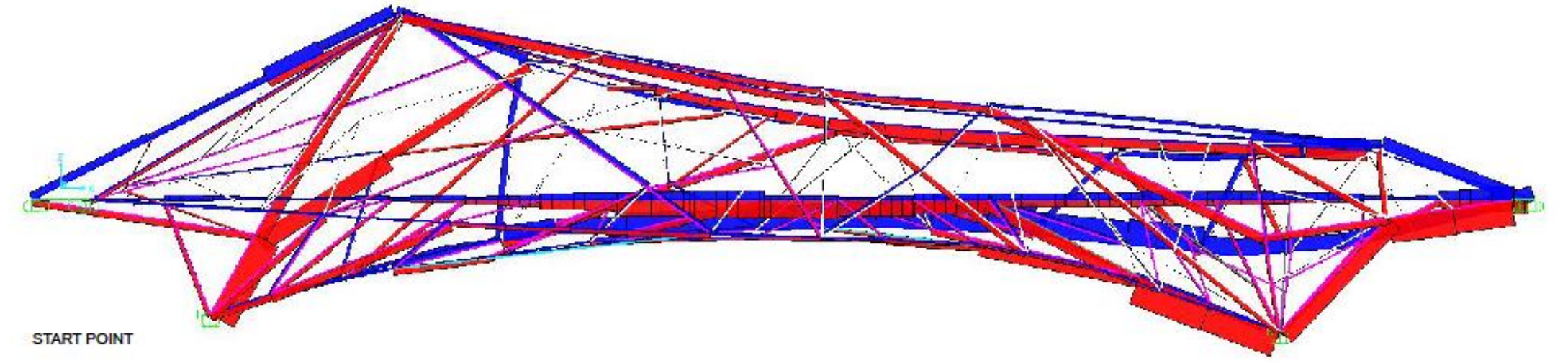
 **AUTODESK**. TECHNOLOGY CENTERS



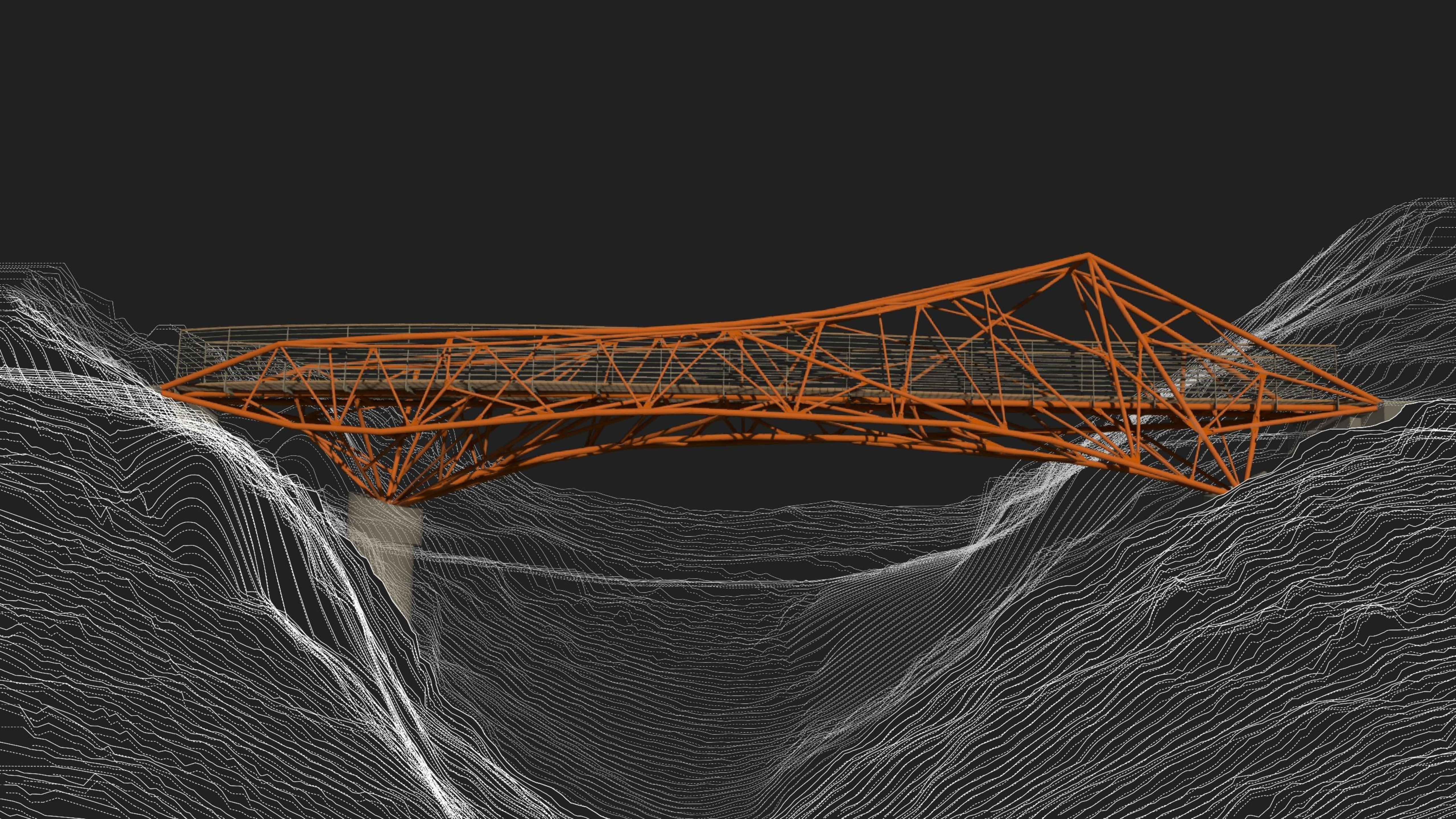




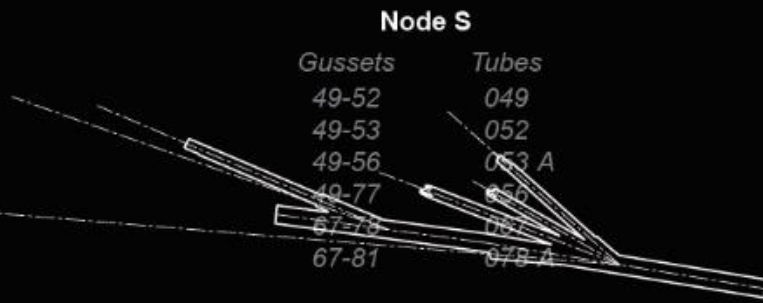
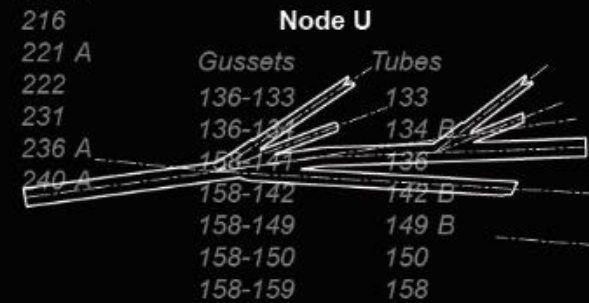
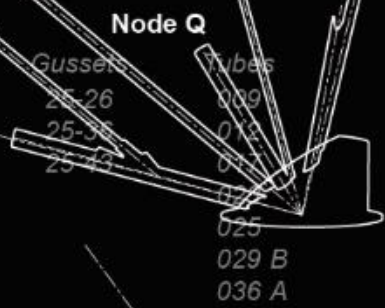
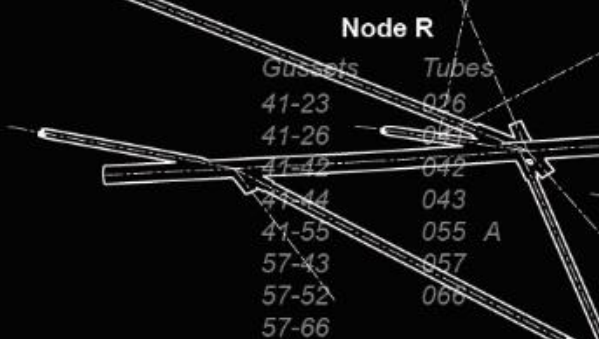
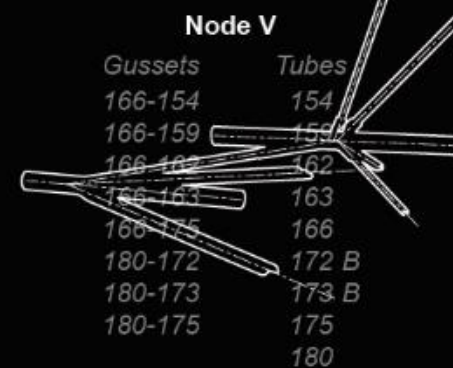
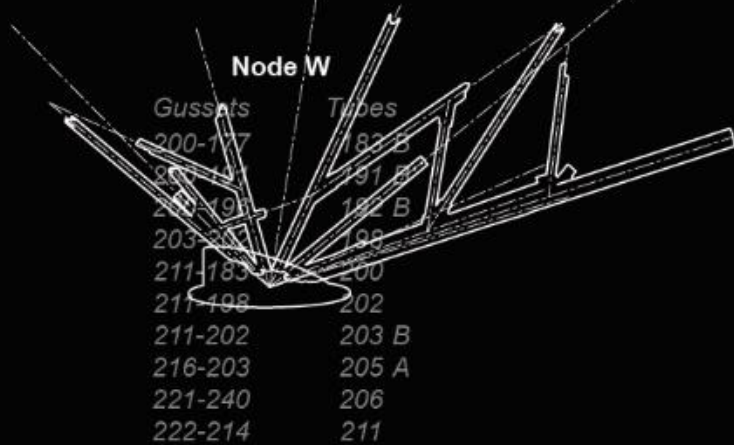
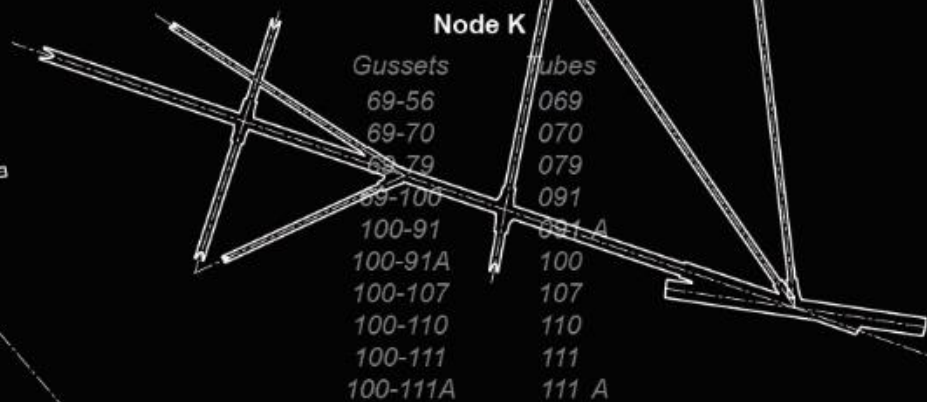
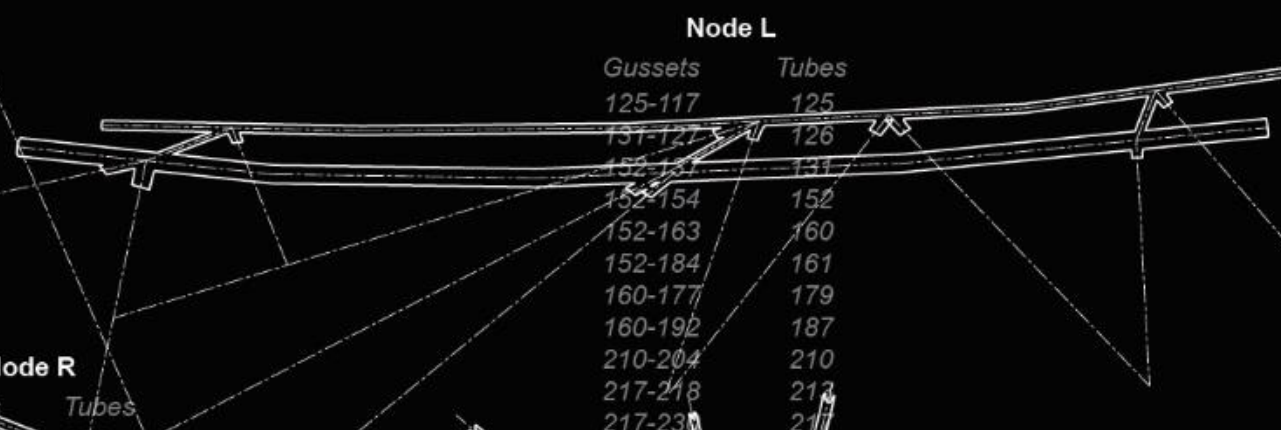
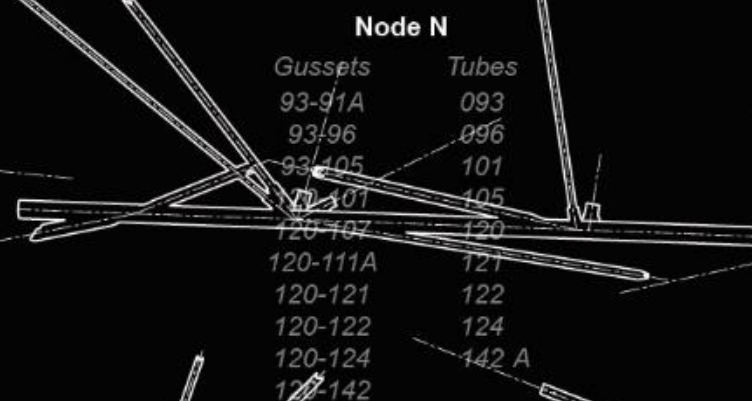
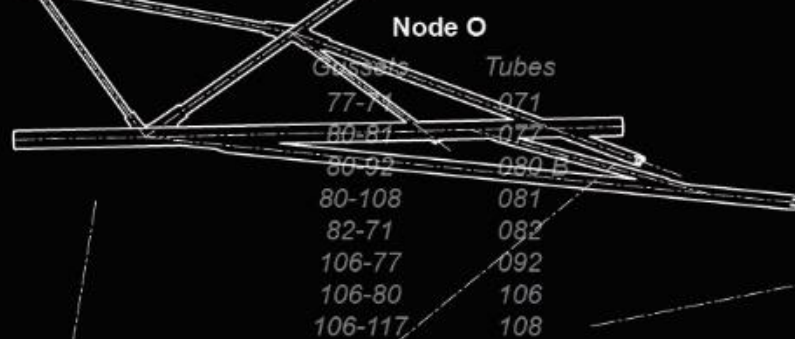
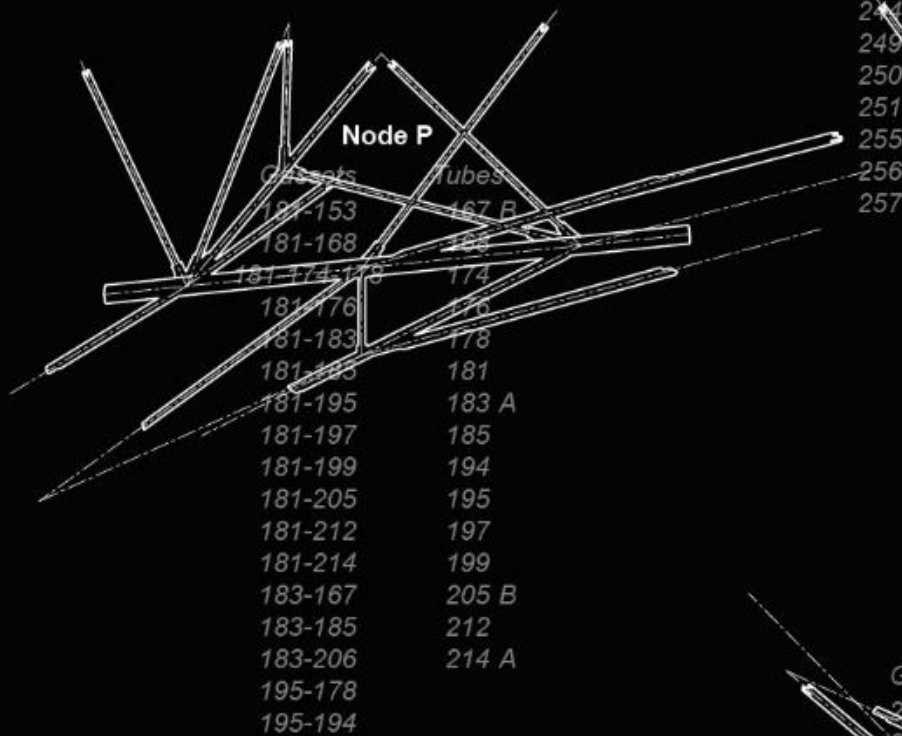
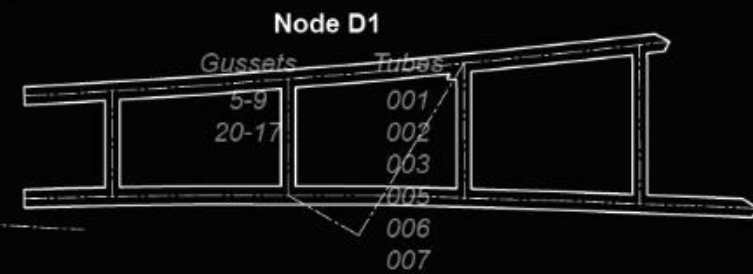
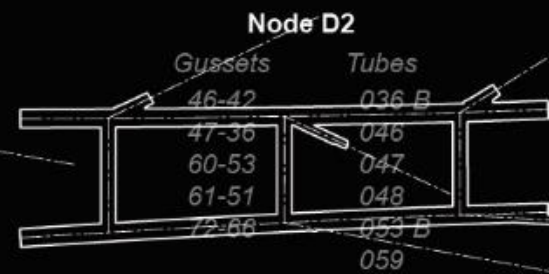
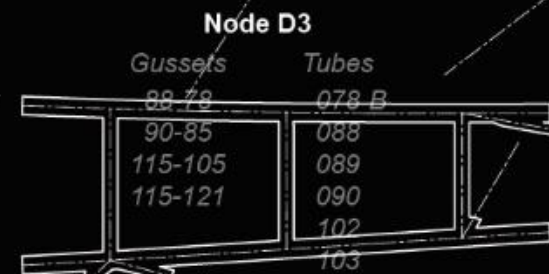
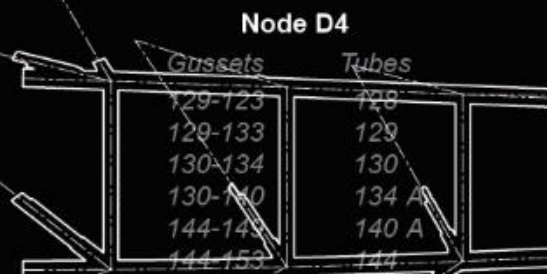
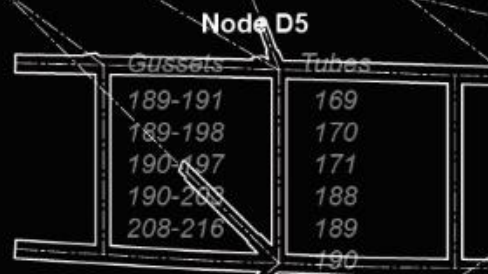
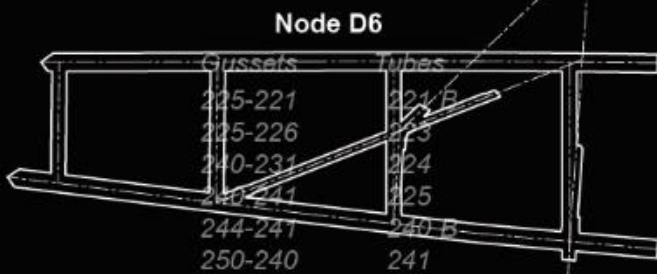
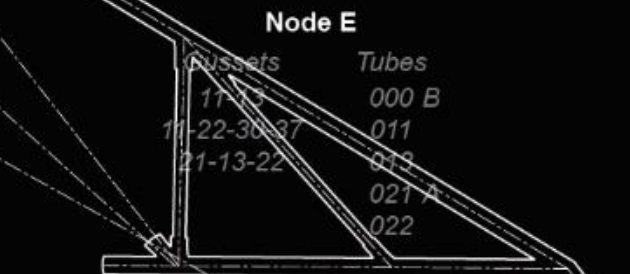
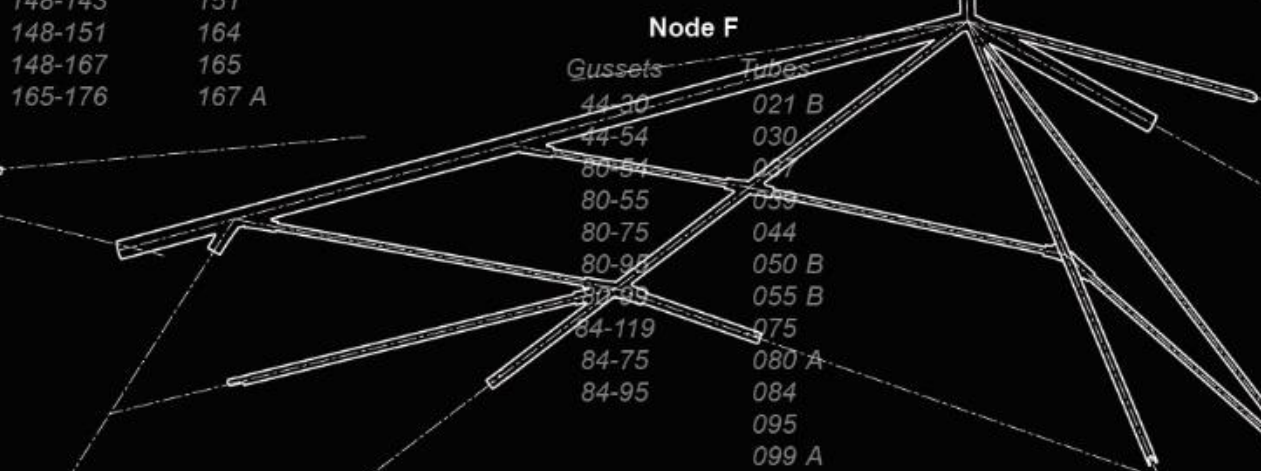
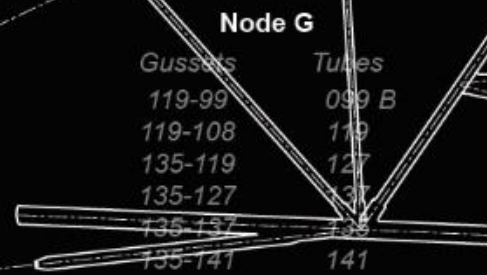
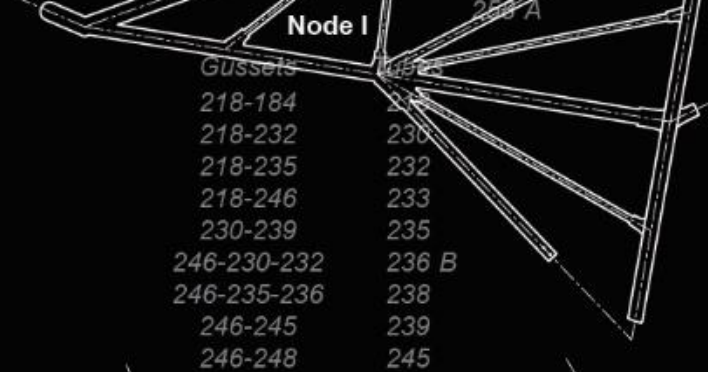
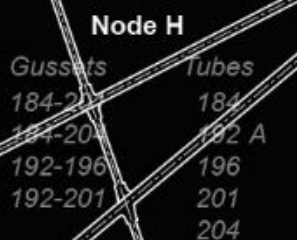
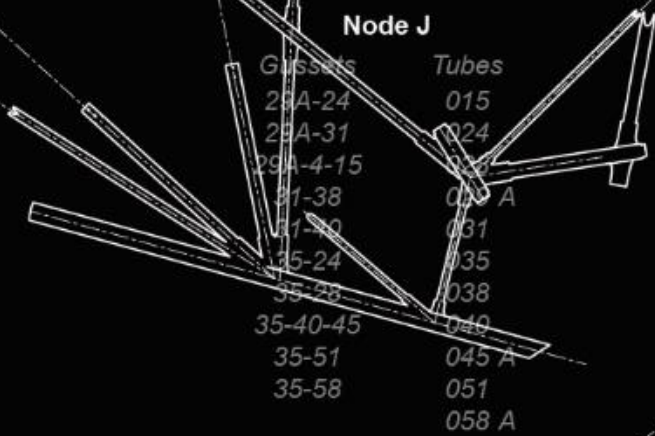
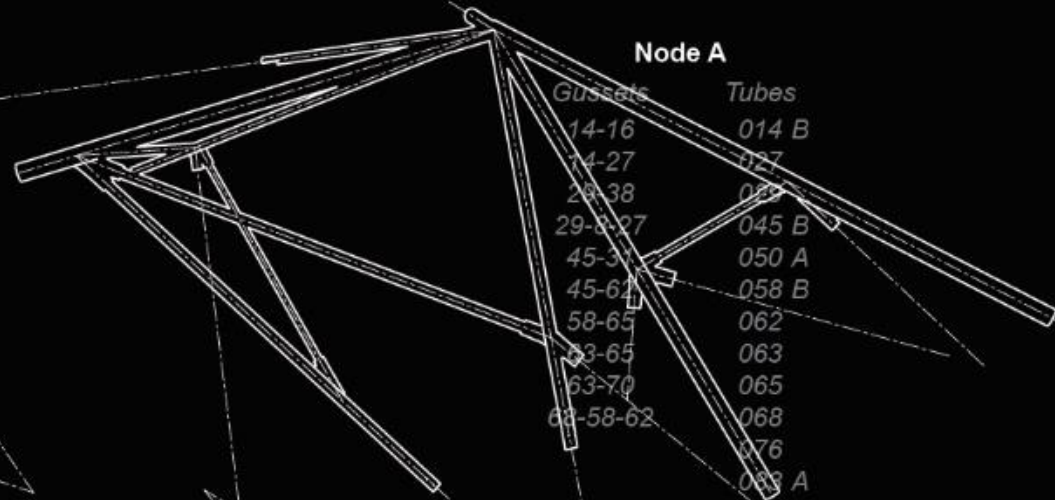
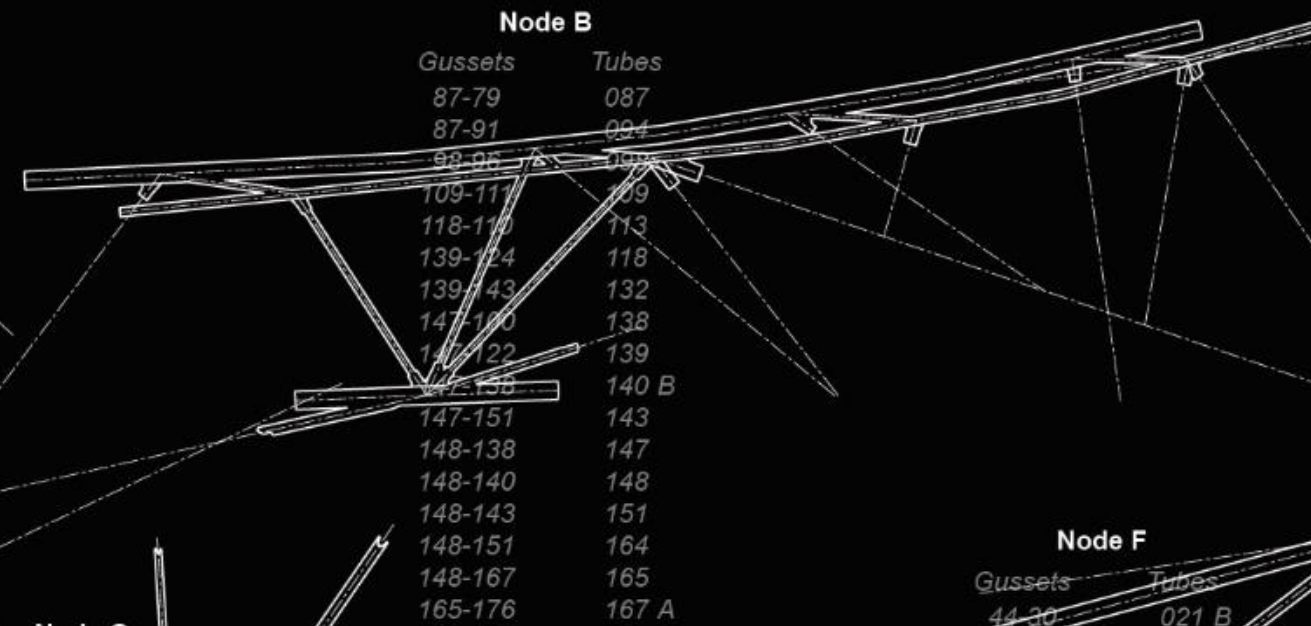
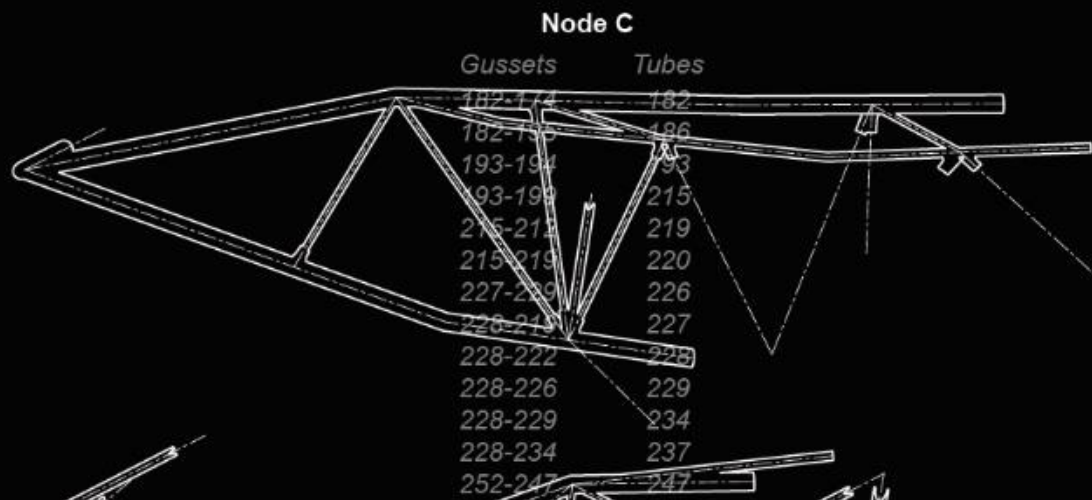
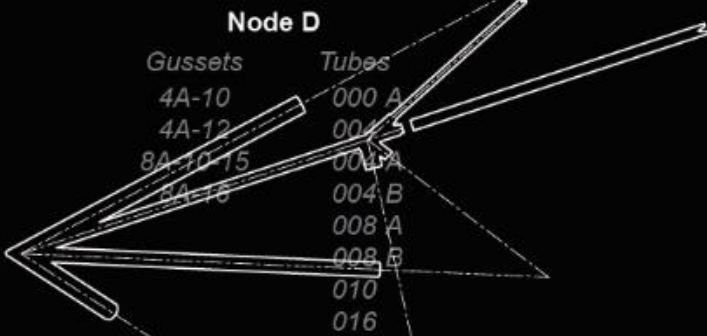
STRUCTURAL ANALYSIS - STRESS RATIO
JANUARY RESULTS

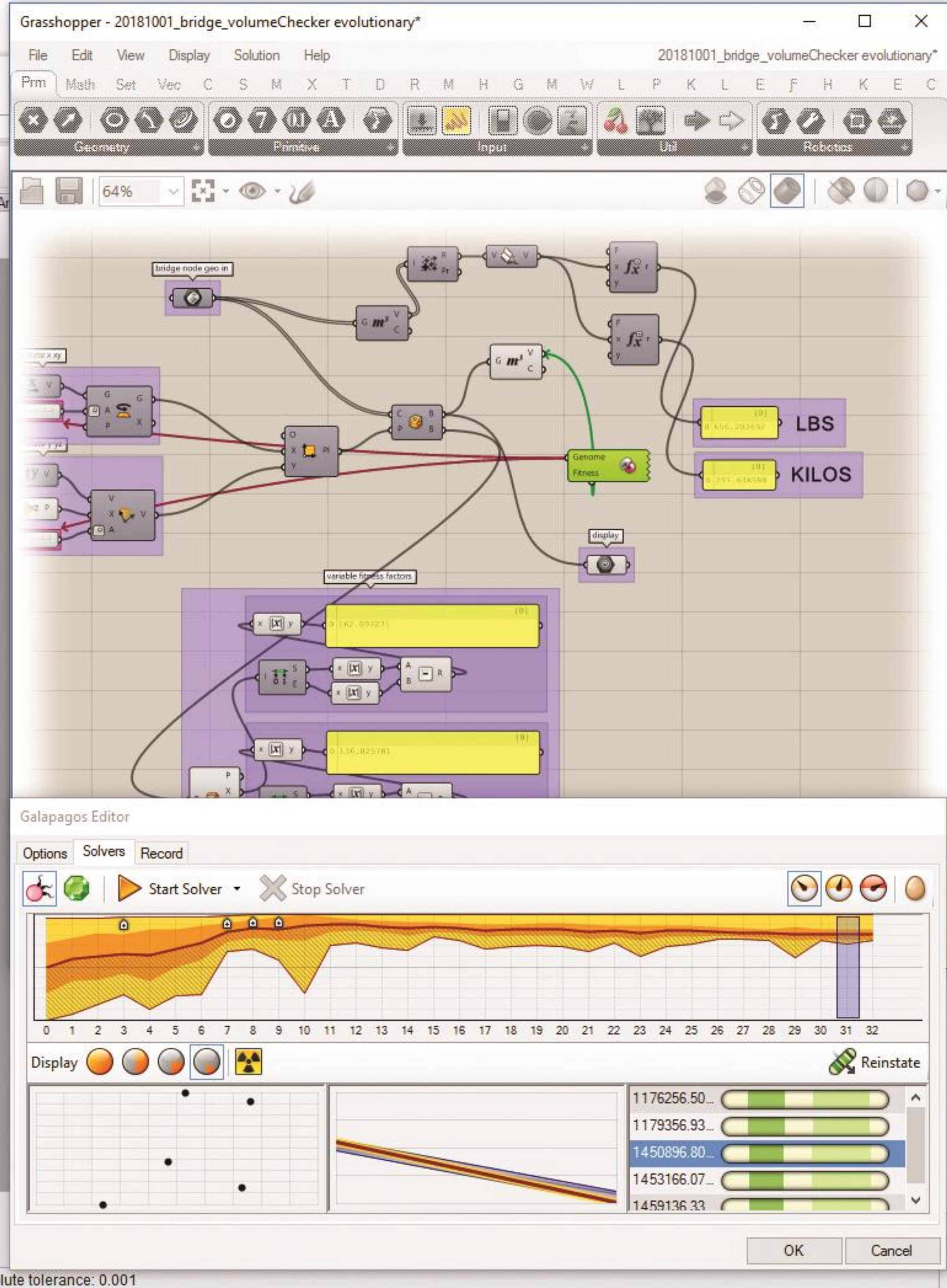
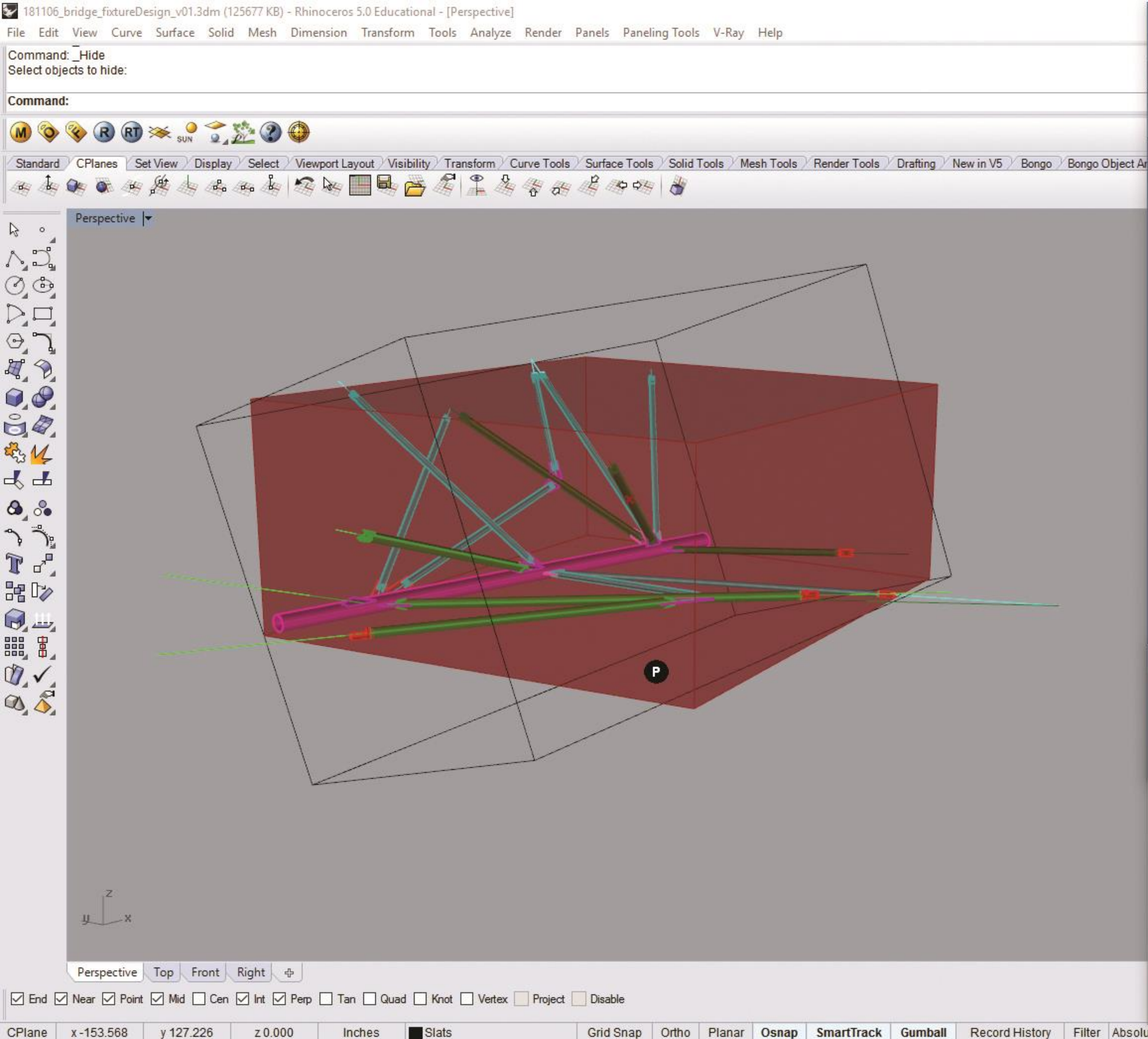


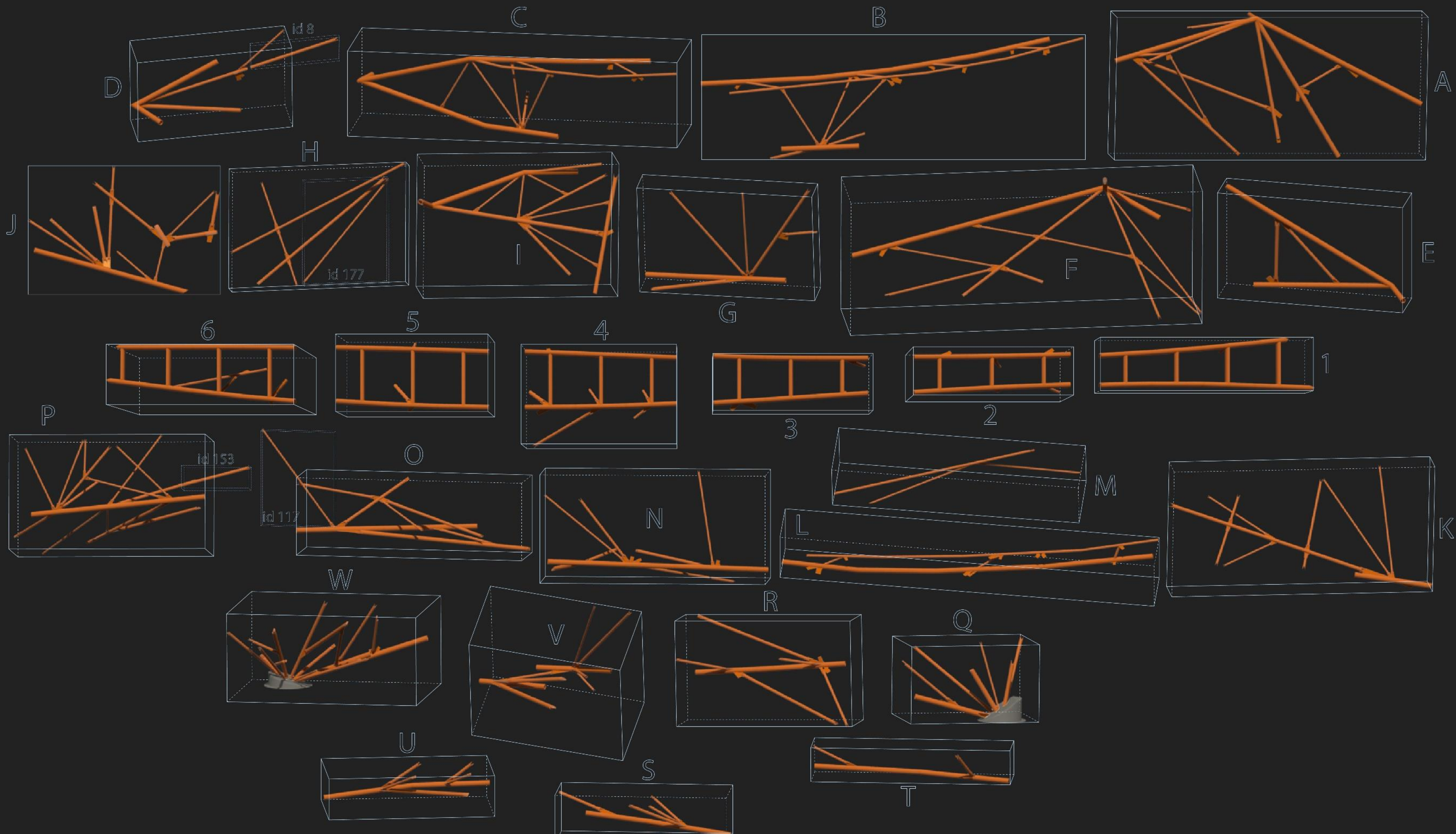
STRUCTURAL ANALYSIS - AXIAL FORCES
JANUARY RESULTS

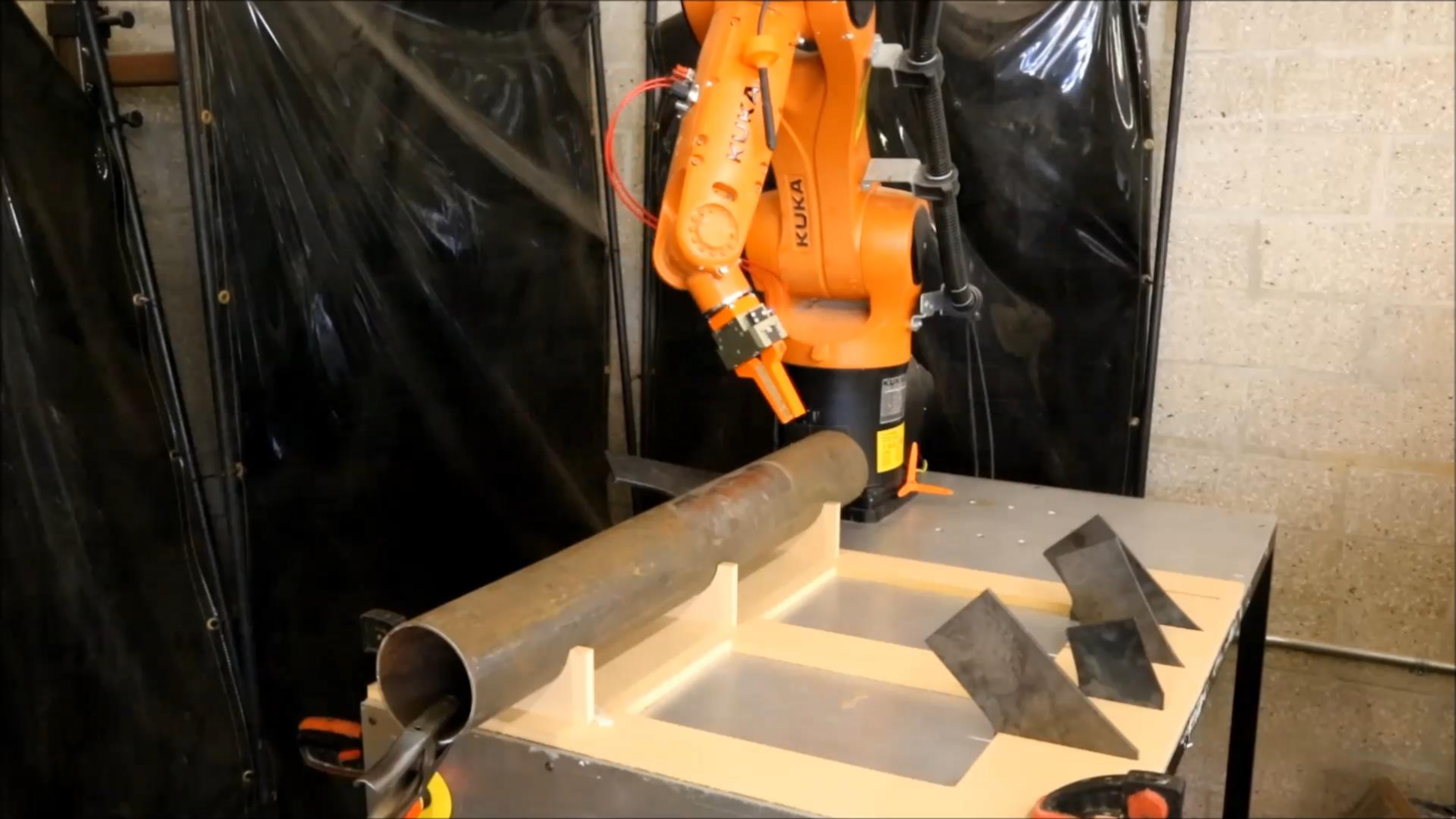


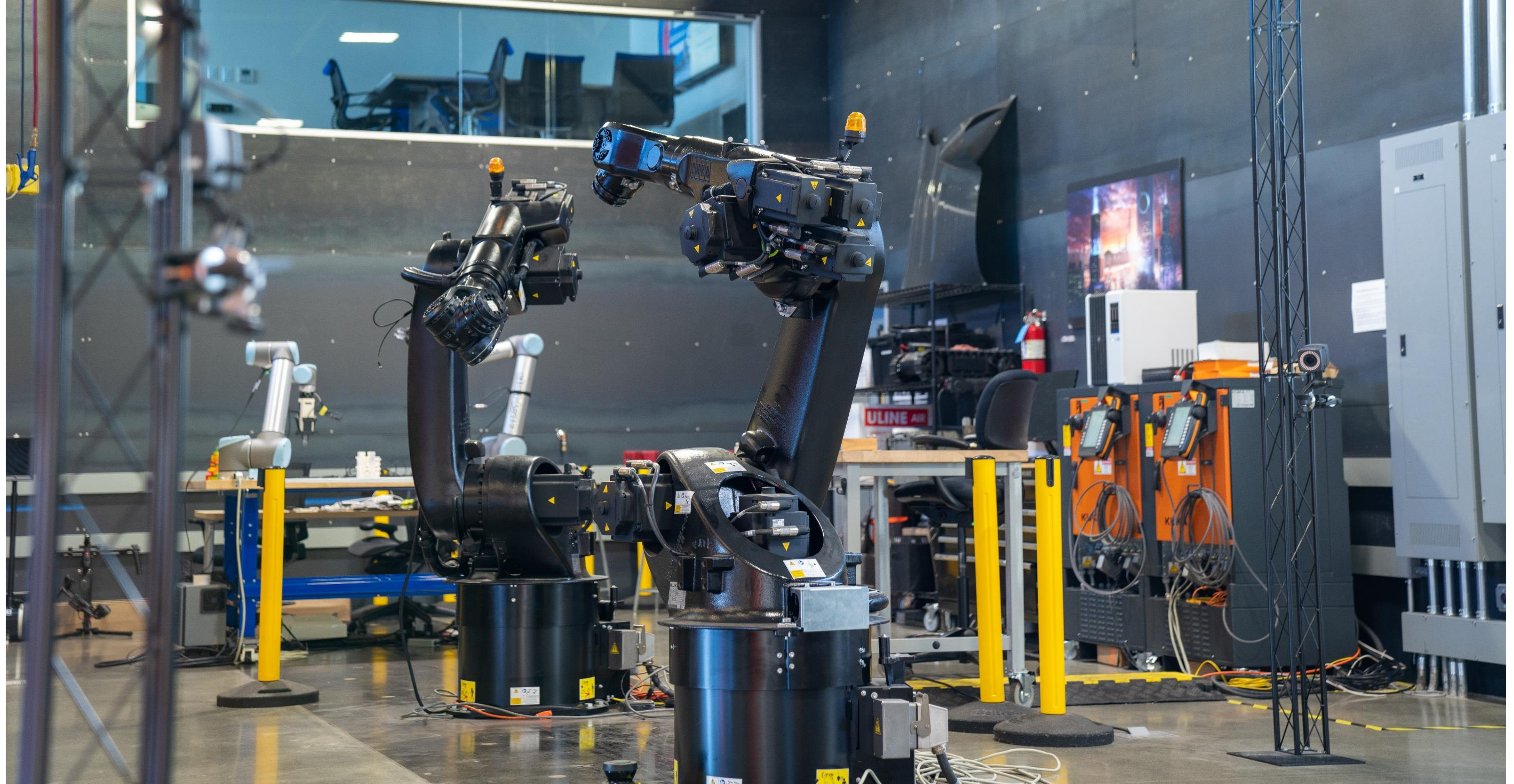












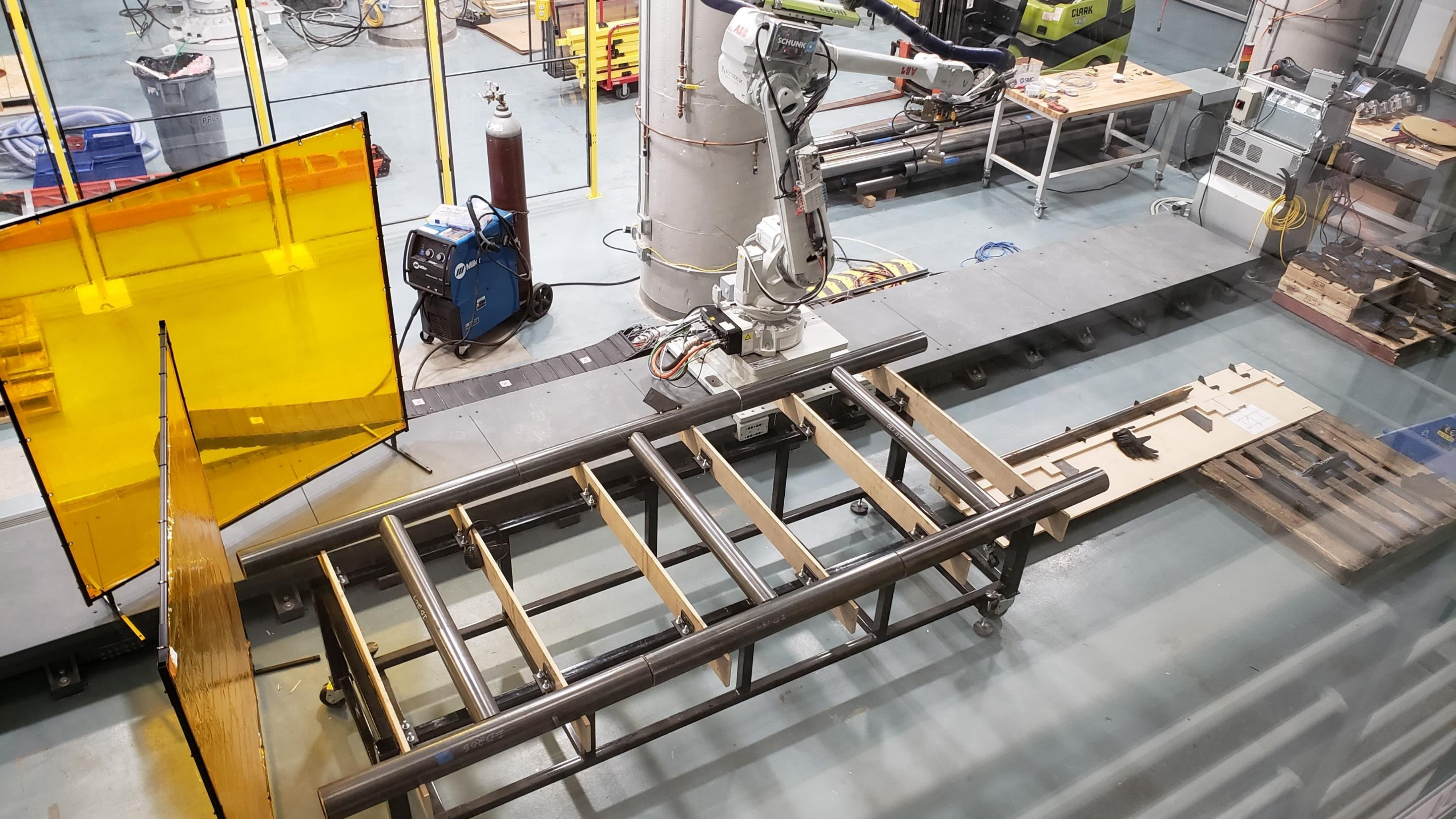
 **AUTODESK.**
RESEARCH



AUTODESK[®]
RESEARCH

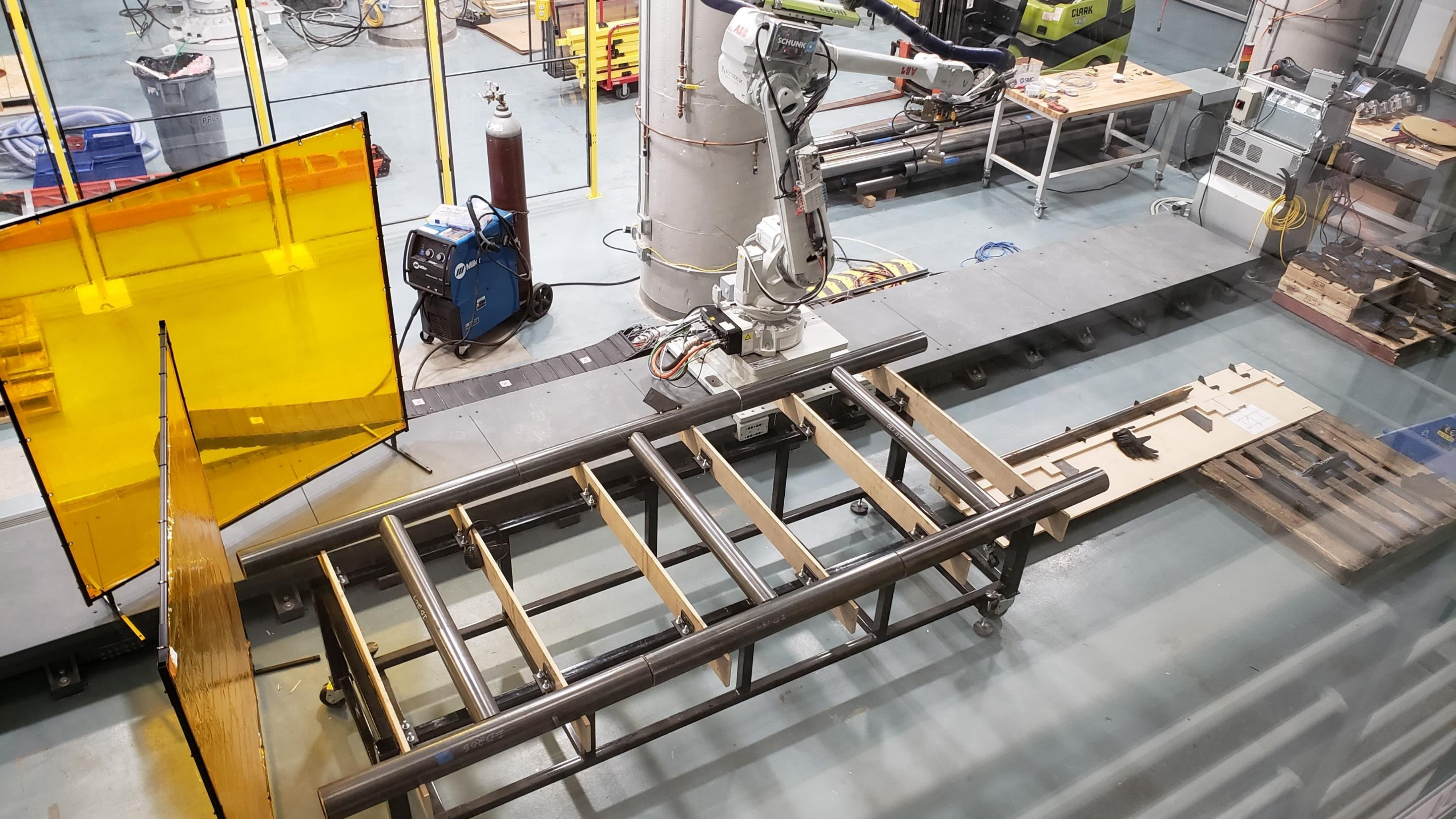


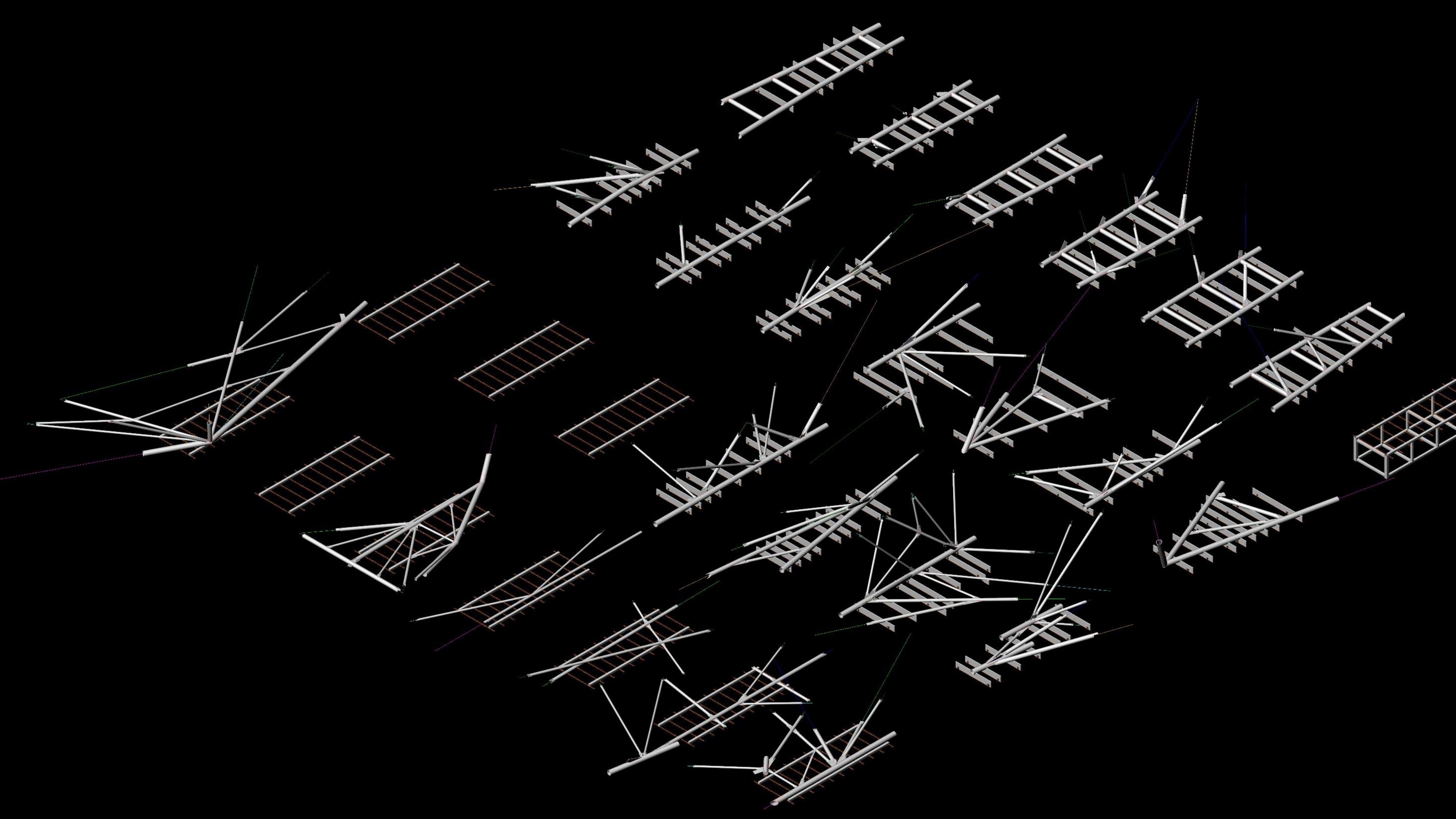
AUTODESK[®]
TECHNOLOGY CENTER
BOSTON

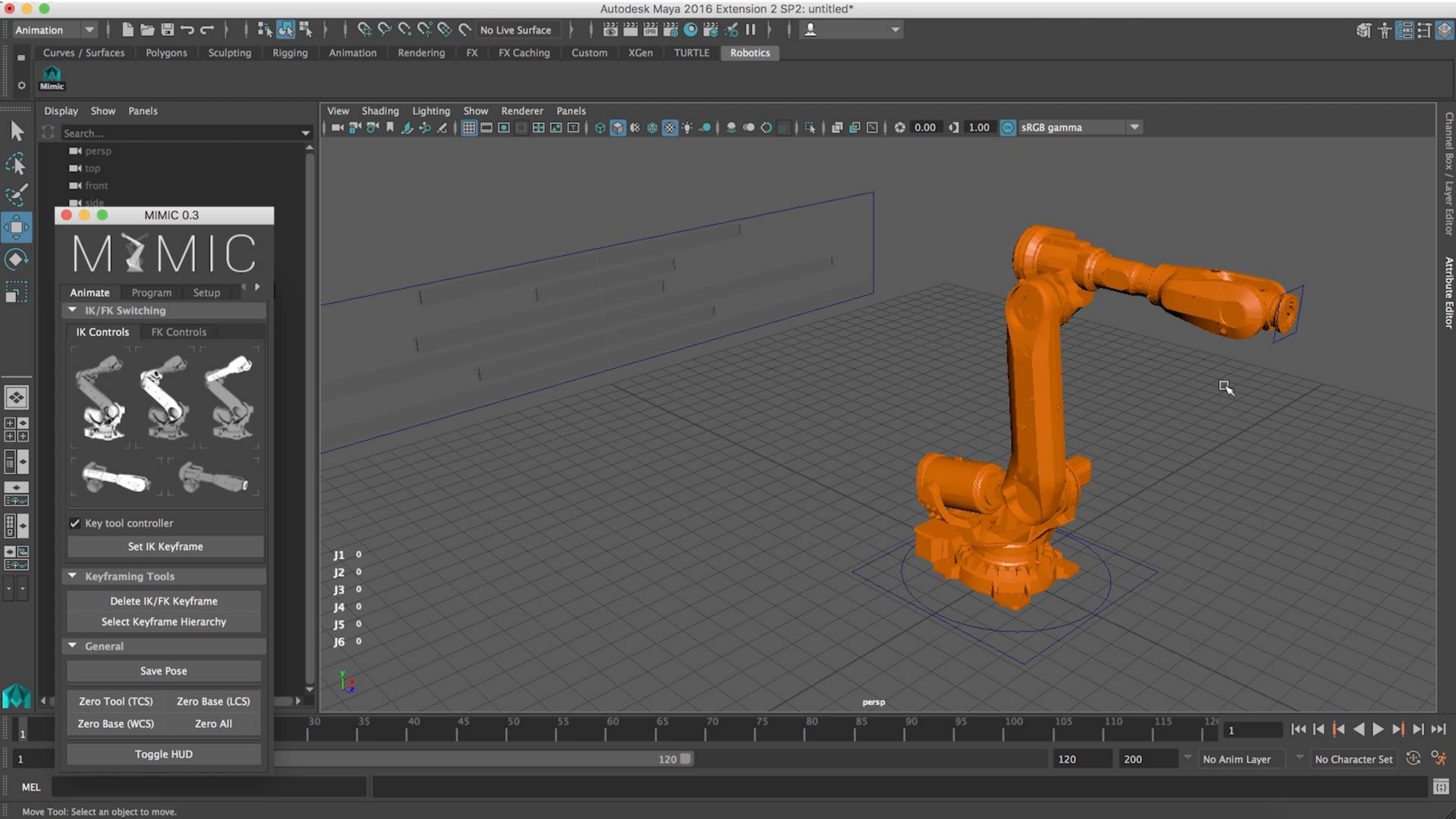












MIMIC

An open-source Autodesk Maya plugin for controlling Industrial Robots



DOWNLOAD

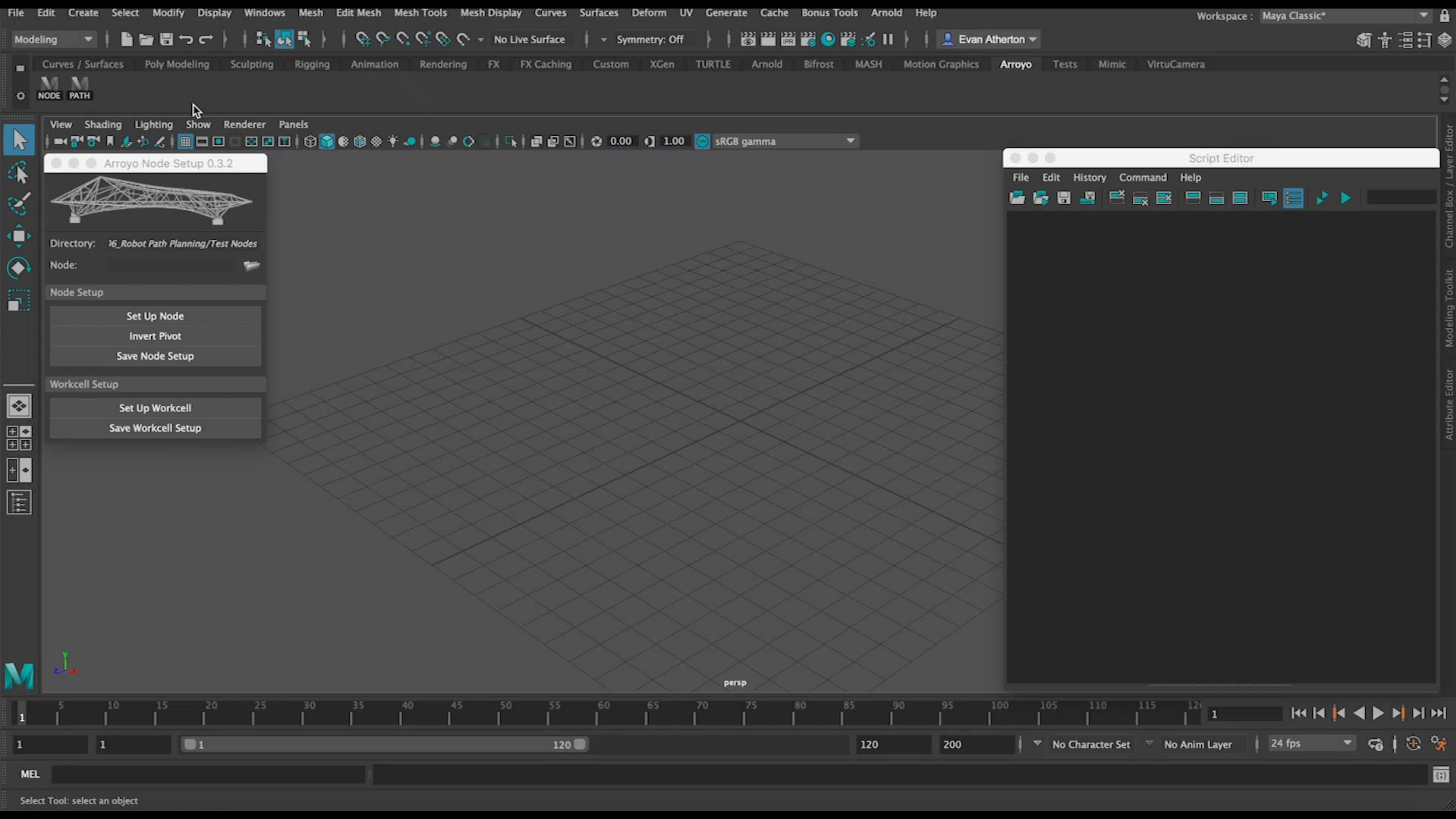
<https://www.mimicformaya.com/>

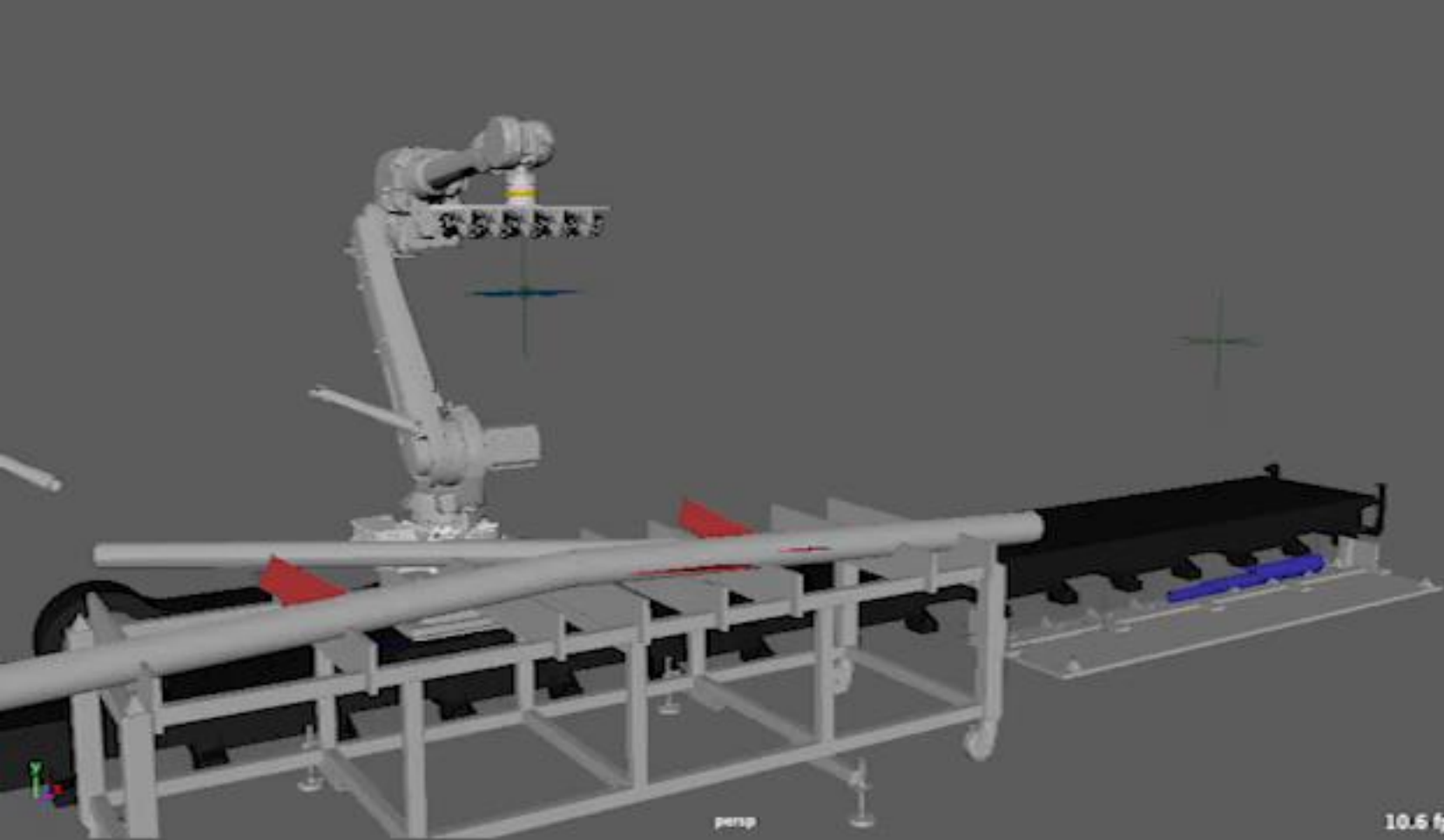


MIMIC

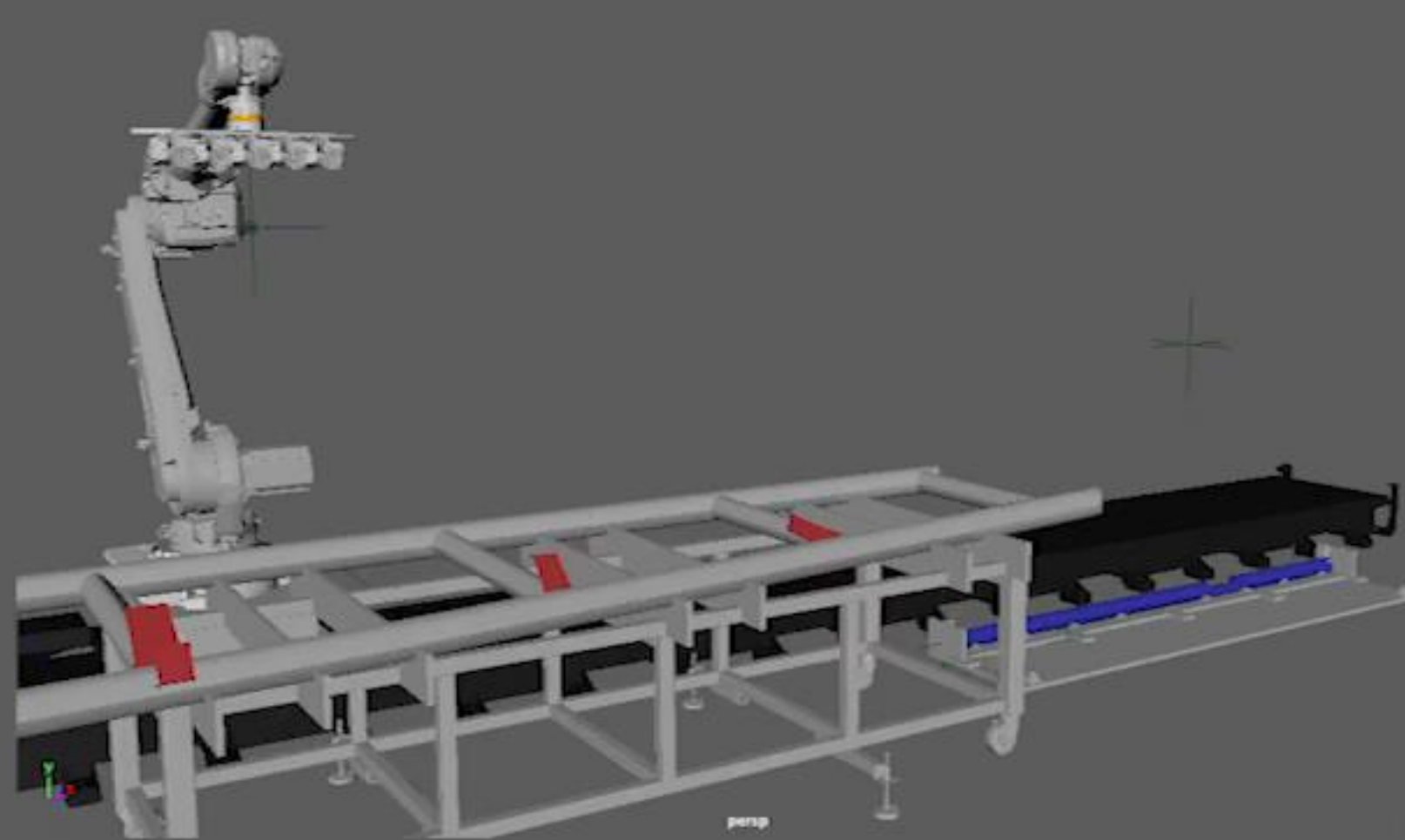
GETTING STARTED

<https://youtu.be/bc3SqEXcE5Q>

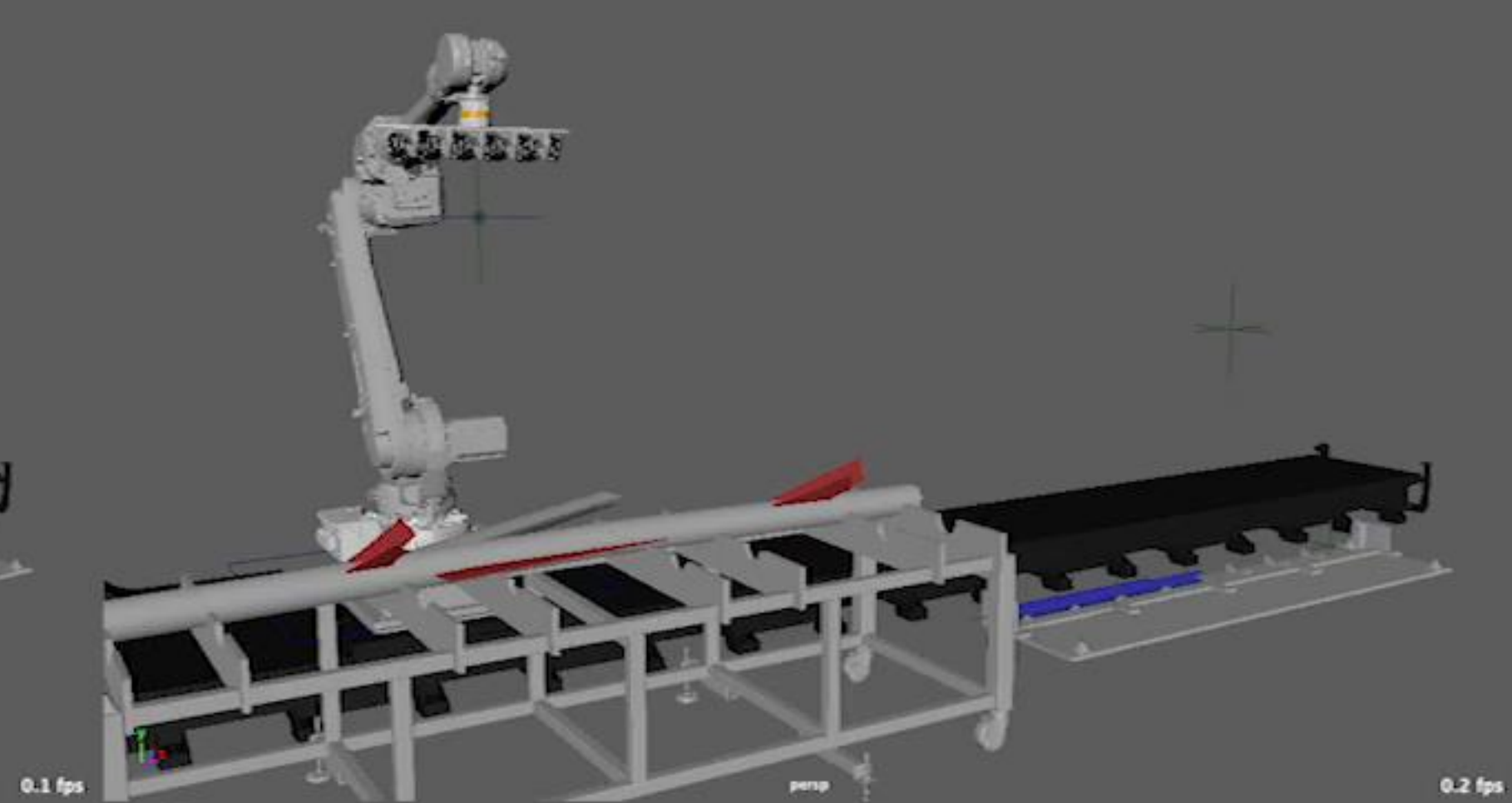




10.6 fps

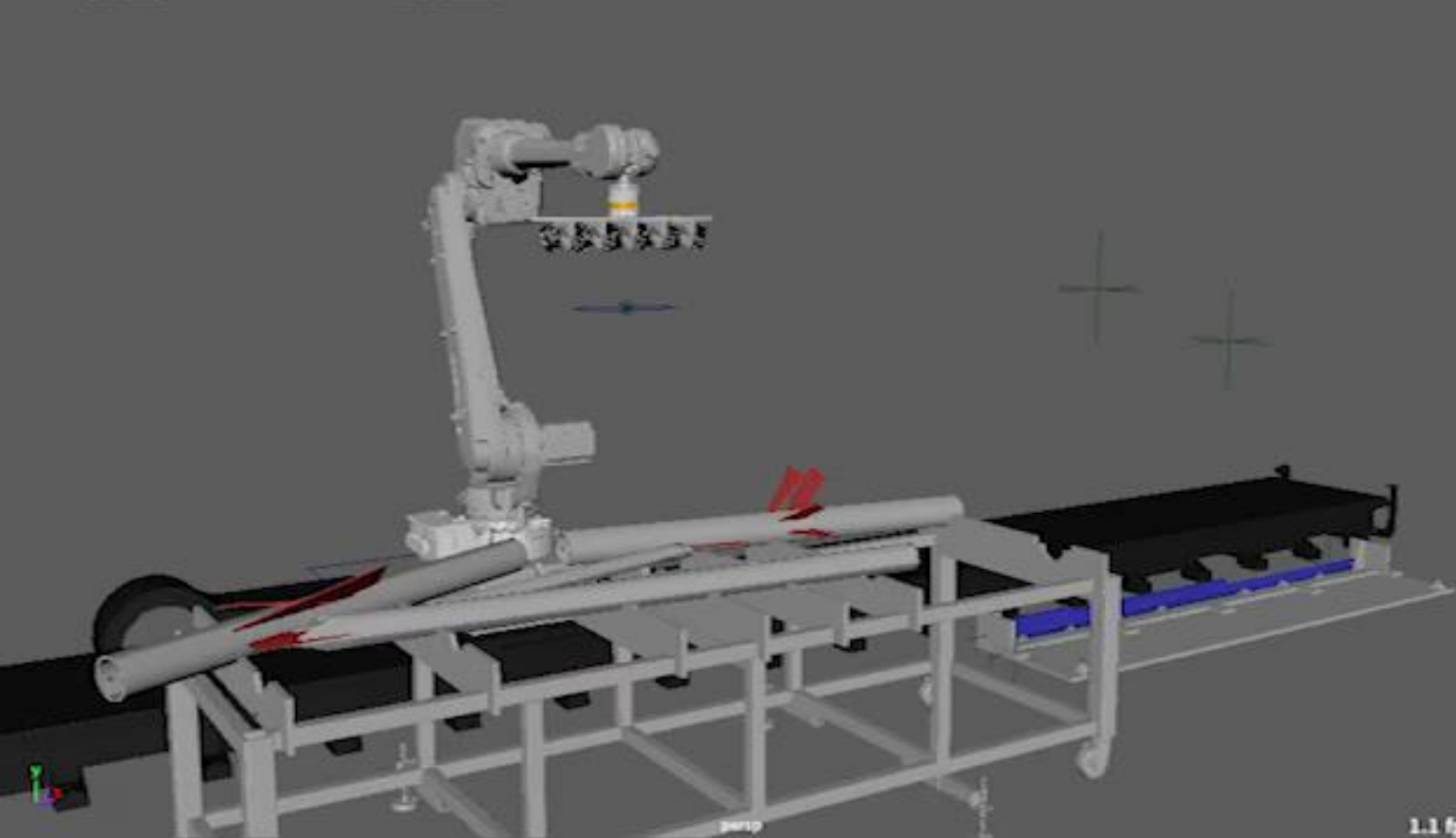


persp

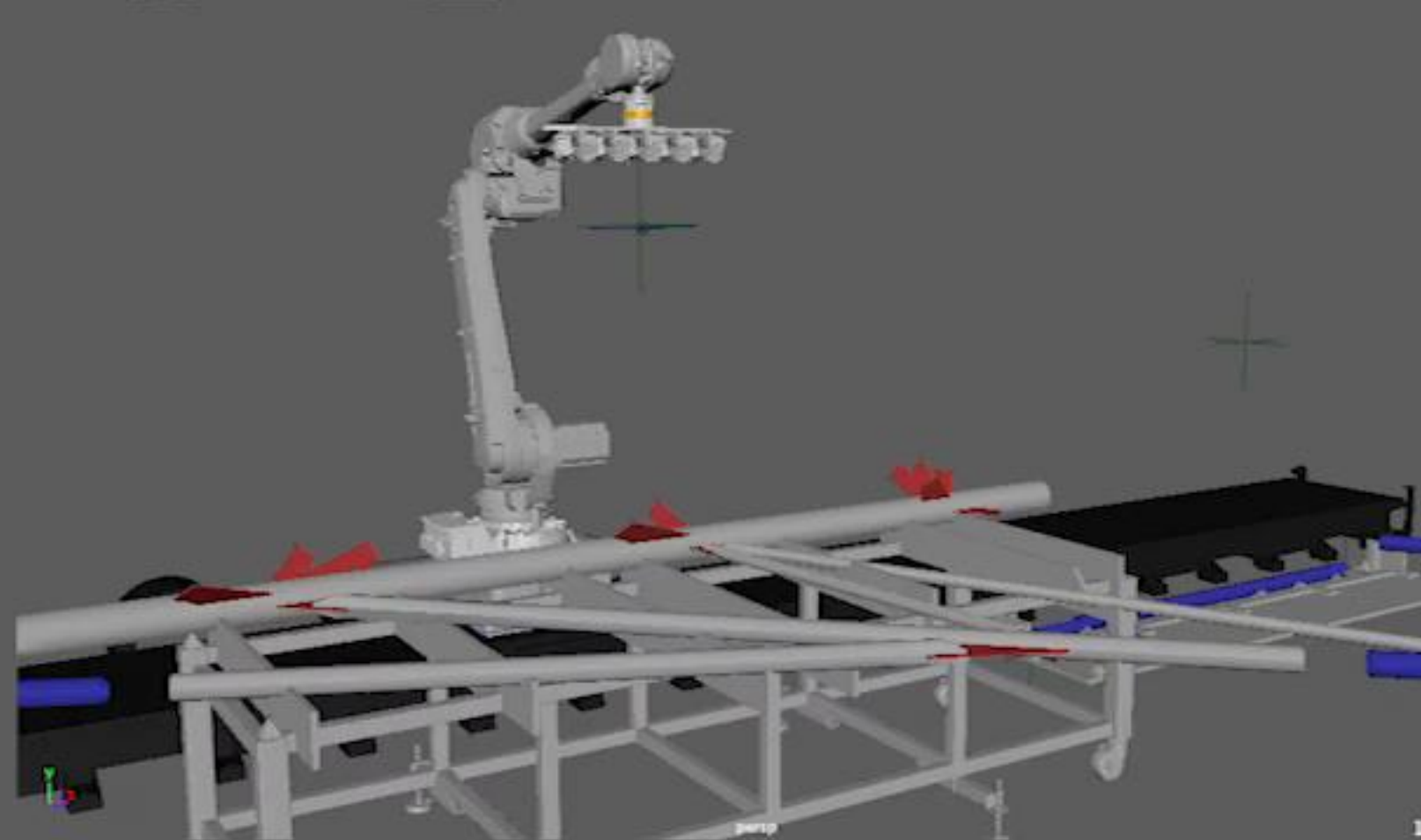


0.1 fps

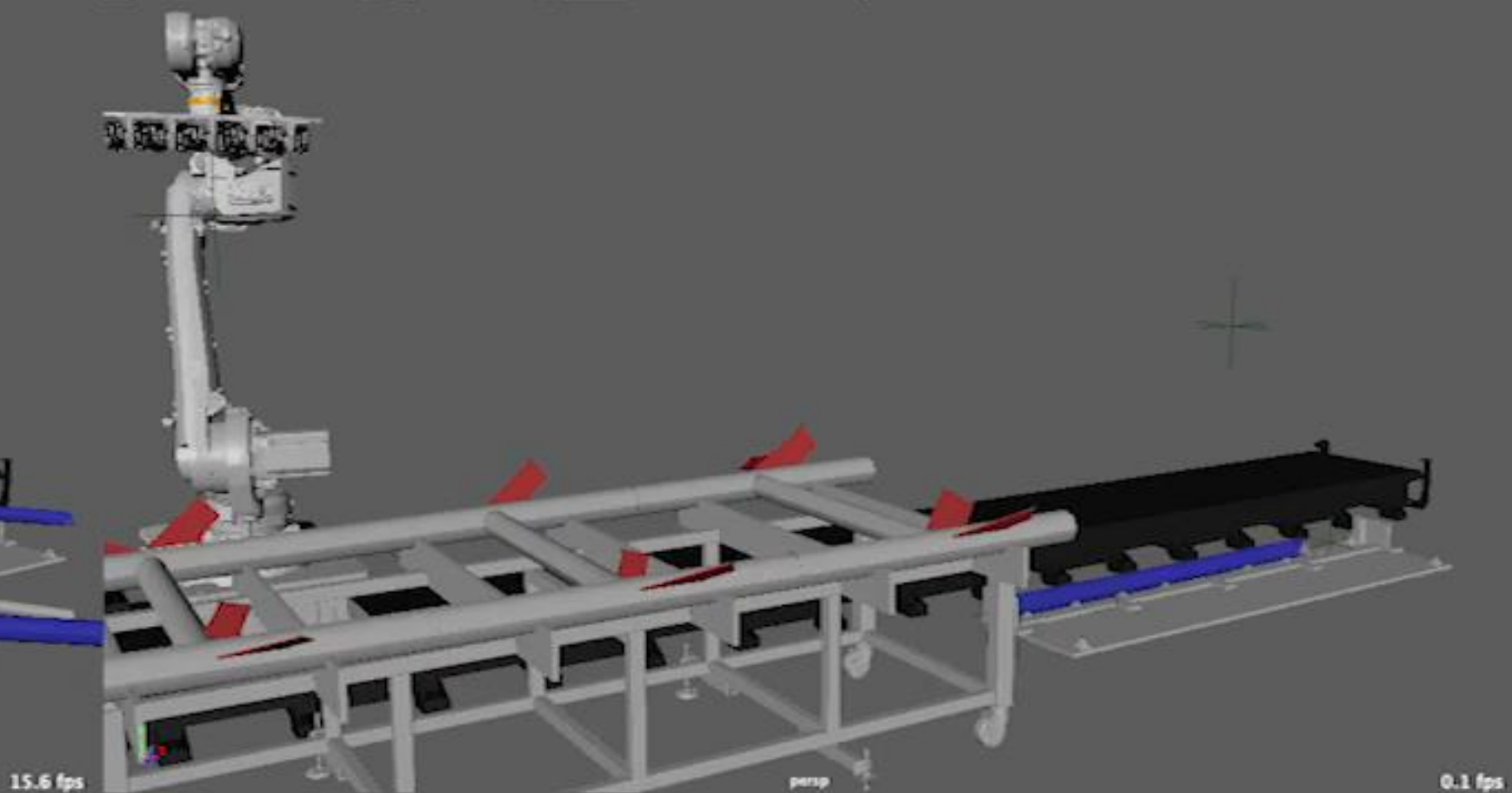
0.2 fps



1.1 fps

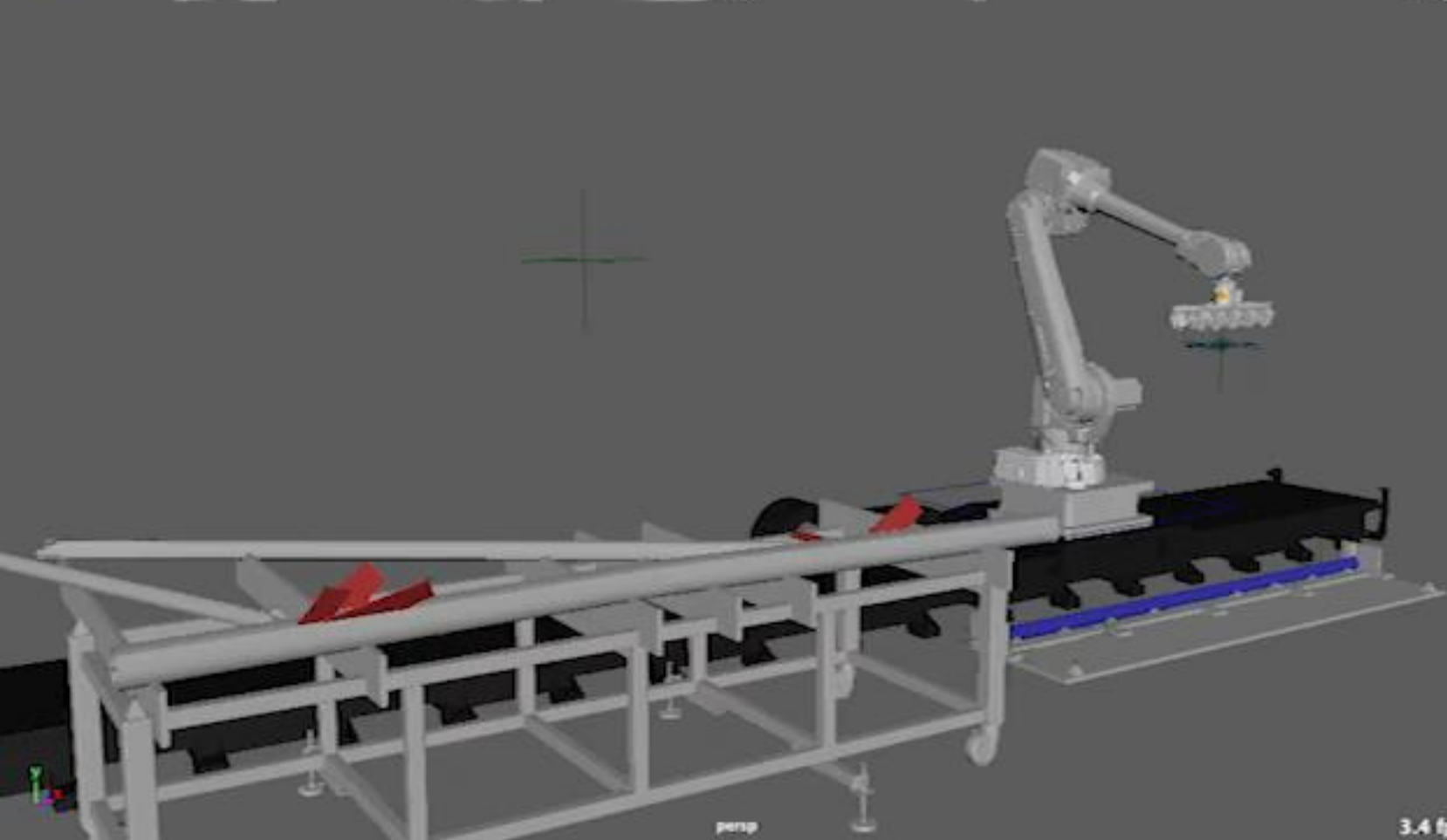


persp

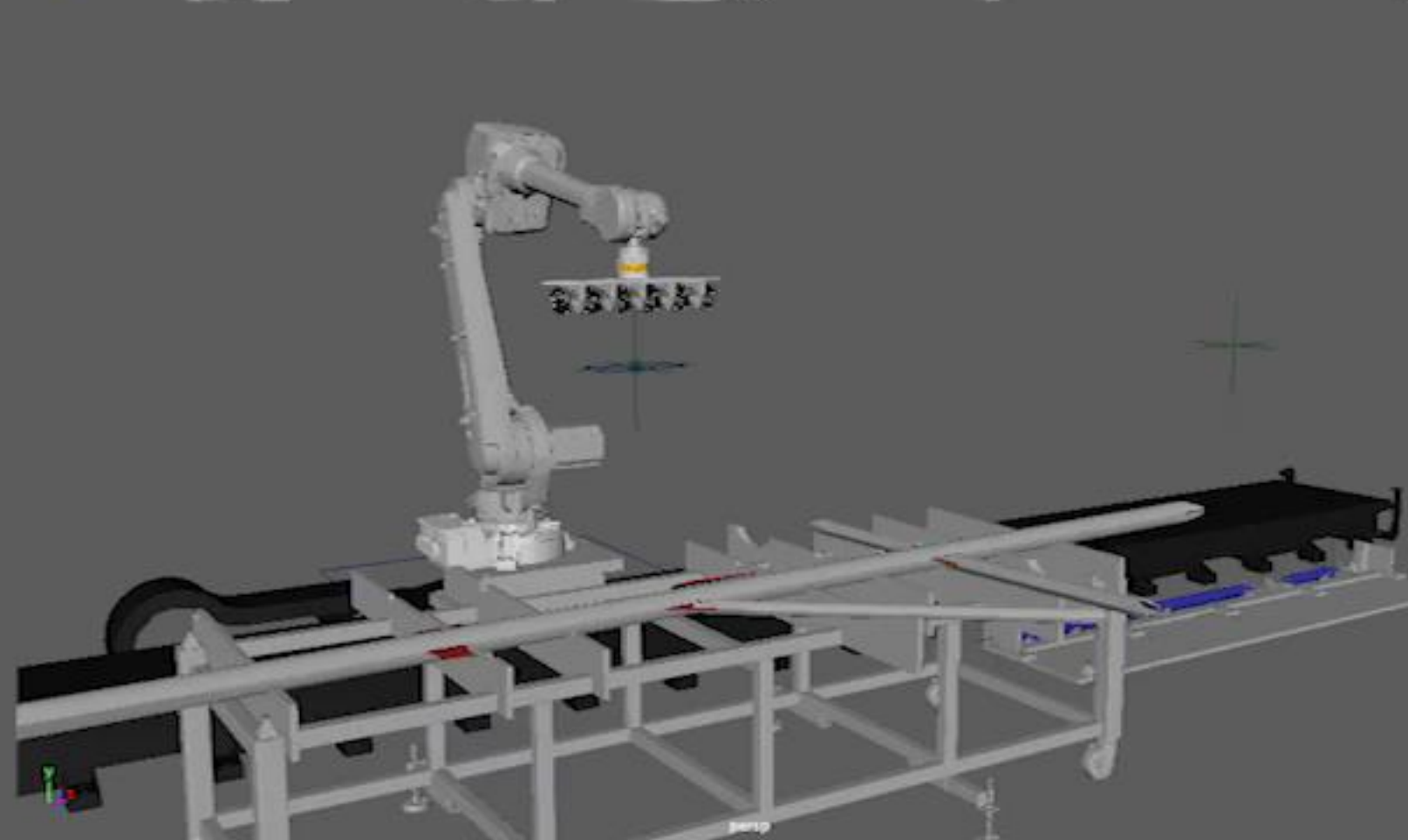


15.6 fps

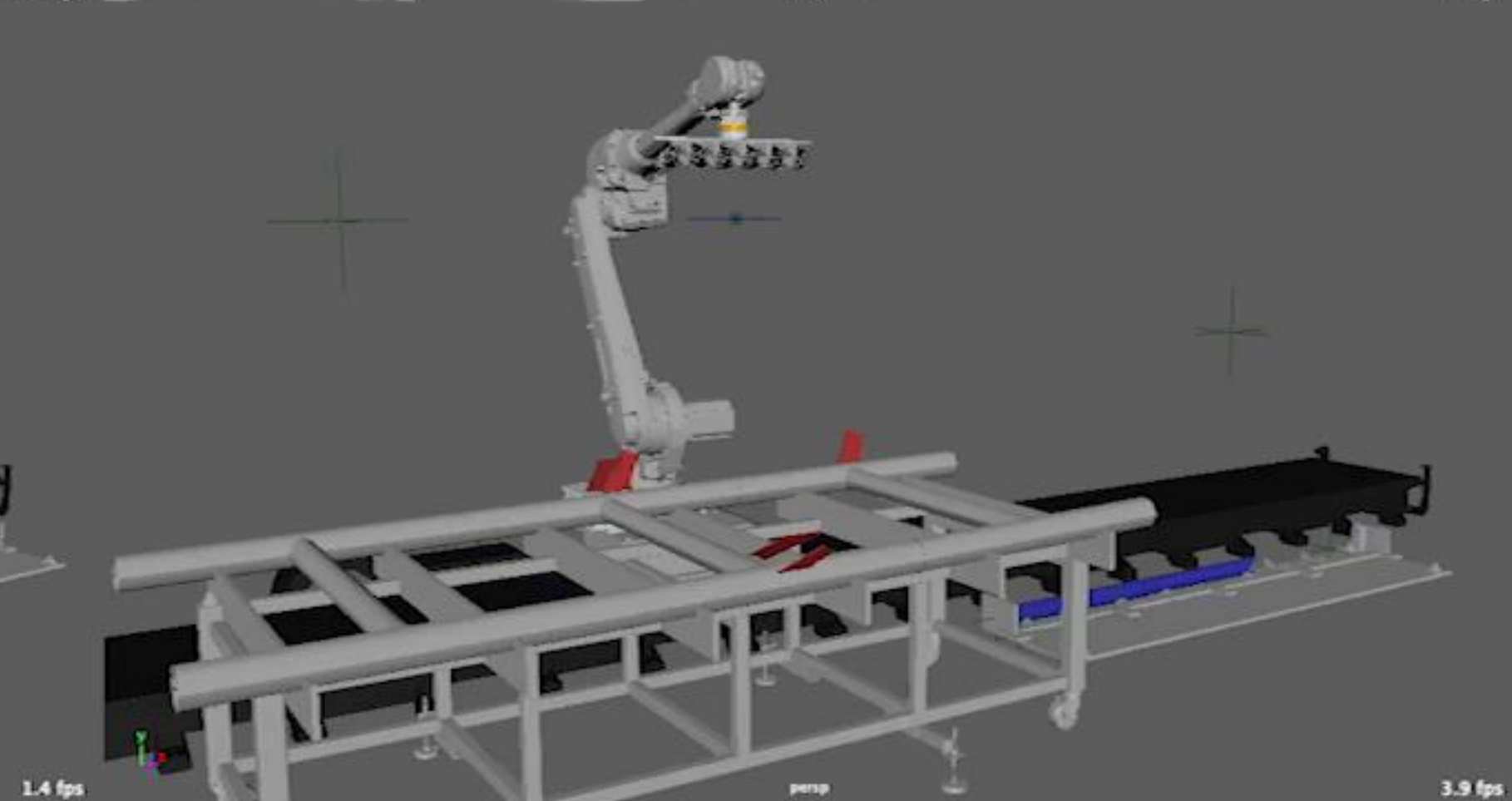
0.1 fps



3.4 fps



persp



1.4 fps

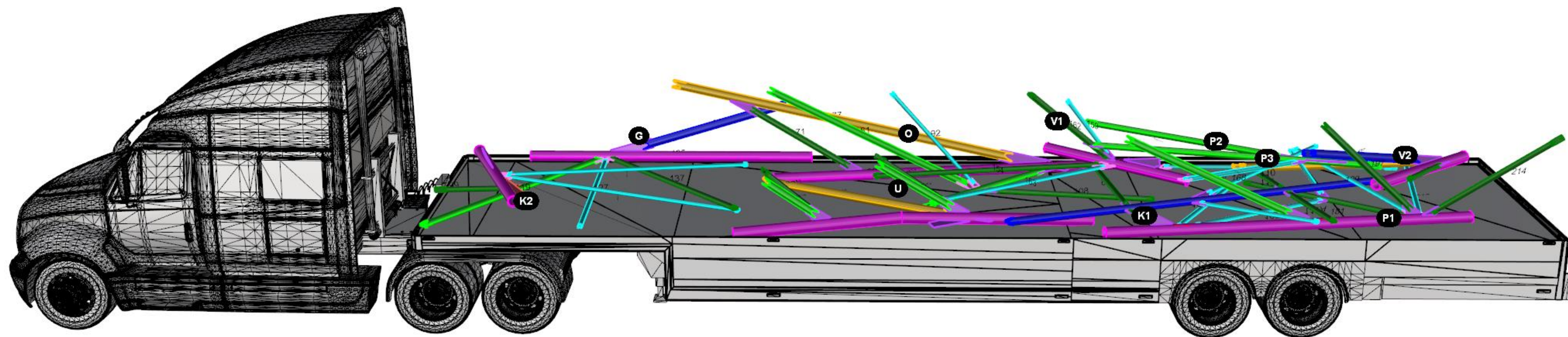
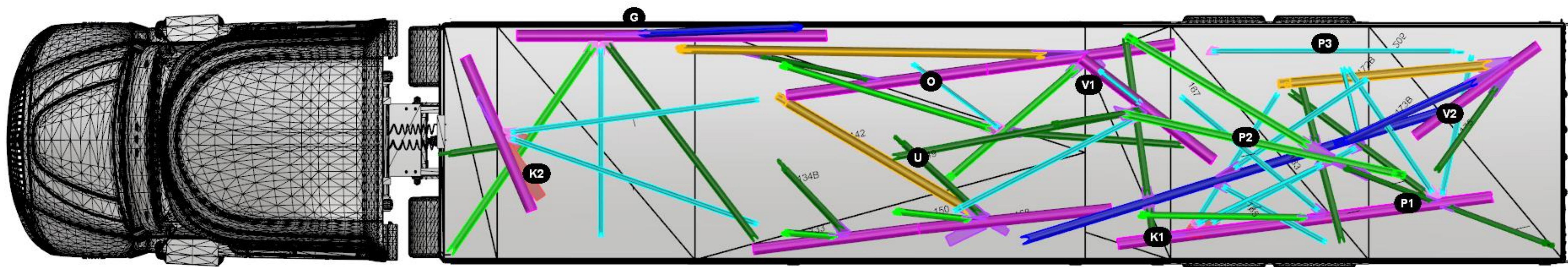
3.9 fps











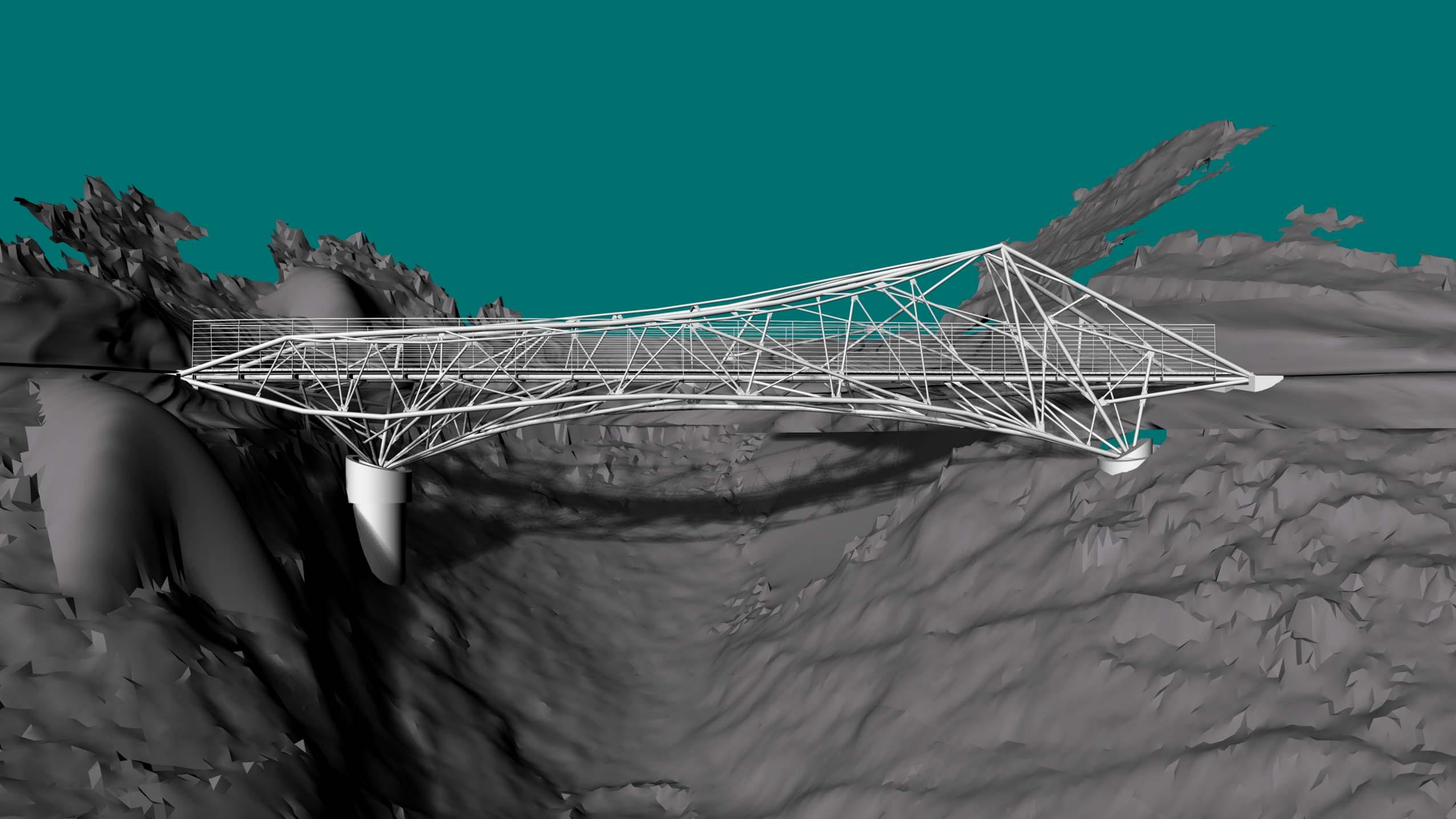










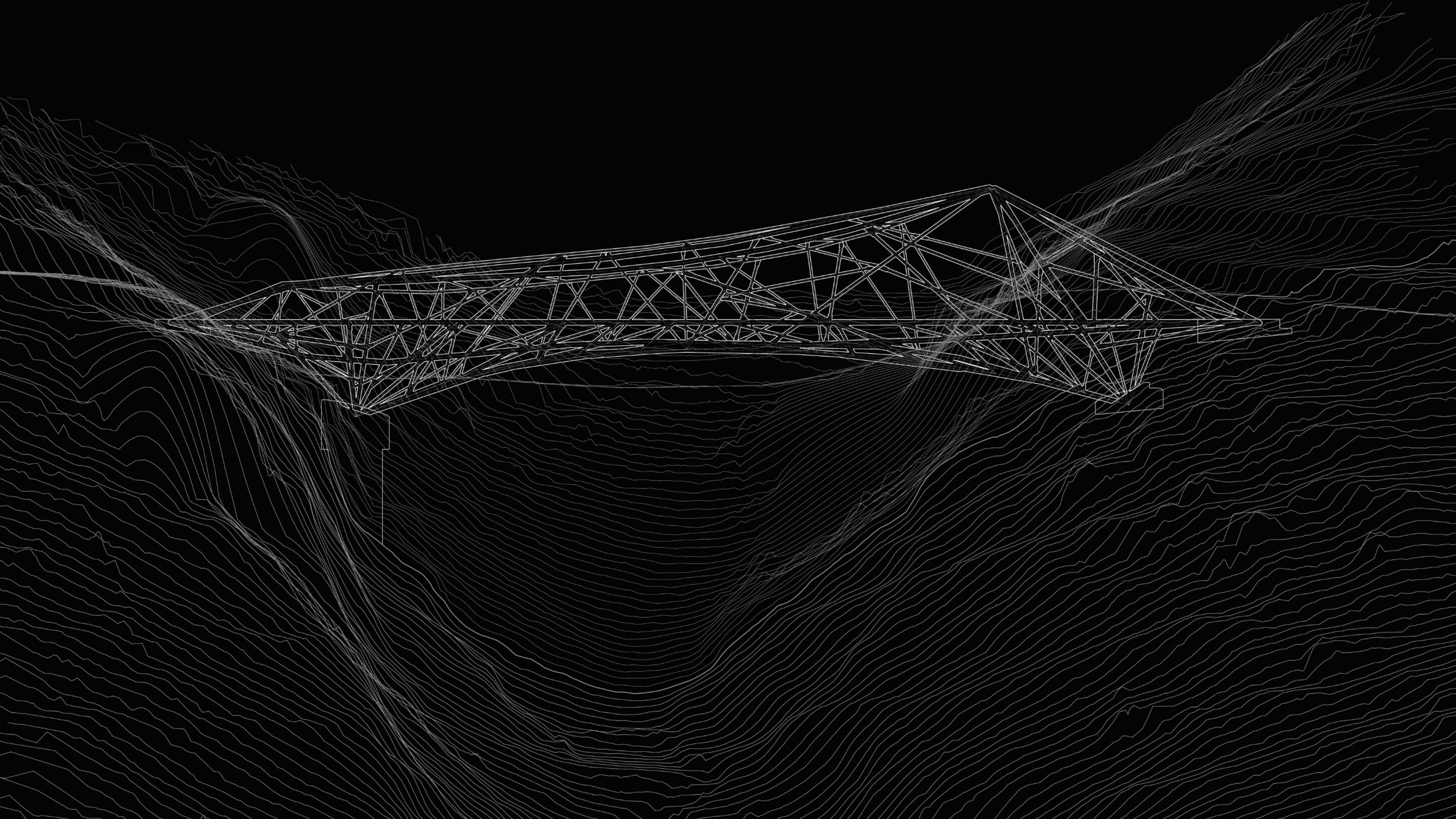












Special thanks to:

Heather Kerrick

Evan Atherton

Alex Weisfeld

Adan Macias

Diana Yan

R. Scott Mitchell

Hakim Hasan

Anna Chen

Nikita Chen-iun-tai

David Riedel



AUTODESK®

Make anything™

Autodesk and the Autodesk logo are registered trademarks or trademarks of Autodesk, Inc., and/or its subsidiaries and/or affiliates in the USA and/or other countries. All other brand names, product names, or trademarks belong to their respective holders. Autodesk reserves the right to alter product and services offerings, and specifications and pricing at any time without notice, and is not responsible for typographical or graphical errors that may appear in this document.

© 2019 Autodesk. All rights reserved.

