Multiaxis Large-Scale AM with Netfabb and Powermill High-Rate Technology

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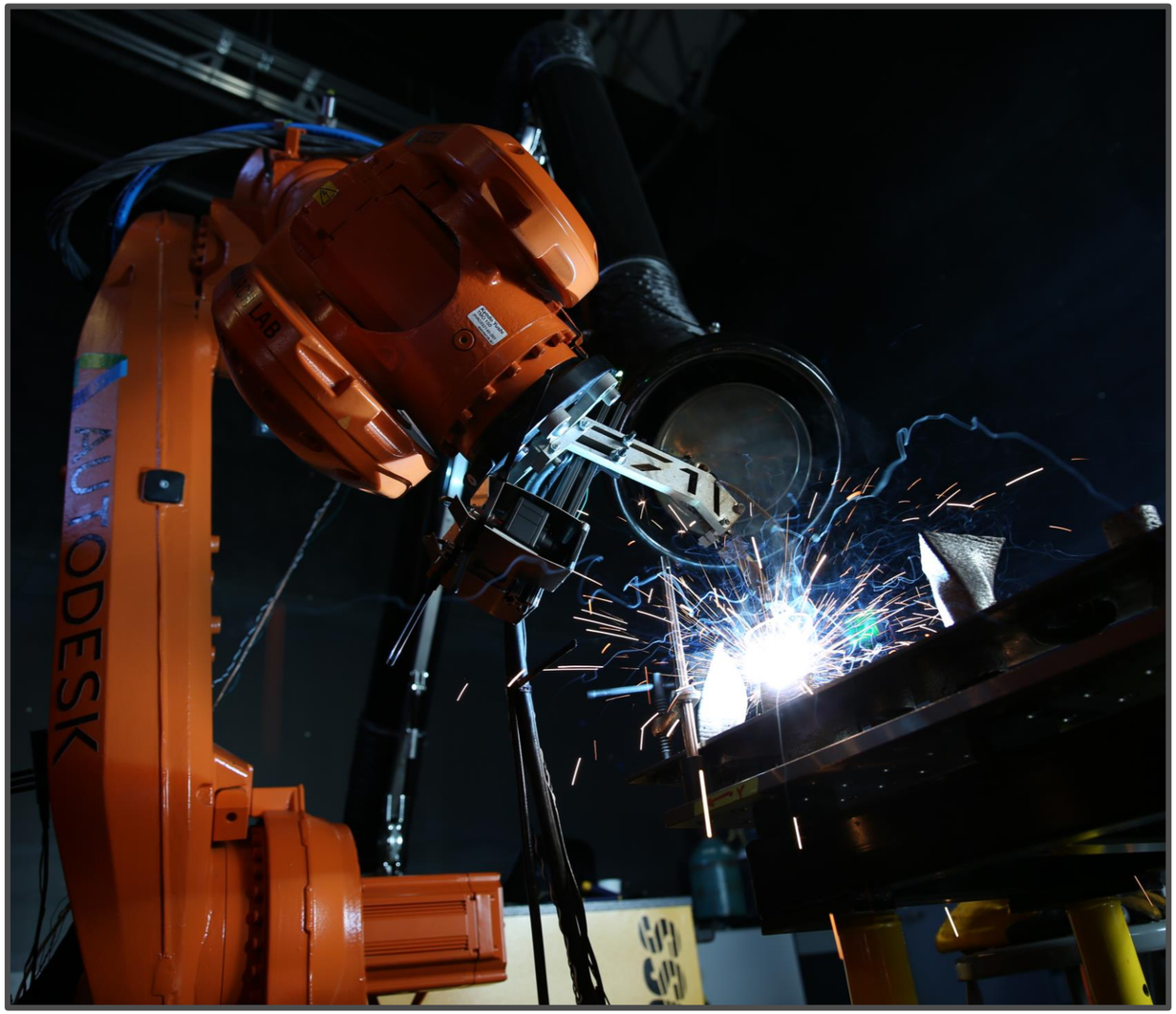
Senior Research Engineer

AUTODESK. UNIVERSITY

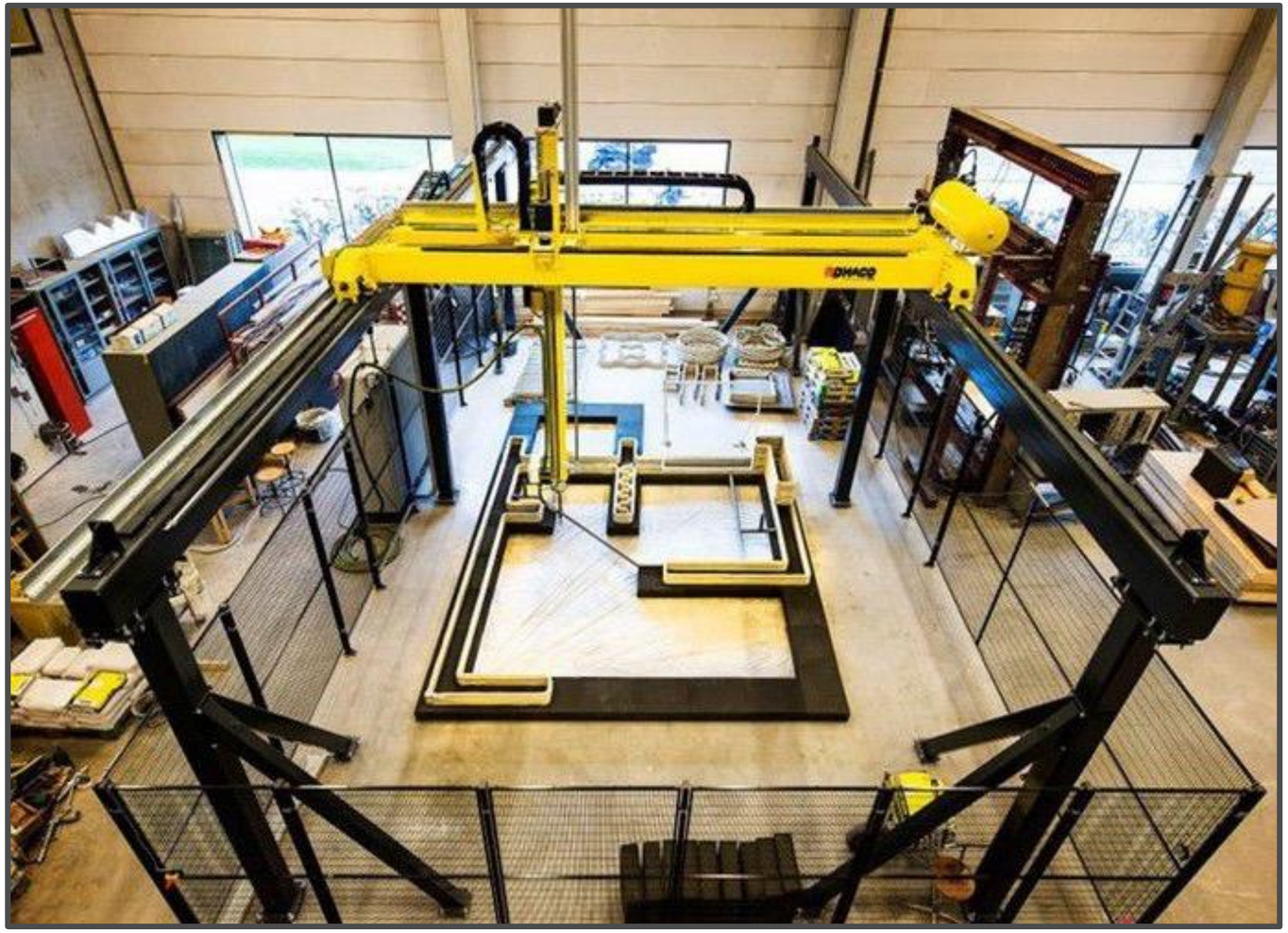
AGENDA

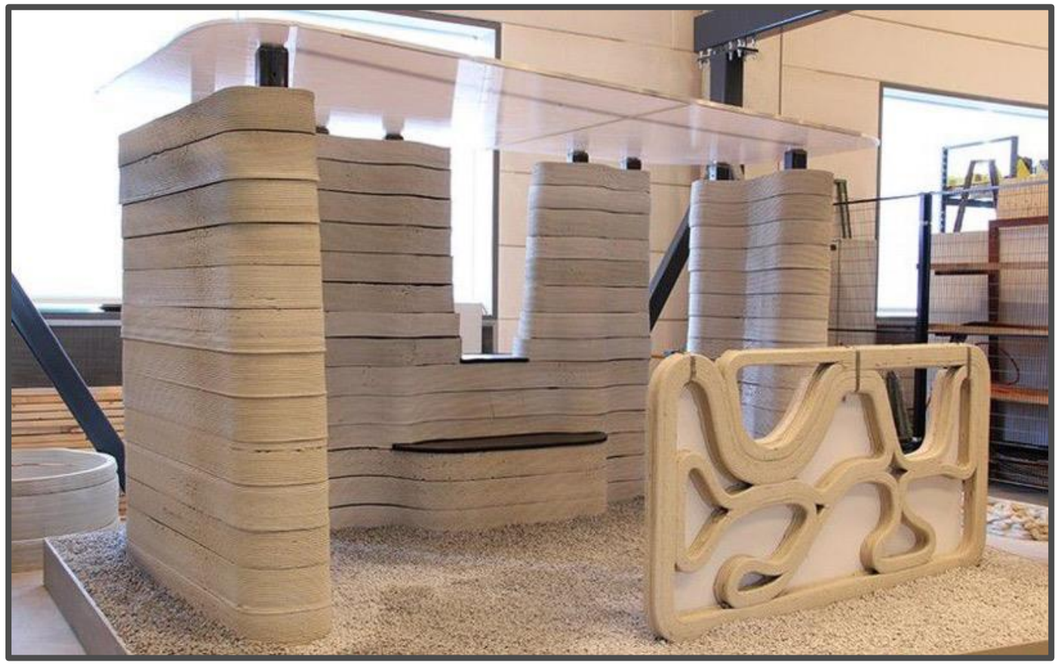
- **Large Scale Additive Manufacturing**
  - Architecture & Construction
  - Manufacturing & Engineering
- **System configuration**
  - Understand your system and materials
  - Understand your application and requirements
- **Software tools**
  - Autodesk Netfabb
  - Autodesk Powermill
  - Autodesk Dynamo
- **Q & A**



Large Scale Additive Manufacturing

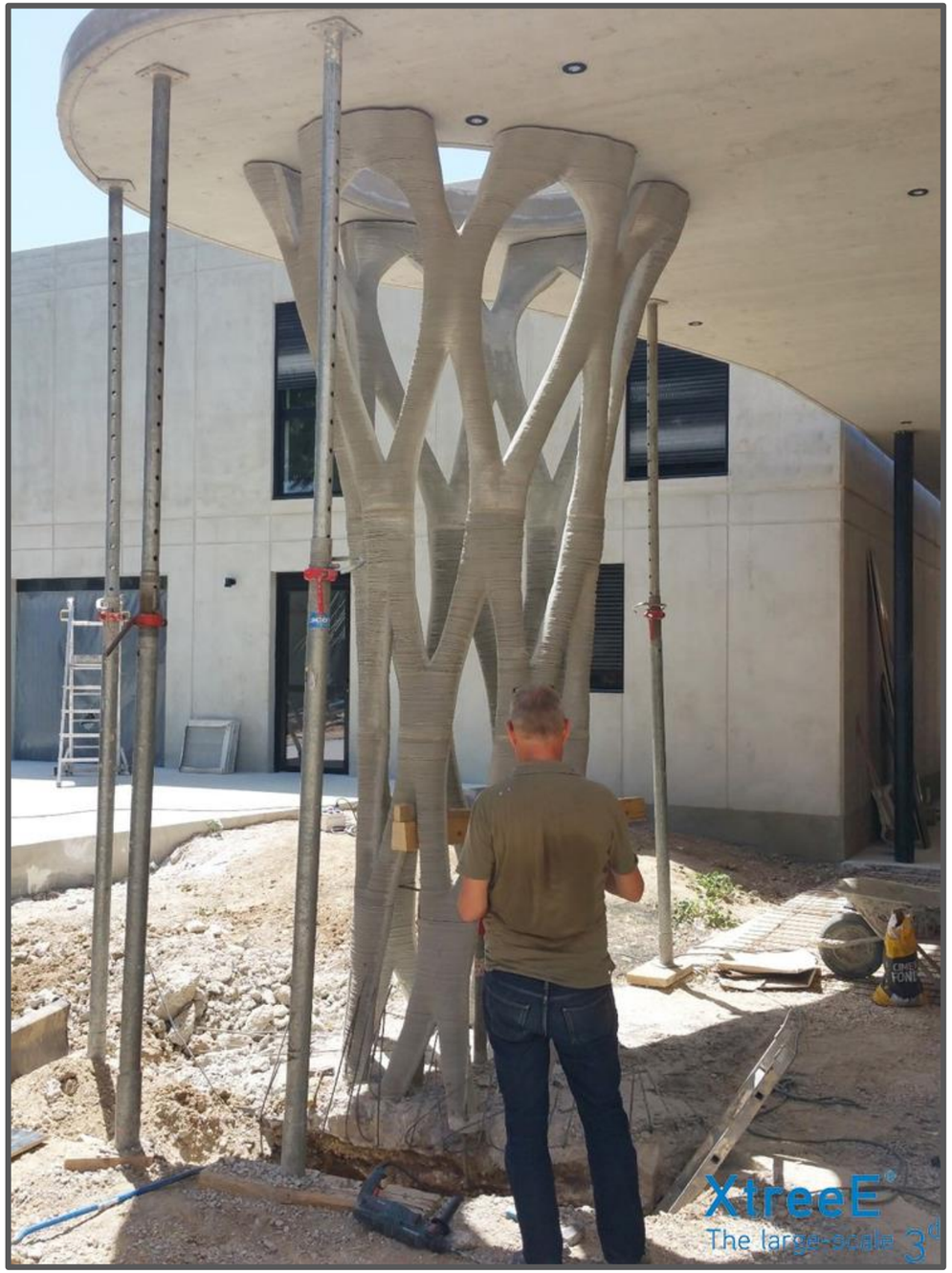
What means large scale additive manufacturing?





TU Eindhoven and Rohaco company, Netherlands

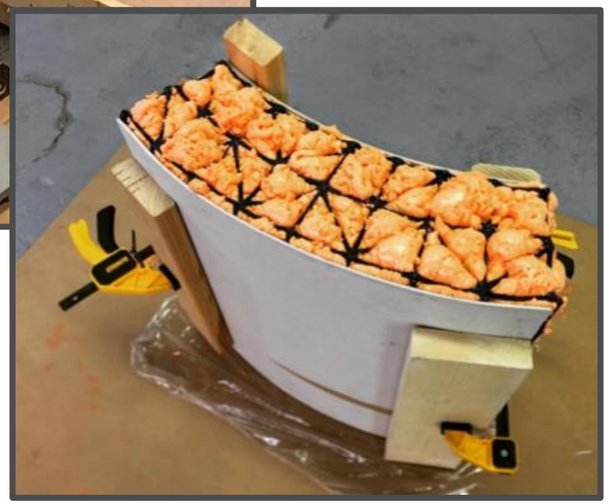
XtreeE, France https://www.xtreee.eu



FloandJet by Branch Technology

Knoxville Bureau of Air and Space by Branch Technology

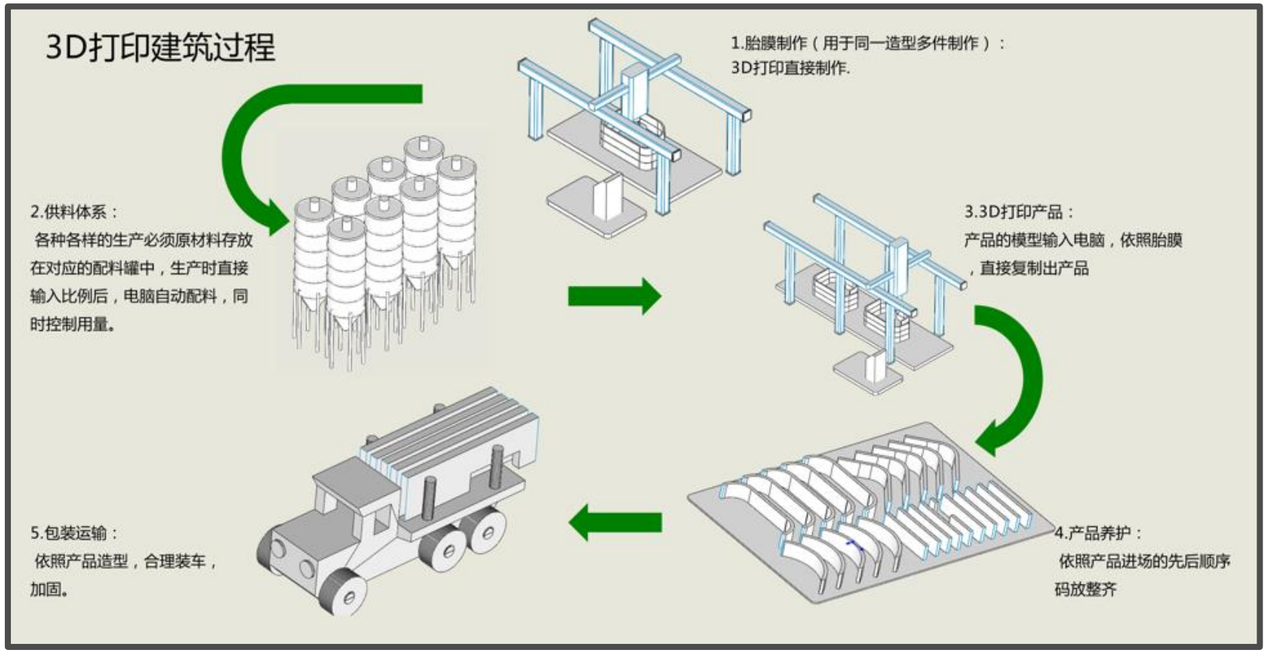
Gramazio and Kohler, ETH Zurich



Branch Technology (USA)

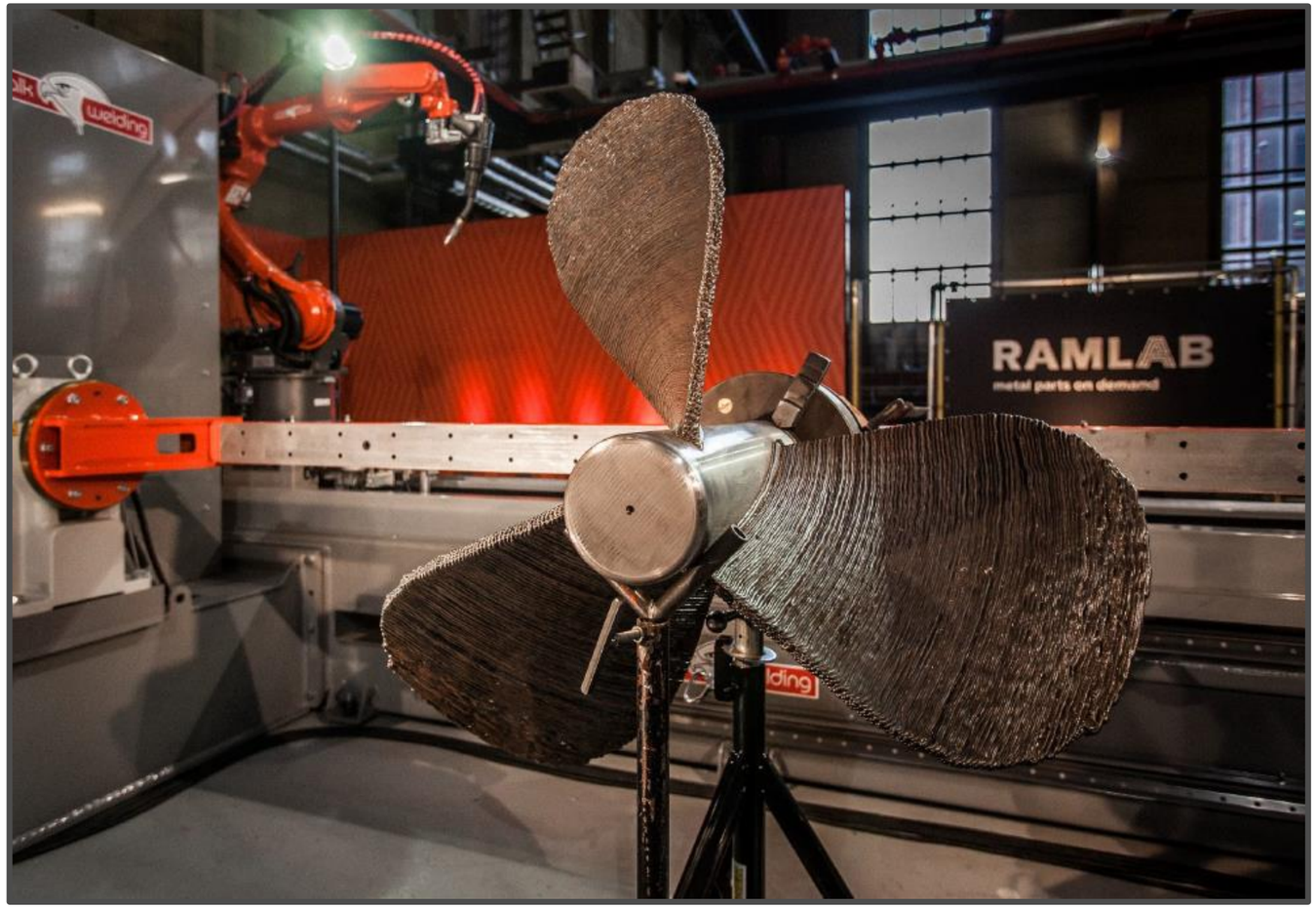
Dubai 3D Printing Strategy

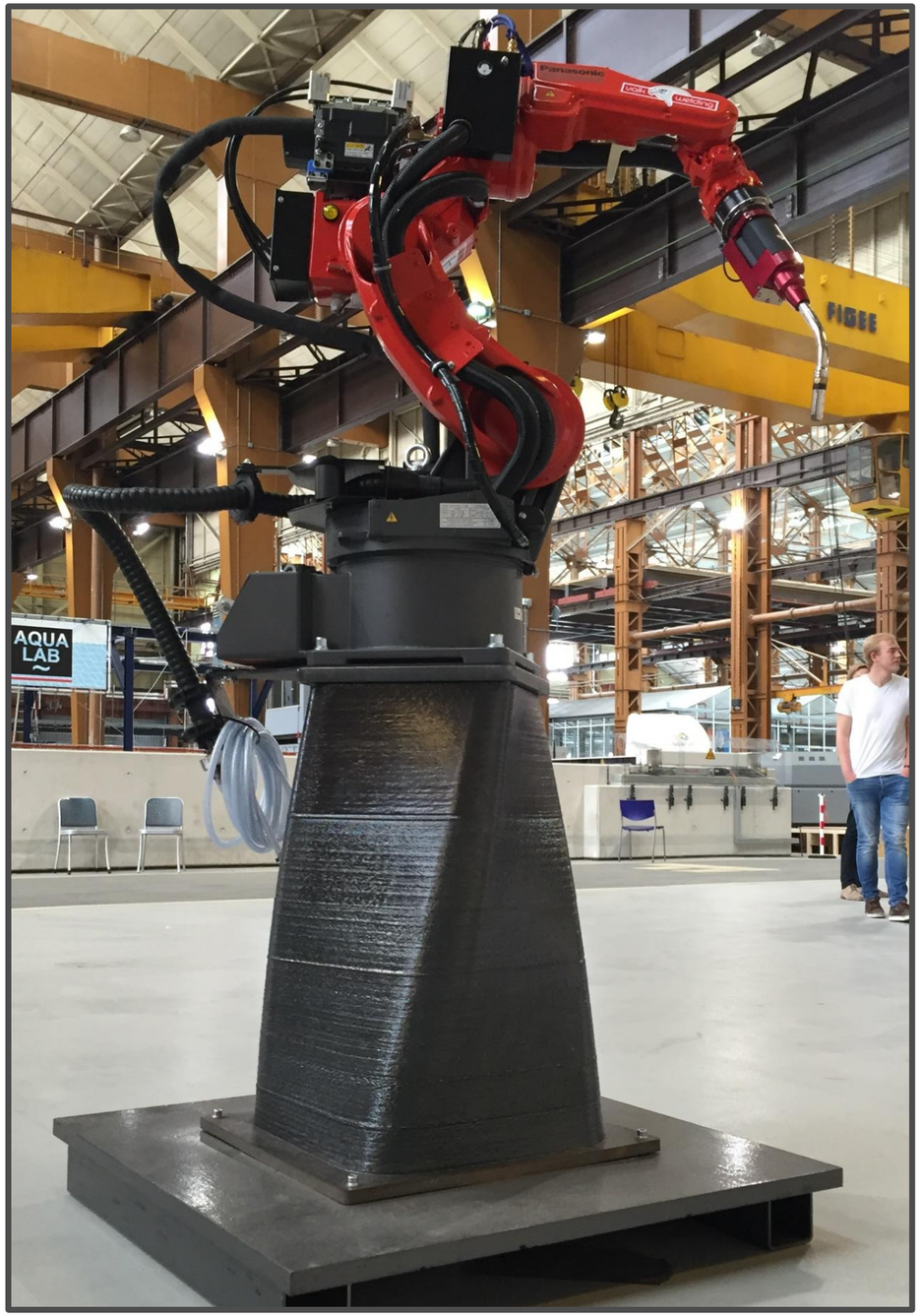
- 300 billion dollar market by 2025
- 25% of all of Dubai’s new construction to be 3D printed by the year 2025
- 1.7 billion expected medical products market in Dubai by 2025
- 2.8 billion expected consumer products market in Dubai by 2025

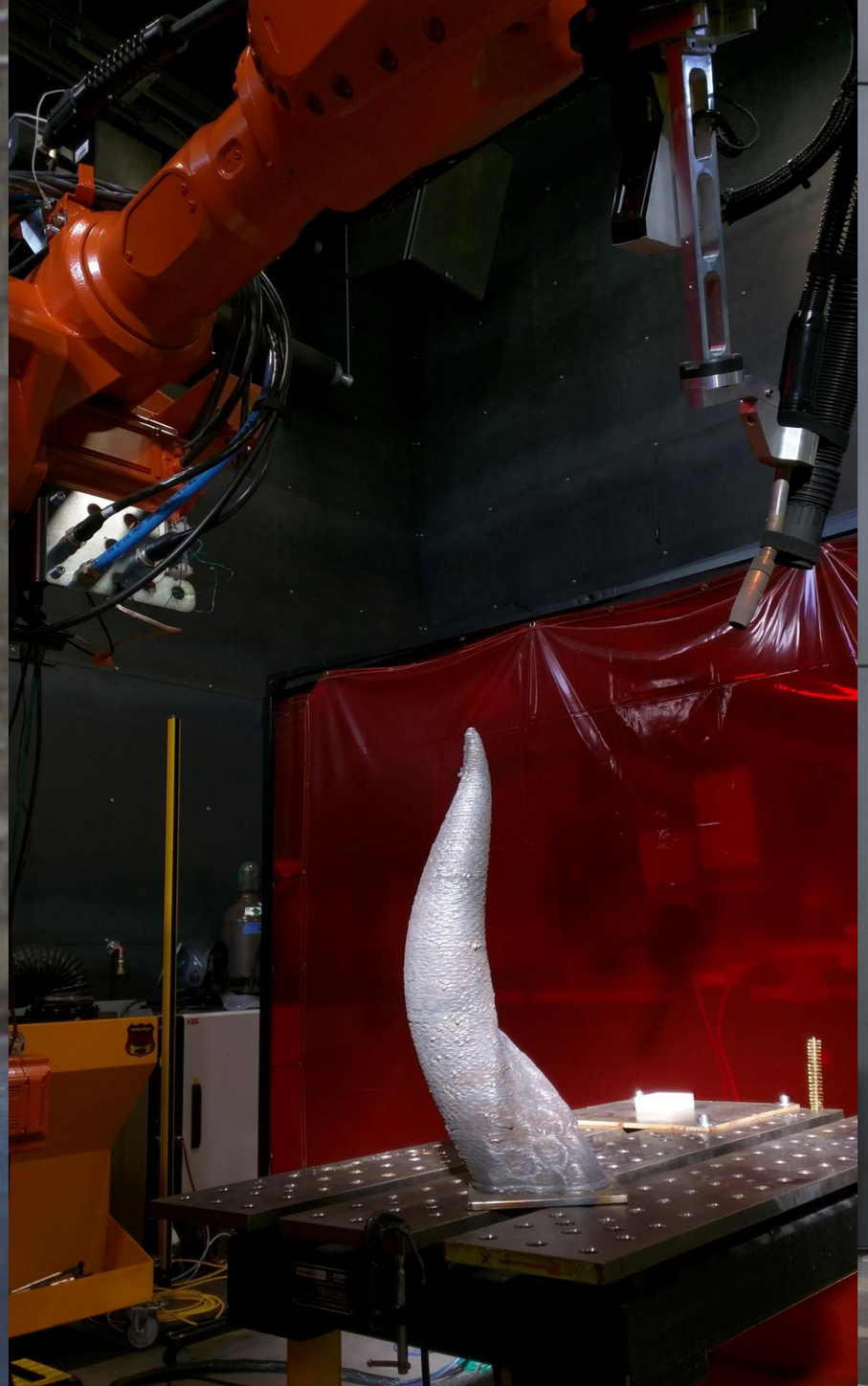


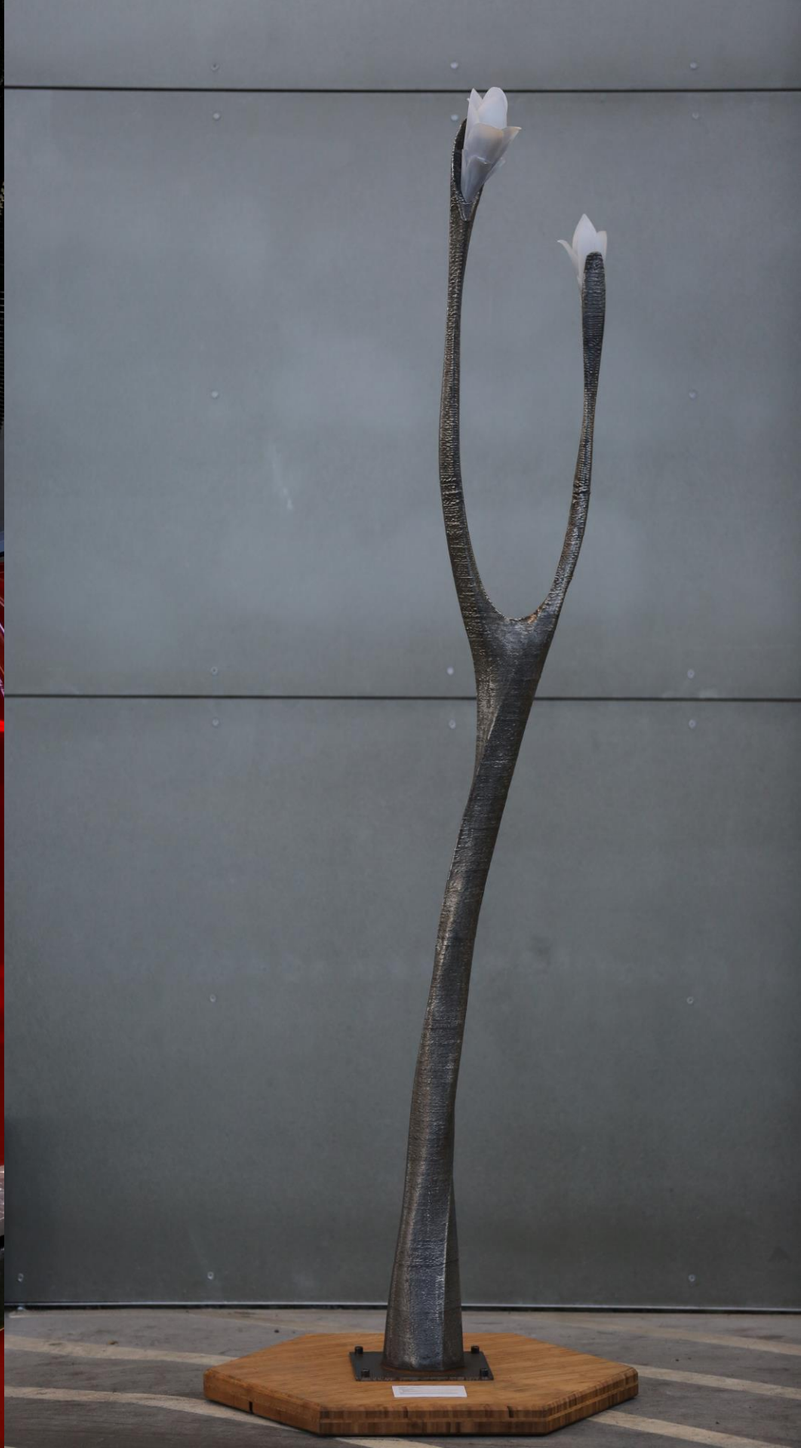
WinSun Decoration Design Engineering Co, China
http://www.yhbm.com/index.php?sitei
d=3

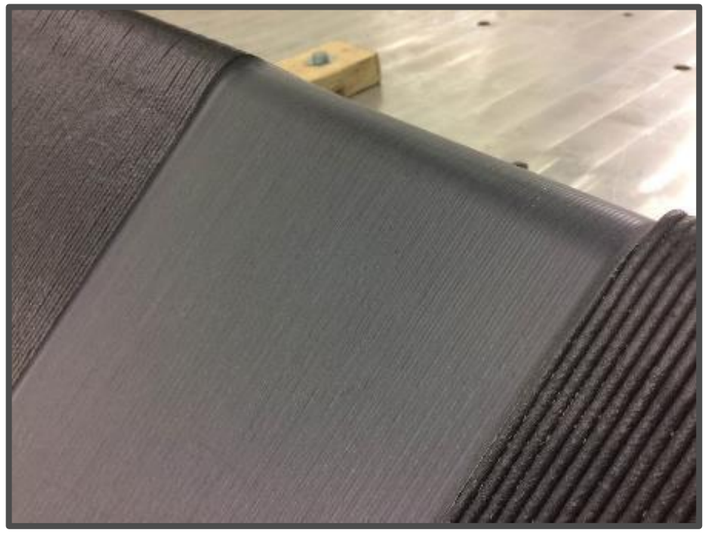
Downtime - $200k/day



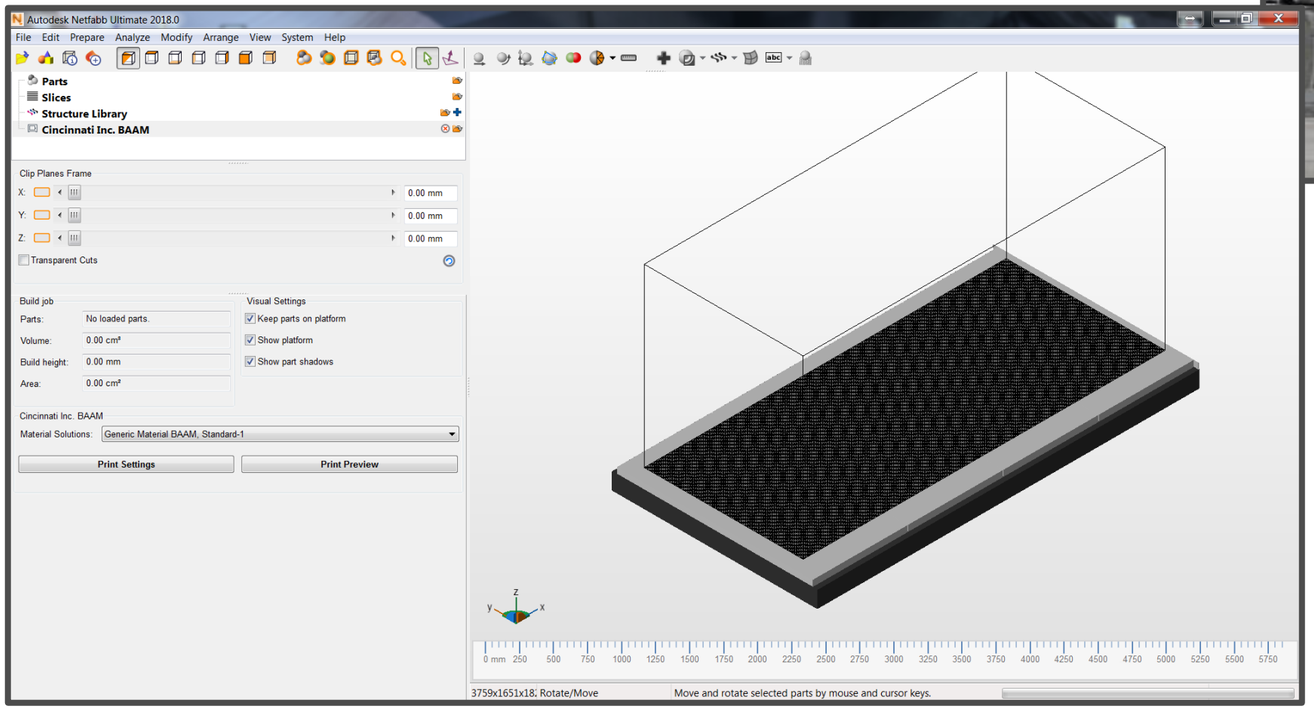


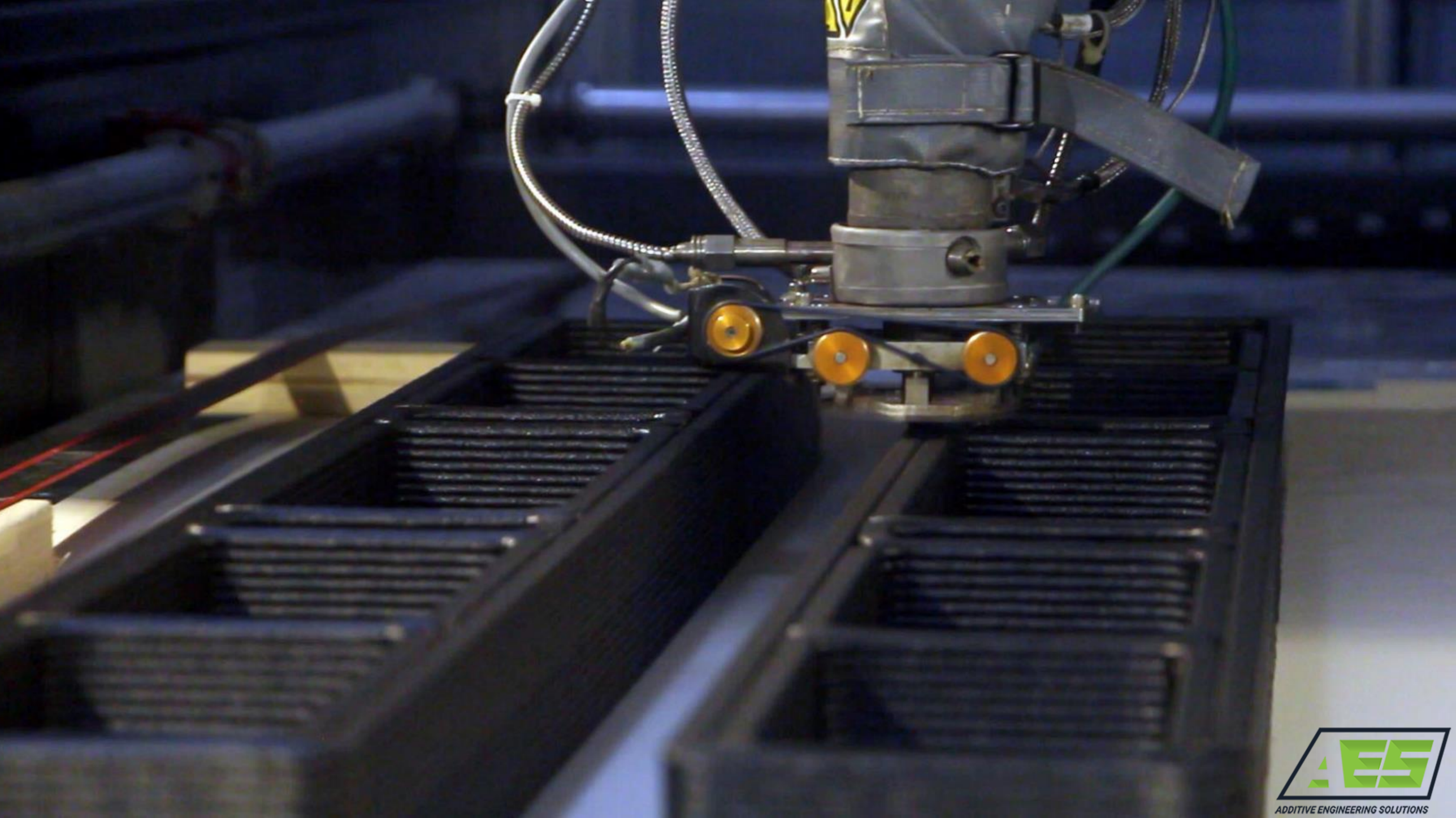


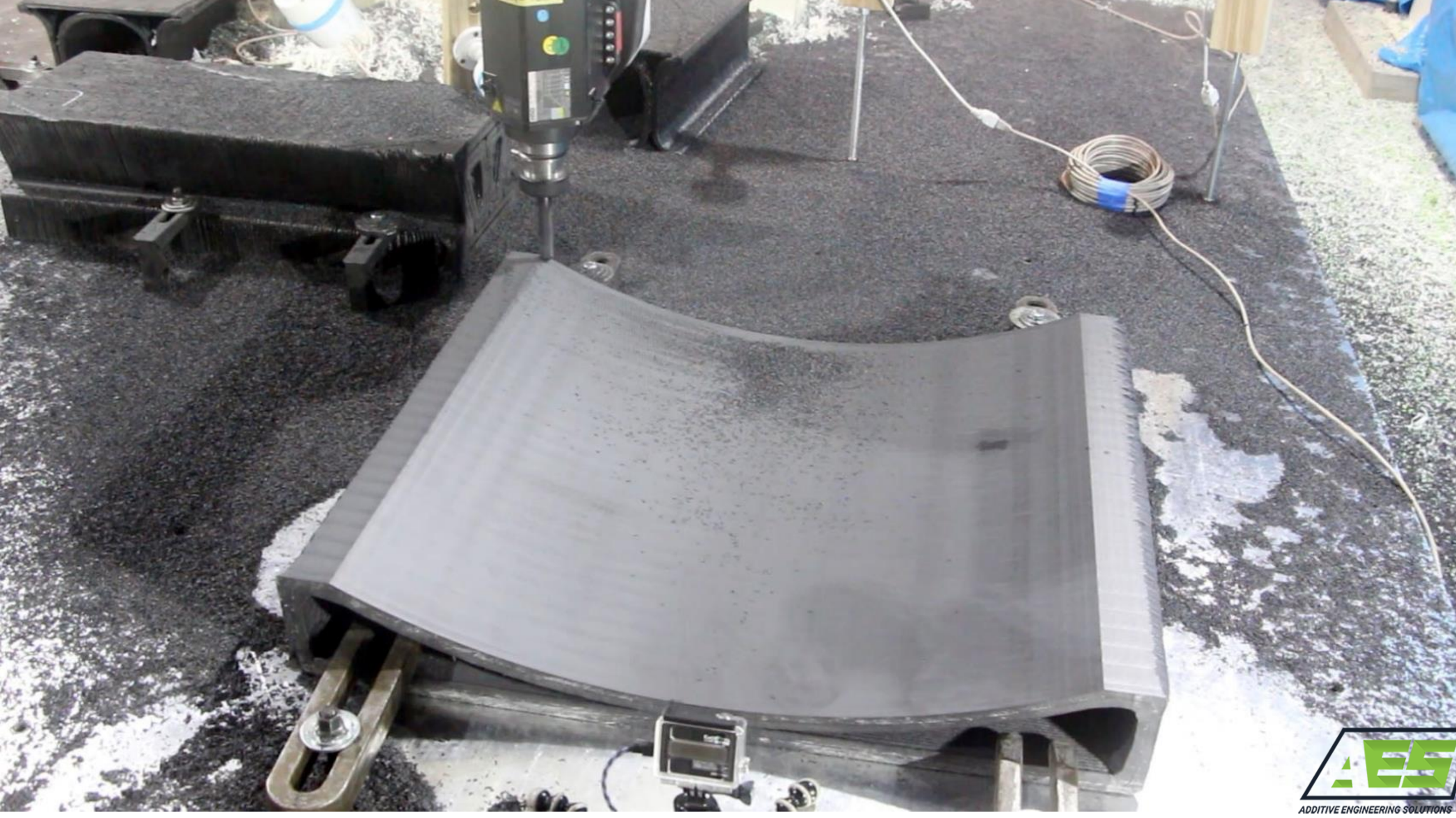




CINCINNATI
BAAM


Autodesk Netfabb Ultimate 2018.0
File Edit Prepare Analyze Modify Arrange View System Help
Parts
Slices
Structure Library
Cincinnati Inc. BAAM
Clip Planes Frame
X: 0.00 mm
Y: 0.00 mm
Z: 0.00 mm
Transparent Cuts
Build job
Parts: No loaded parts.
Volume: 0.00 cm³
Build height: 0.00 mm
Area: 0.00 cm²
Visual Settings
Keep parts on platform
Show platform
Show part shadows
Cincinnati Inc. BAAM
Material Solutions: Generic Material BAAM, Standard-1
Print Settings
Print Preview
0 mm 250 500 750 1000 1250 1500 1750 2000 2250 2500 2750 3000 3250 3500 3750 4000 4250 4500 4750 5000 5250 5500 5750
3759x1651x18: Rotate/Move
Move and rotate selected parts by mouse and cursor keys.

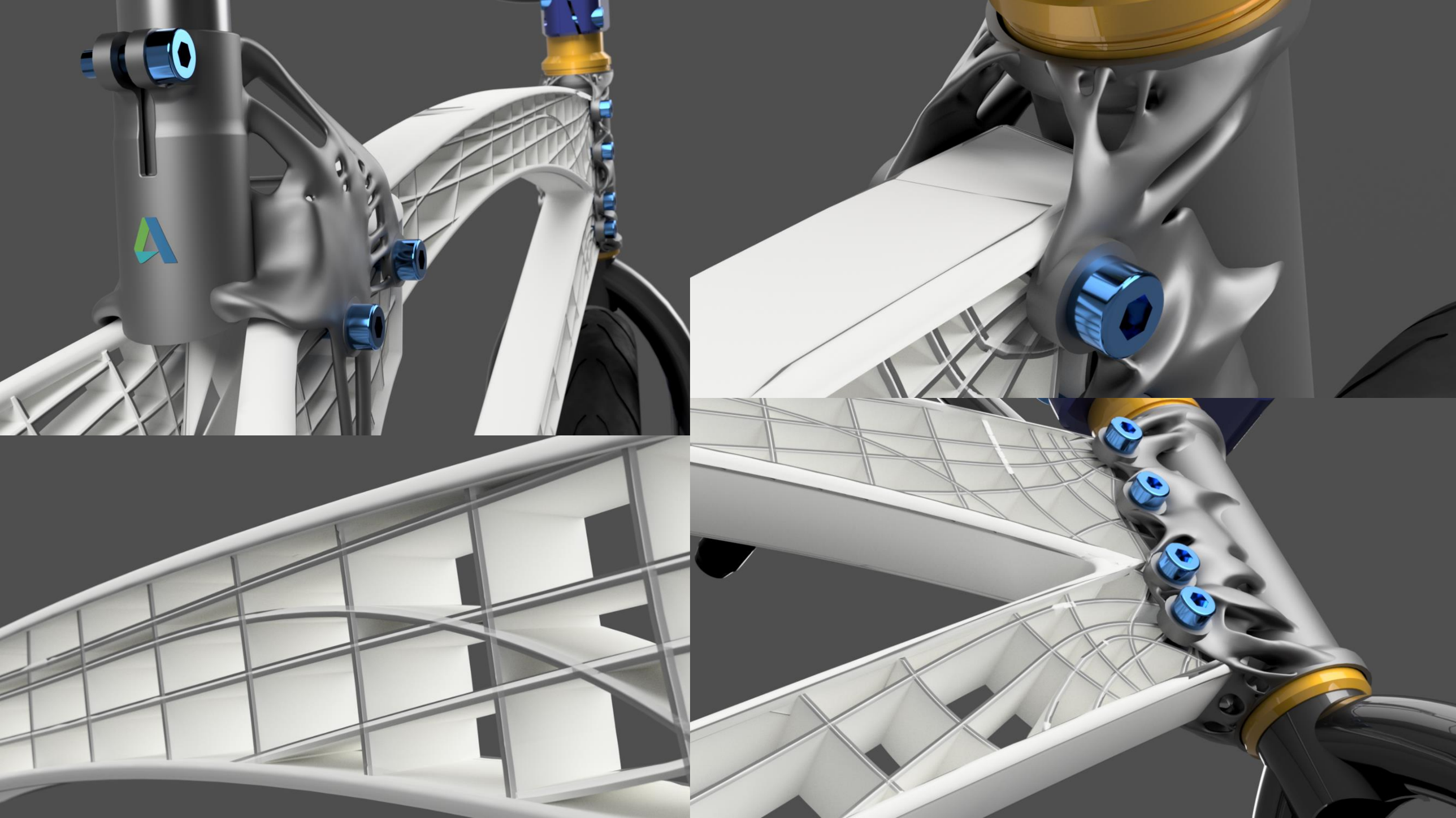

AES
ADDITIVE ENGINEERING SOLUTIONS

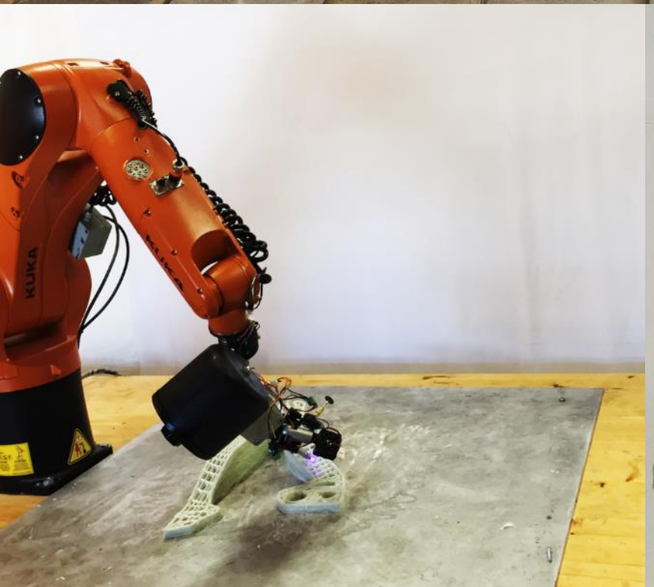


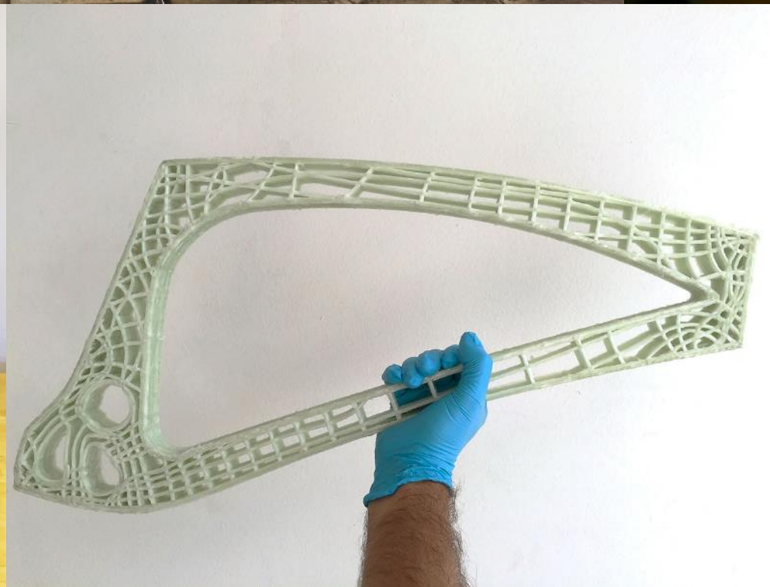
ADDITIVE ENGINEERING SOLUTIONS

+LAB

POLITECNICO
MILANO 1863



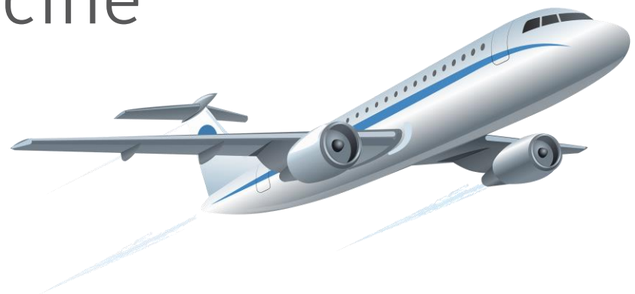

KUKA



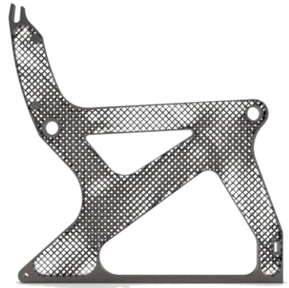
System configuration

Understand your application and requirements

- Architecture
- Aerospace
- Automotive industry
- Marine industry
- Biology
- Medicine
- …

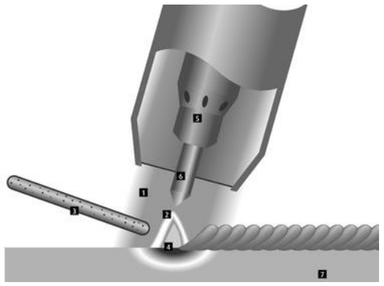


- Costs
- Weight
- Stiffness
- Temperature
- Water residence
- Design
- …



Understand your system and materials

- Robot
- Hybrid
- Gantry
- Laser
- Extruder
- Arc
- …



- Metal
- Polymer
- Concrete
- Composite
- Multi material
- …

Software tools

Autodesk Netfabb Ultimate 2018.0 - Parte57.fabbproject

File Edit Prepare Analyze Modify Arrange View System Help

- Parts
- Parts (KUKA KR900)
  - (100%) 2 (repaired)
- Slices
  - Perimetro Esterno
  - Bottom
  - Infill
  - Top
- Structure Library

Clip Planes Frame

X: 0.00 mm

Y: 0.00 mm

Z: 0.00 mm

Transparent Cuts

Cuts

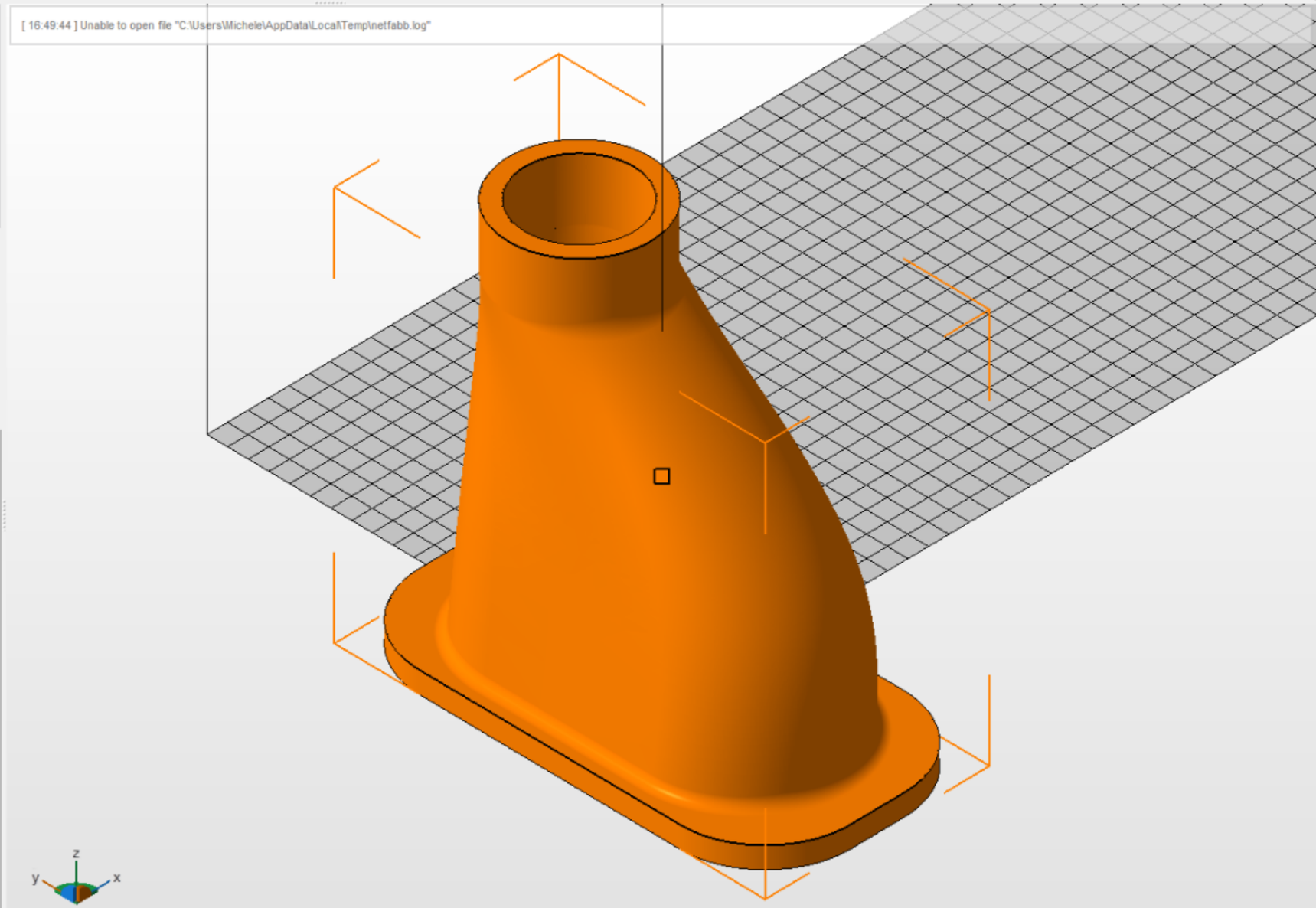
<cutting disabled>

Information

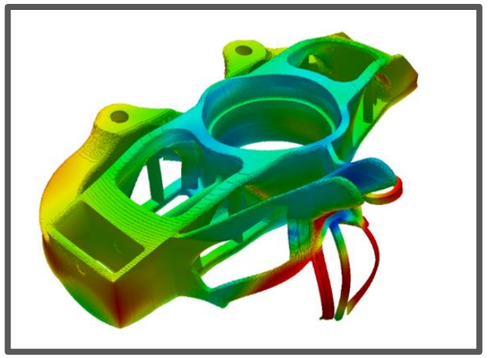
Length:	111.00	mm	Volume:	597.44 cm³
Width:	213.00	mm	Area:	1500.74 cm²
Height:	190.00	mm	Triangles:	408454

1 of 1 part is selected.

[16:49:44] Unable to open file "C:\Users\Michele\AppData\Local\Temp\netfabb.log"

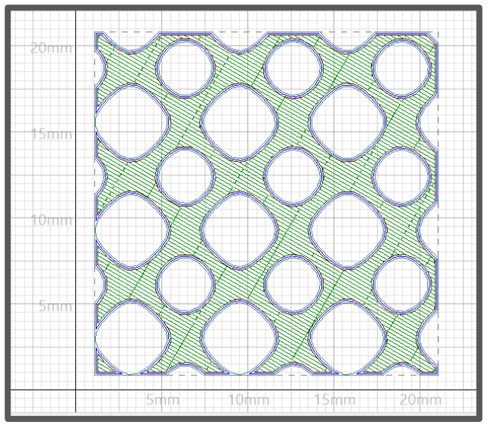


750x225x800 | Rotate/Move | Move and rotate selected parts by mouse and cursor keys.



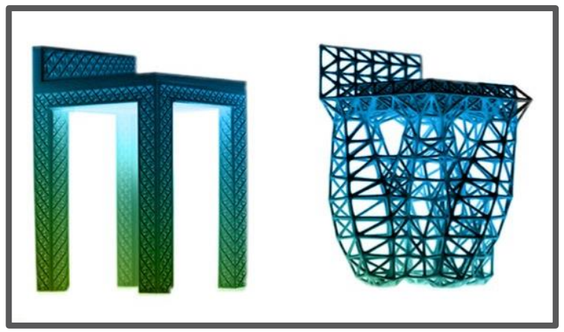
Additive Process Simulation

State of the art Simulation technologies for Metal Powder Bed Sintering and Direct Energy Deposition



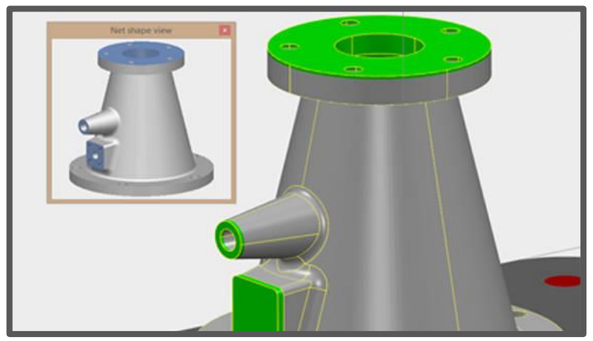
Advanced Toolpathing

Toolpath strategy development tools for laser sintering and deposition modeling.



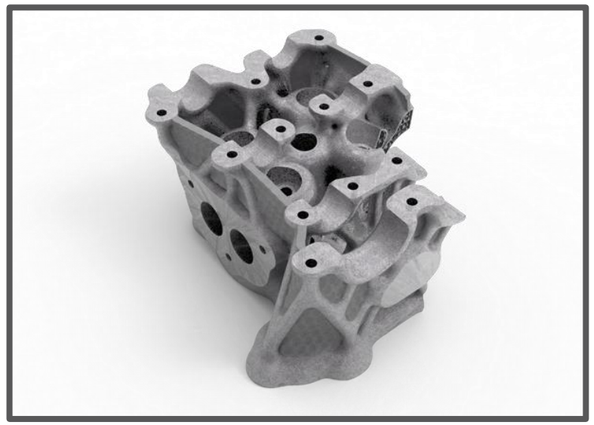
Generative Design

Multi-variate generative synthesis of geometry based on design goals.



Hybrid Manufacturing Data Preparation

Solid modelling capabilities based on PowerShape - for near-netshape planning and handling of CNC postprocessing.

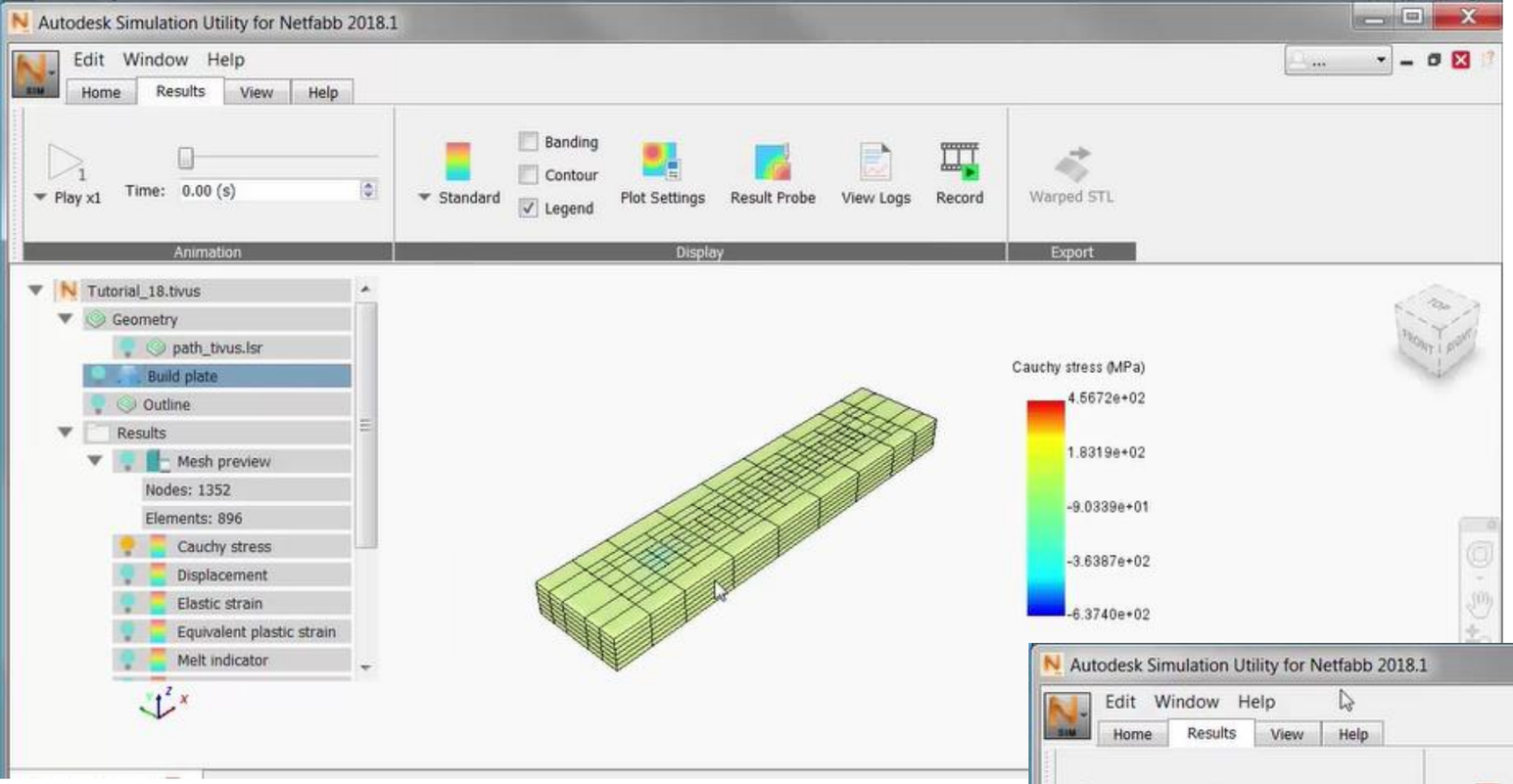


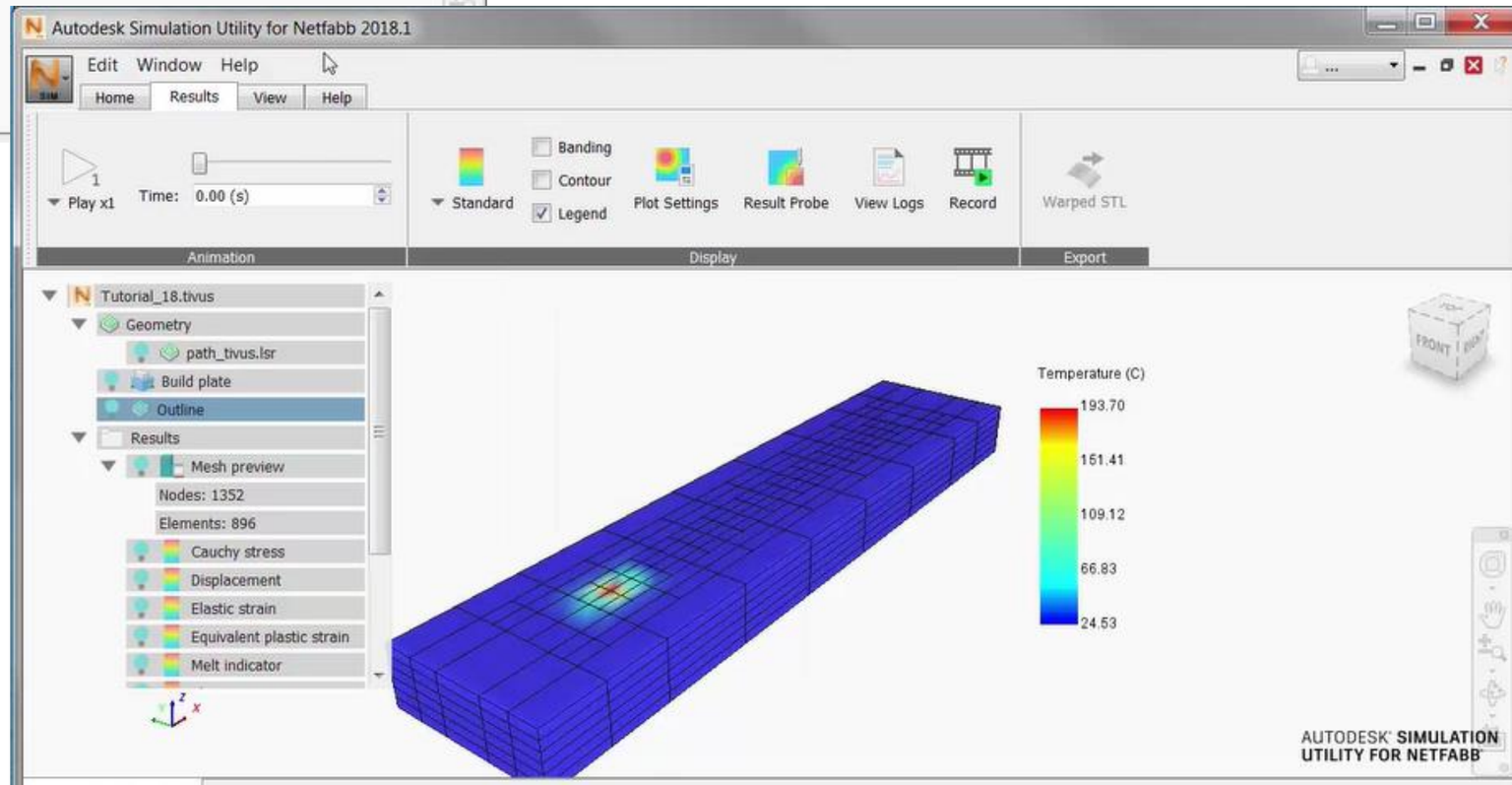
Latticing and Topology Optimization

Design for Manufacturing while combining Topology Optimization / Latticing / Mesh Editing in an interactive workflow.

Process Automation

Script based automation functionality for rich enhancement and UI adaption to custom needs.


Autodesk Simulation Utility for Netfabb 2018.1
Edit Window Help
Home Results View Help
Play x1
Time: 0.00 (s)
Standard
Banding
Contour
Legend
Plot Settings
Result Probe
View Logs
Record
Warped STL
Animation
Display
Export
Tutorial_18.tivus
Geometry
path_tivus.lsr
Build plate
Outline
Results
Mesh preview
Nodes: 1352
Elements: 896
Cauchy stress
Displacement
Elastic strain
Equivalent plastic strain
Melt indicator
Cauchy stress (MPa)
4.5672e+02
1.8319e+02
-9.0339e+01
-3.6387e+02
-6.3740e+02


Autodesk Simulation Utility for Netfabb 2018.1
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Time: 0.00 (s)
Standard
Banding
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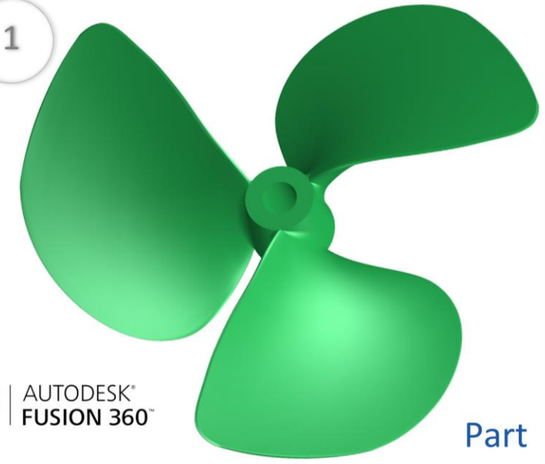
Plot Settings
Result Probe
View Logs
Record
Warped STL
Animation
Display
Export
Tutorial_18.tivus
Geometry
path_tivus.lsr
Build plate
Outline
Results
Mesh preview
Nodes: 1352
Elements: 896
Cauchy stress
Displacement
Elastic strain
Equivalent plastic strain
Melt indicator
Temperature (C)
193.70
151.41
109.12
66.83
24.53
AUTODESK SIMULATION UTILITY FOR NETFABB

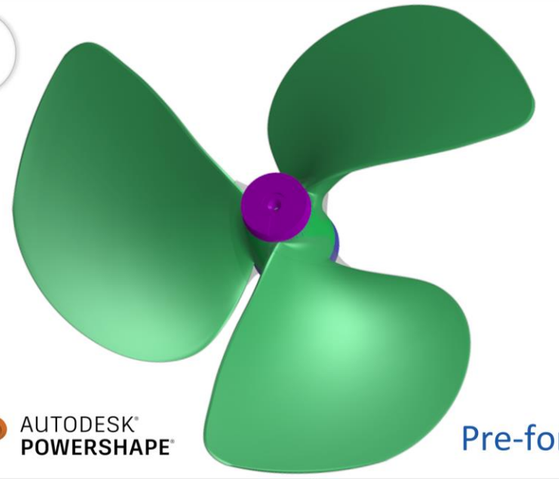
1



AUTODESK® FUSION 360™

Part

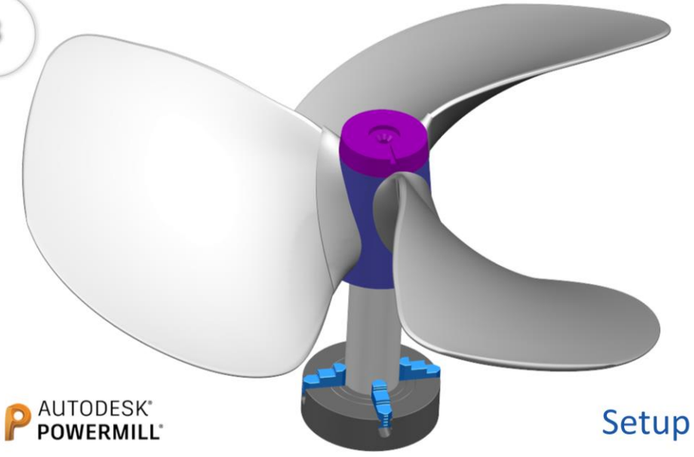
2



AUTODESK® POWERSHAPE®

Pre-form

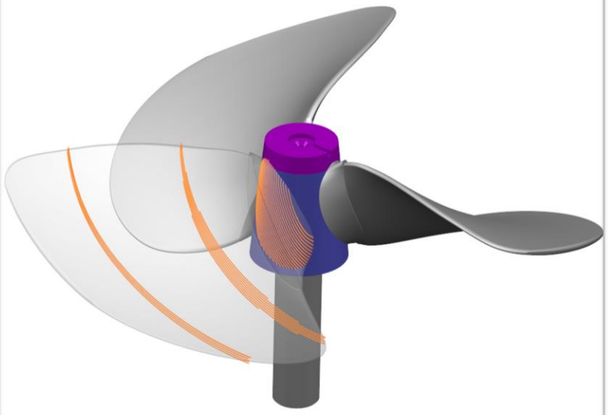
3



AUTODESK® POWERMILL®

Setup

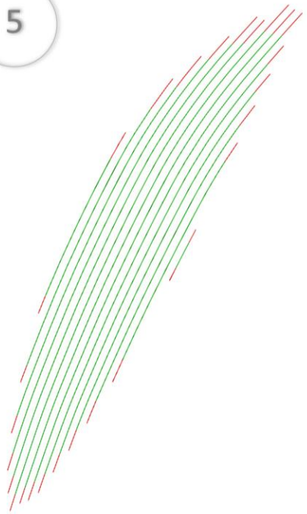
4



AUTODESK® POWERMILL®

Trajectory

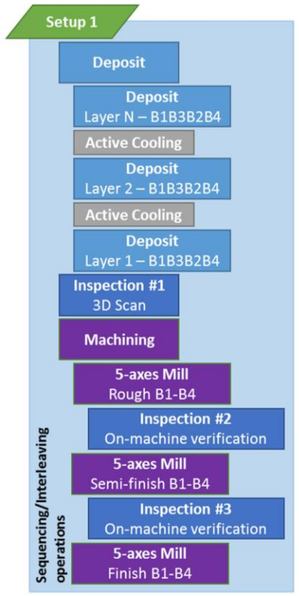
5



AUTODESK® POWERMILL®

Trajectory Decoration

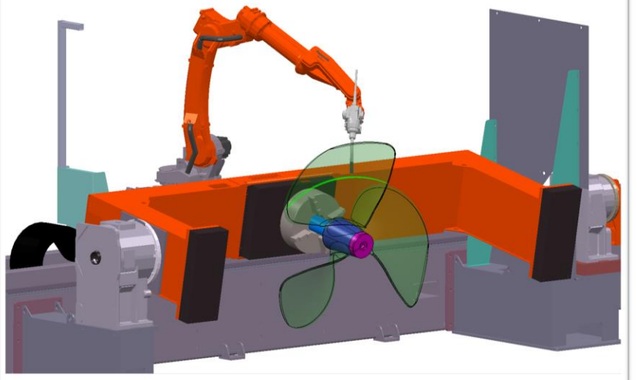
6



AUTODESK® POWERMILL®

Mfg Sequence

7



AUTODESK® POWERMILL®

Simulation & NC Program

Autodesk PowerMill Ultimate 2018 [Editable Project * 7_feature-on-preform]

File | Home | Toolpath | Toolpath Edit | Tool | Boundary | Pattern | Hole Feature Set | Feature Group | Workplane | Model | Stock Model | Machine Tool | Simulation | NC Program | View | DED-WAAM | DED-EBAM - EWI | Additive

Netfabb Strategies | Surface Coating | Feature Construction | Convert to Additive | Import Netfabb Toolpath | Curve Editor | Planar Section | Medial Axis — Create Toolpaths

Reverse Layers | Layer Indices | Split Layers | Process Parameters — Editing

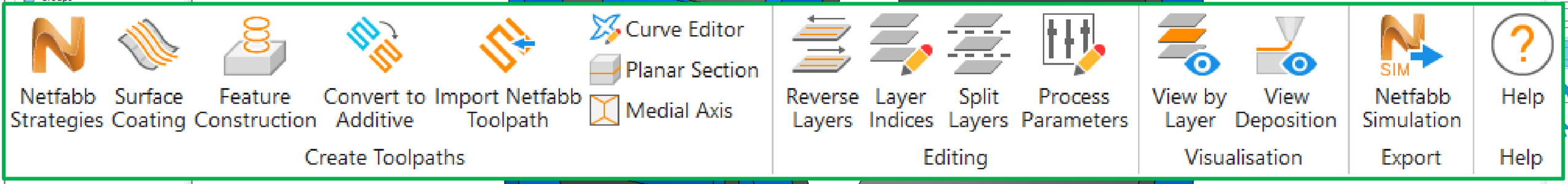
View by Layer | View Deposition — Visualisation

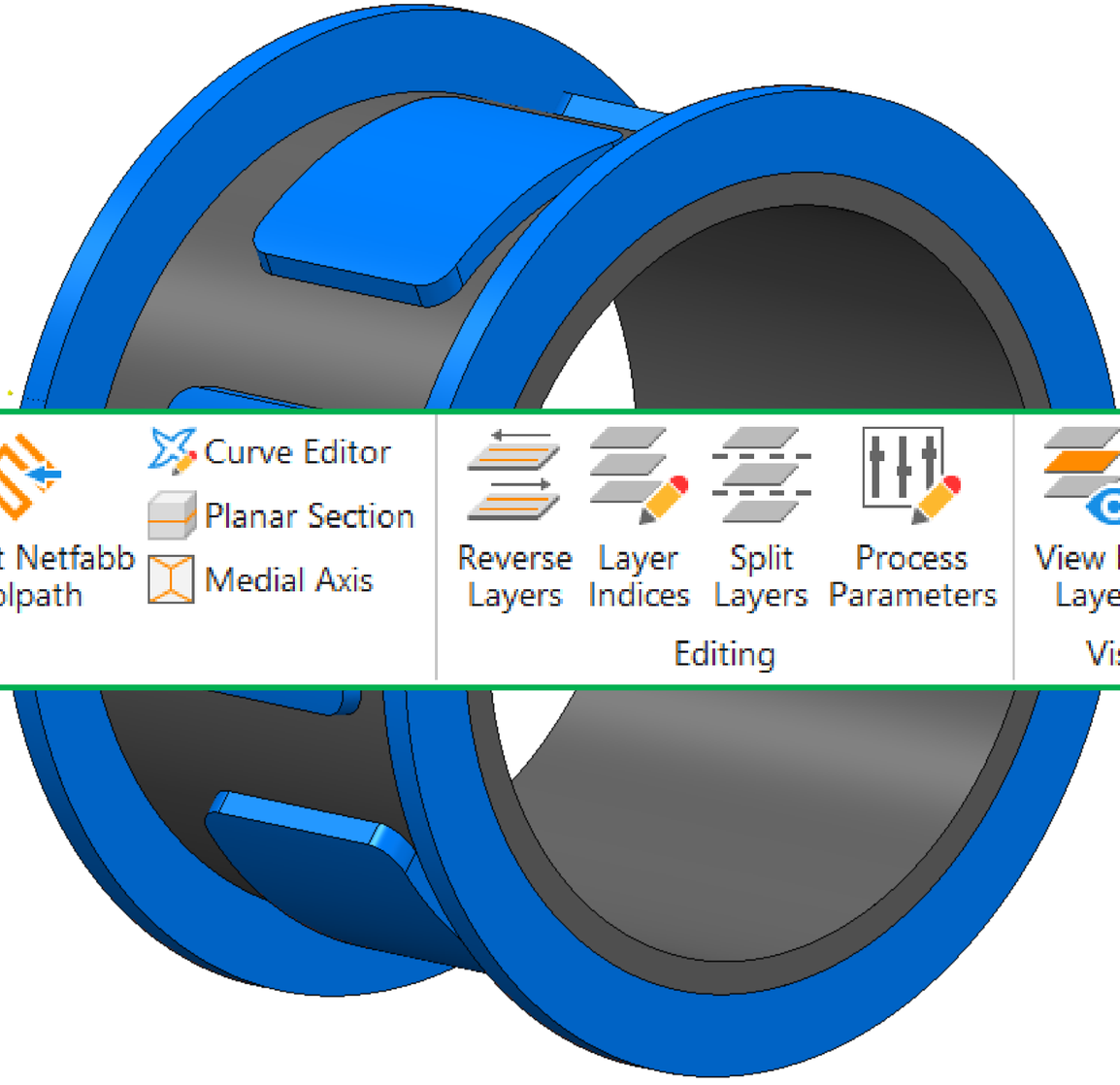
Netfabb Simulation — Export

Help — Help

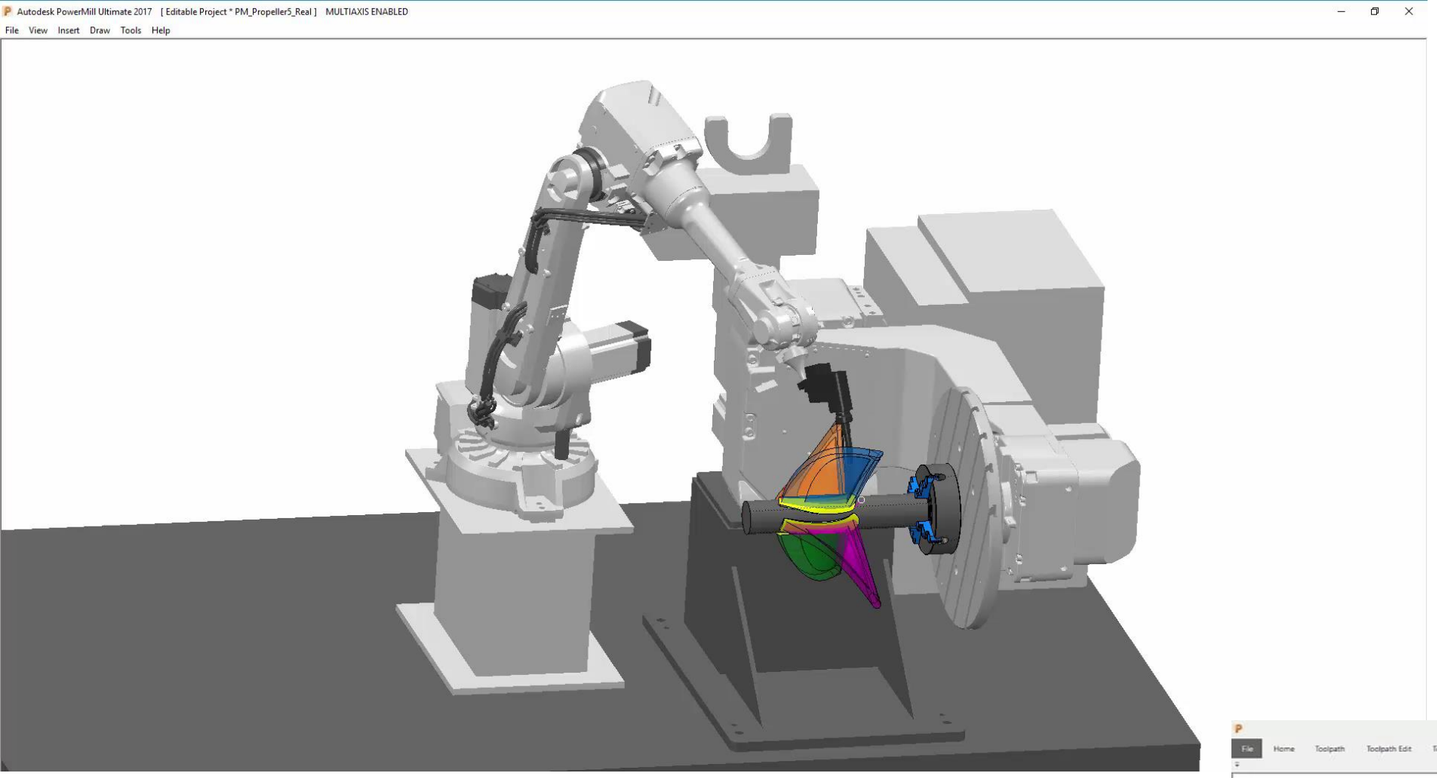
Explorer

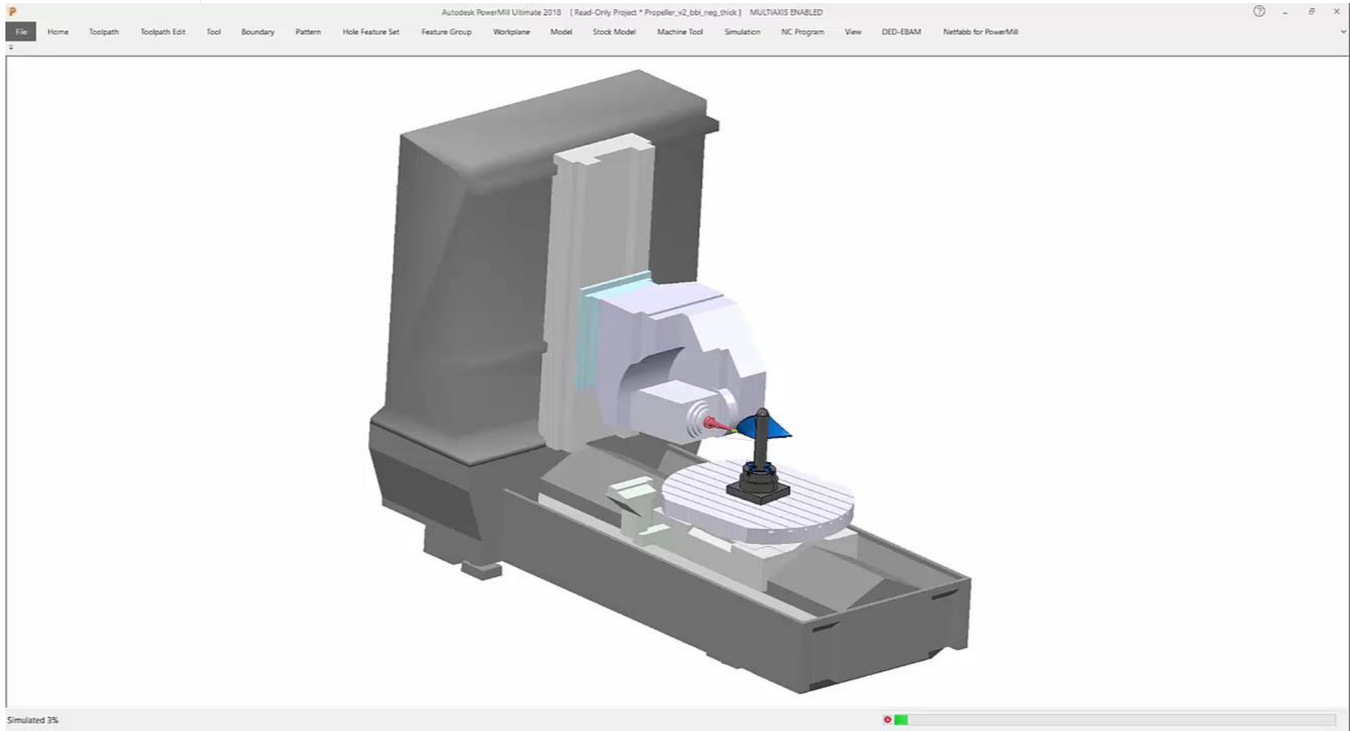
- Active
- Machine Tools
- NC Programs
- Toolpaths
- **Tools**
- Boundaries
- Patterns
- Hole Feature Sets
- Feature Groups
- **Workplanes**
- **Levels and Sets**
- Models
- Stock Models
- Groups



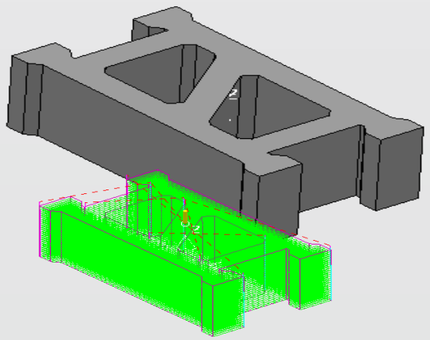


1 | 0 | -73.164 | 375.528 | mm | 3.0 | 1.5

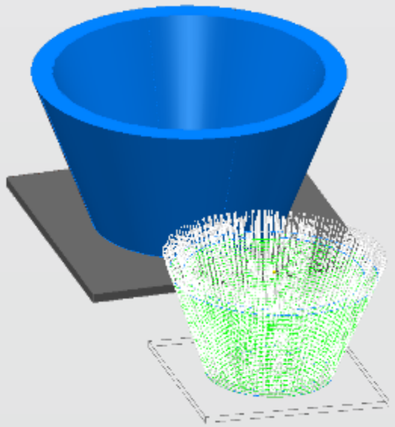

Autodesk PowerMill Ultimate 2017 [Editable Project * PM_Propeller5_Real] MULTIAXIS ENABLED
File View Insert Draw Tools Help


Autodesk PowerMill Ultimate 2018 [Read-Only Project * Propeller_v2_bbi_neg_thick] MULTIAXIS ENABLED
File Home Toolpath Toolpath Edit Tool Boundary Pattern Hole Feature Set Feature Group Workplane Model Stock Model Machine Tool Simulation NC Program View DED-EBAM Nettabb for PowerMill
Simulated 3%

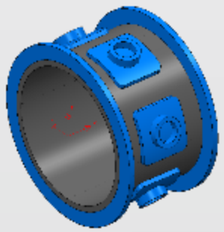
1 – Linear 2.5D extrusions – walls and bricks

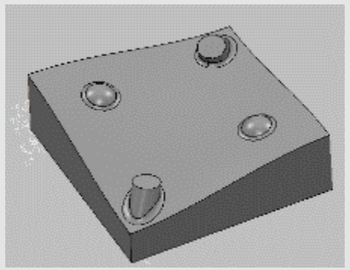


2 – Surface of revolution – buckets

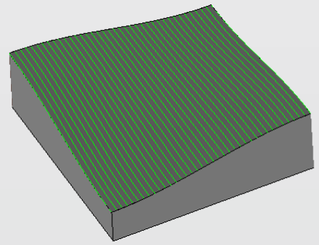


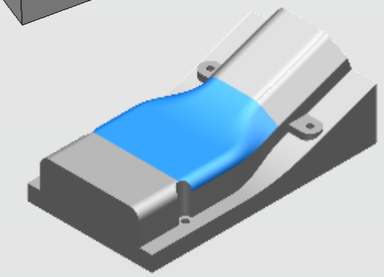
3 – Features – on cylinders, planes and arbitrary bases



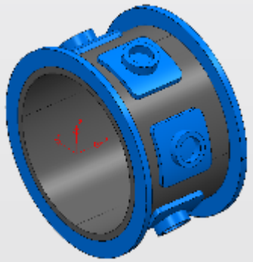


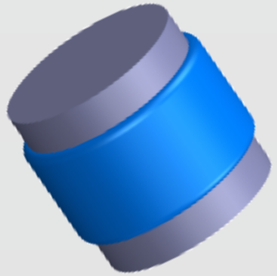
4 – Surface coating – patches and single layers





5 – Coaxial features – 360deg





Autodesk Dynamo Studio

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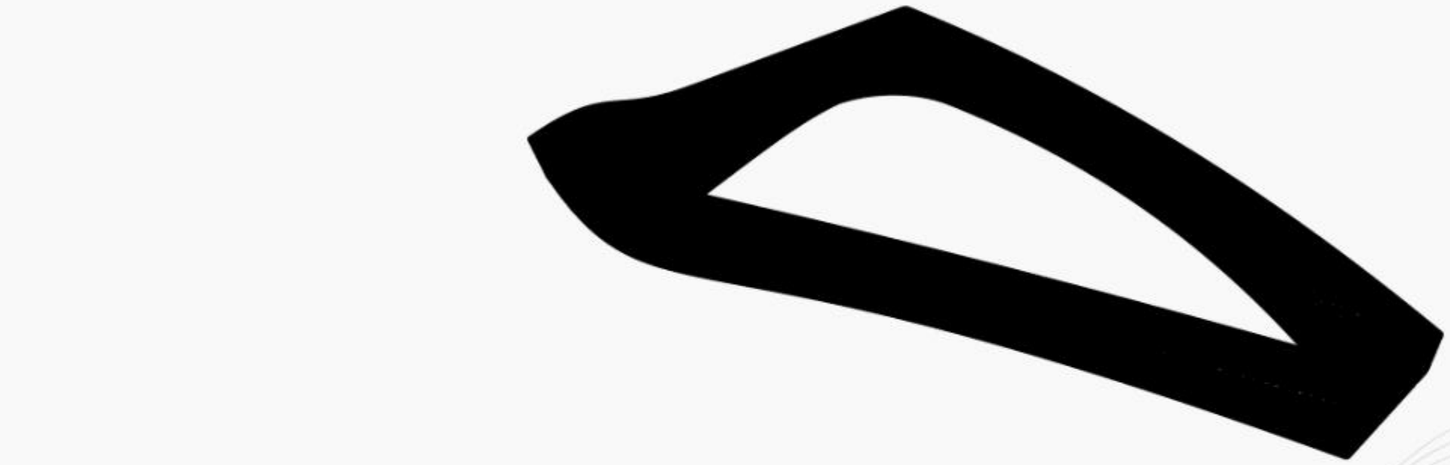
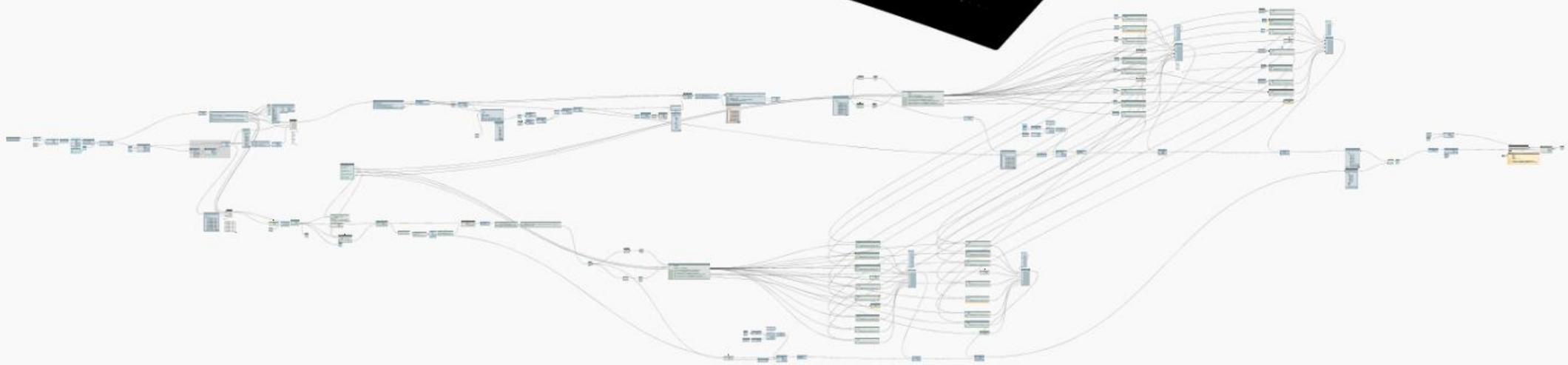
- Core
- Display
- DynamoUnits
- Geometry
- LunchBox
- MachinaDynamo
- Office
- Operators
- SVGImport
- Translation

Add

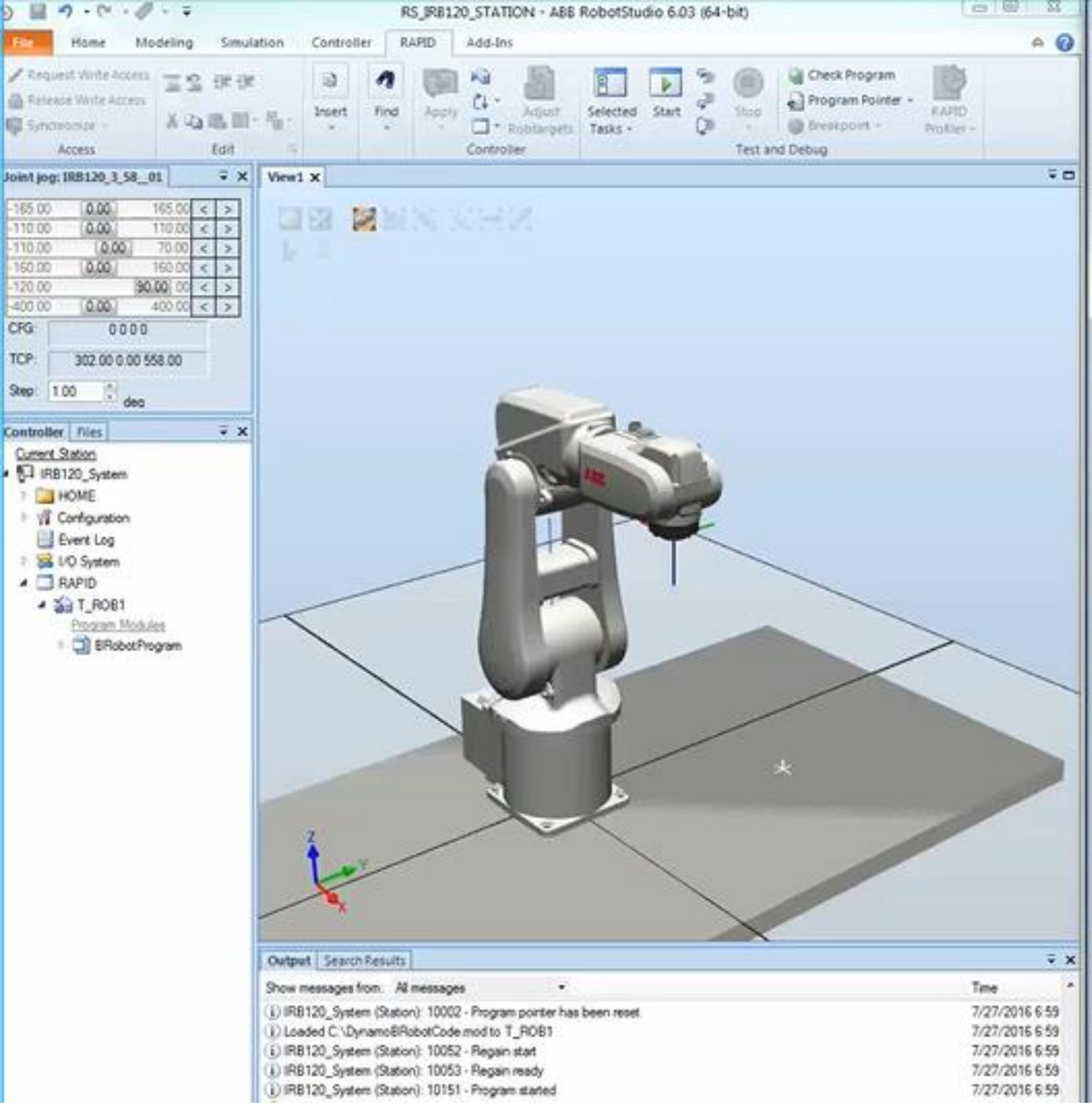
Import from netfabb.dyn*

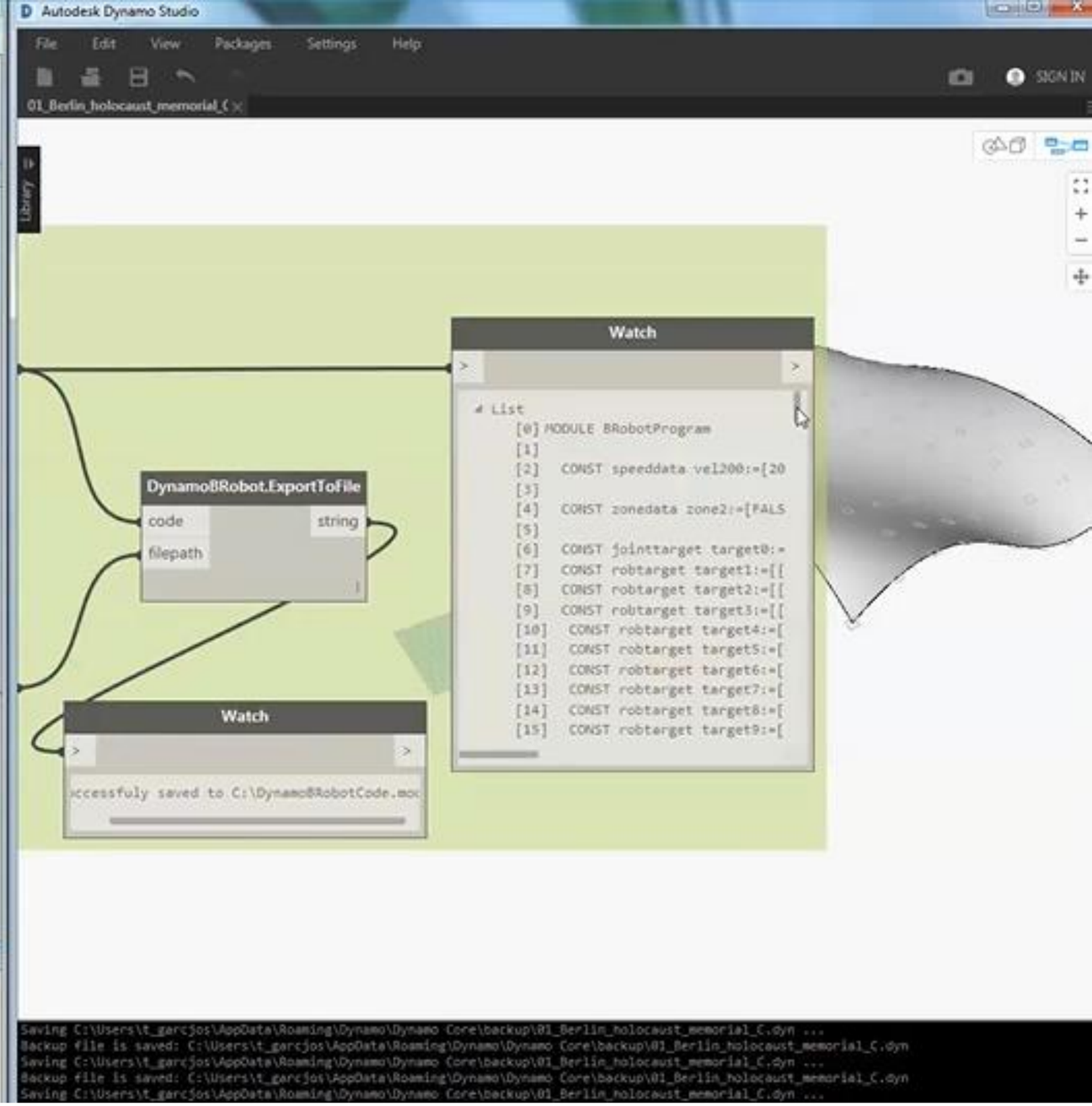


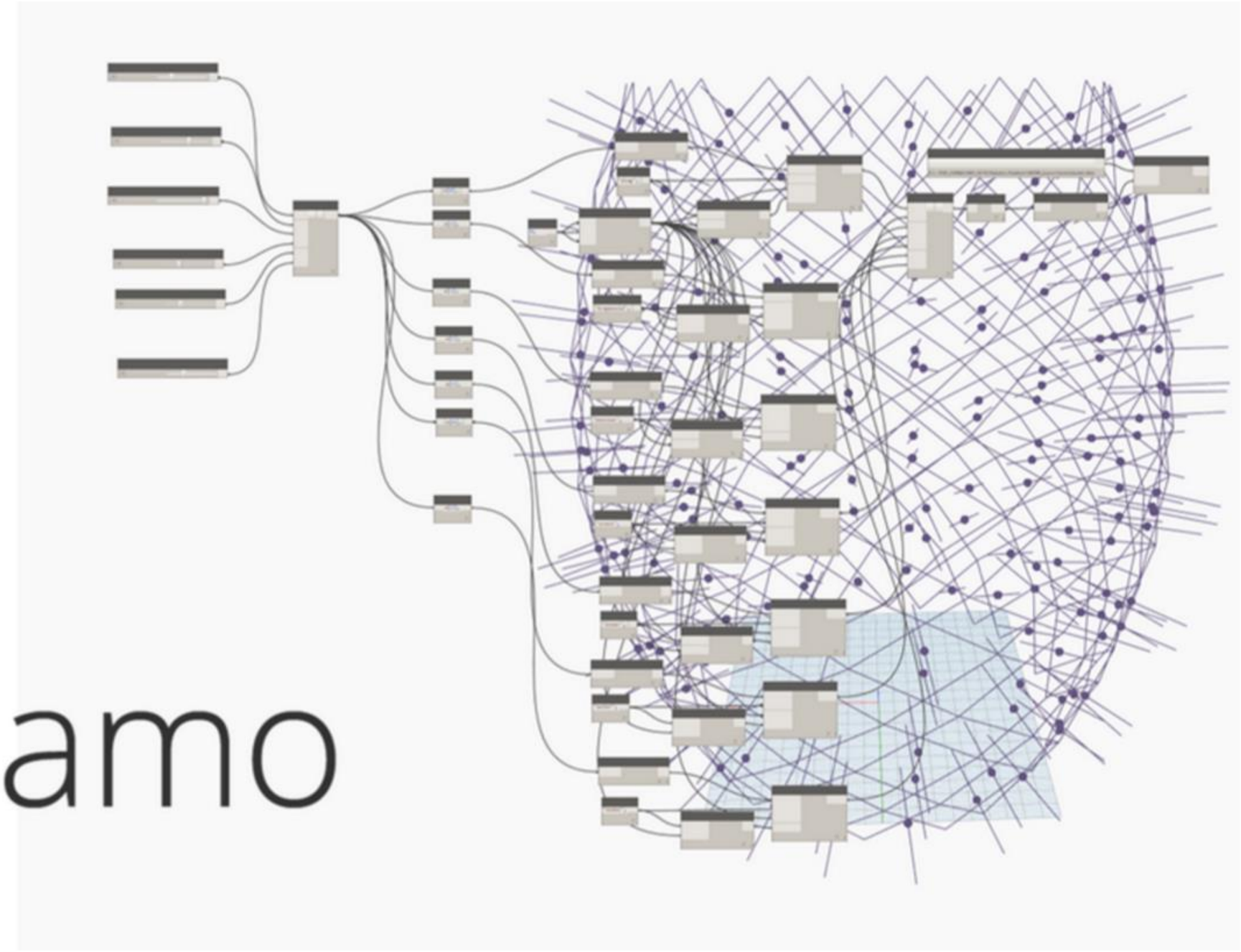


Manual Run

Run completed with warnings.


RS_IRB120_STATION - ABB RobotStudio 6.03 (64-bit)
File
Home
Modeling
Simulation
Controller
RAPID
Add-Ins
Request Write Access
Release Write Access
Synchronize
Access
Insert
Find
Apply
Adjust Robtargets
Edit
Selected Tasks
Start
Stop
Check Program
Program Pointer
Breakpoint
RAPID Profiler
Controller
Test and Debug
Joint jog: IRB120_3_58__01
-165.00 0.00 165.00
-110.00 0.00 110.00
-110.00 0.00 70.00
-160.00 0.00 160.00
-120.00 90.00 00
-400.00 0.00 400.00
CFG: 0 0 0 0
TCP: 302.00 0.00 558.00
Step: 1.00 deg
View1
Controller
Files
Current Station
IRB120_System
HOME
Configuration
Event Log
I/O System
RAPID
T_ROB1
Program Modules
BRobotProgram
Output
Search Results
Show messages from: All messages
Time
IRB120_System (Station): 10002 - Program pointer has been reset 7/27/2016 6:59
Loaded C:\Dynamo8RobotCode.mod to T_ROB1 7/27/2016 6:59
IRB120_System (Station): 10052 - Regain start 7/27/2016 6:59
IRB120_System (Station): 10053 - Regain ready 7/27/2016 6:59
IRB120_System (Station): 10151 - Program started 7/27/2016 6:59


Autodesk Dynamo Studio
File
Edit
View
Packages
Settings
Help
SIGN IN
01_Berlin_holocaust_memorial_C
Library
Watch
List
[0] MODULE BRobotProgram
[1]
[2] CONST speeddata vel200:=[20
[3]
[4] CONST zonedata zone2:=[FALS
[5]
[6] CONST jointtarget target0:=
[7] CONST robtarget target1:=[[
[8] CONST robtarget target2:=[[
[9] CONST robtarget target3:=[[
[10] CONST robtarget target4:=[
[11] CONST robtarget target5:=[
[12] CONST robtarget target6:=[
[13] CONST robtarget target7:=[
[14] CONST robtarget target8:=[
[15] CONST robtarget target9:=[
DynamoBRobot.ExportToFile
code
filepath
string
Watch
ccessfuly saved to C:\DynamoBRobotCode.mo
Saving C:\Users\t_garcjos\AppData\Roaming\Dynamo\Dynamo Core\backup\01_Berlin_holocaust_memorial_C.dyn ...
Backup file is saved: C:\Users\t_garcjos\AppData\Roaming\Dynamo\Dynamo Core\backup\01_Berlin_holocaust_memorial_C.dyn
Saving C:\Users\t_garcjos\AppData\Roaming\Dynamo\Dynamo Core\backup\01_Berlin_holocaust_memorial_C.dyn ...
Backup file is saved: C:\Users\t_garcjos\AppData\Roaming\Dynamo\Dynamo Core\backup\01_Berlin_holocaust_memorial_C.dyn
Saving C:\Users\t_garcjos\AppData\Roaming\Dynamo\Dynamo Core\backup\01_Berlin_holocaust_memorial_C.dyn ...



Dynamo

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Q&A