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Additive Manufacturing: Understanding and Applying Key Design Considerations

Brian Jeong

Shop Supervisor, Autodesk | *brian.jeong@autodesk.com*

Tyson Fogel

Shop Supervisor, Autodesk | *tyson.fogel@autodesk.com*

Objectives

Explain the process of metal additive manufacturing (LPBF)

Identify key variables that affect the quality of a metal 3D-printed part

Sustainable best practices within additive manufacturing

Workflow strategies to address key variables

Brian Jeong

Shop Supervisor

Autodesk Technology Centers, Toronto

Brian Jeong is a Shop Supervisor at the Autodesk Technology Centers in Toronto, Canada. Brian has a background in automotive and mechanical engineering, additive manufacturing, and project management. Brian has an extensive research and laboratory background in process optimization methods in laser powder bed fusion additive manufacturing and design for additive manufacturing. Brian is passionate about exploring new ways of designing and making.

Tyson Fogel

Shop Supervisor

Autodesk Technology Centers, Toronto

Inspired by circularity and biomimicry, Tyson is an avid maker and sustainability advocate. He works directly with residents, innovation communities and researchers to provide technical expertise and fabrication consultation through the Autodesk Outsight Network. A designer and cabinetmaker by trade, Tyson's past work includes everything from additive, subtractive manufacturing, woodworking to CAD/CAM, Generative Design, construction and more recently - robotics.

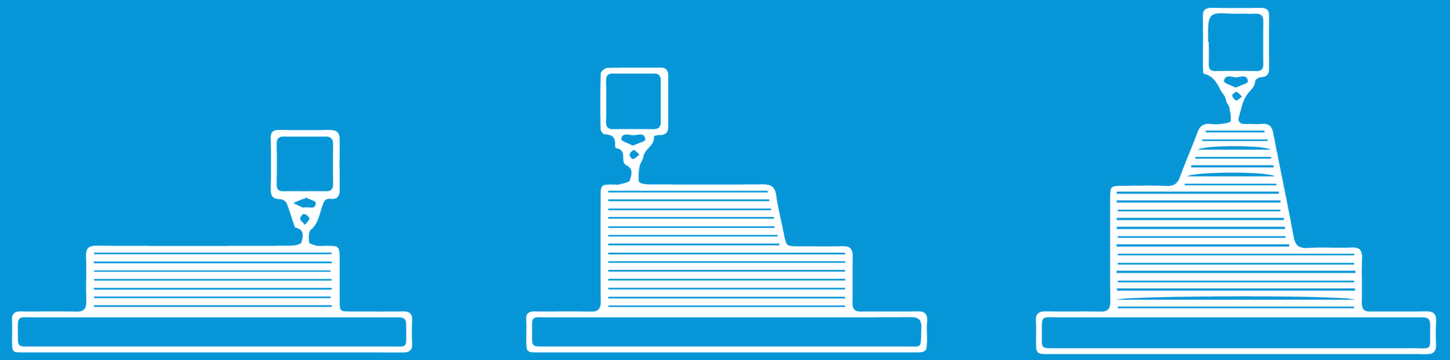
The Future of Making

Starts Here

The **Autodesk Technology Centers Outsight Network** brings together pioneers innovating in design, architecture, engineering, construction, manufacturing, and emerging technologies.

Through this network, Autodesk helps bring solutions to life that enable people to do more and make better things with more positive impact on the world.

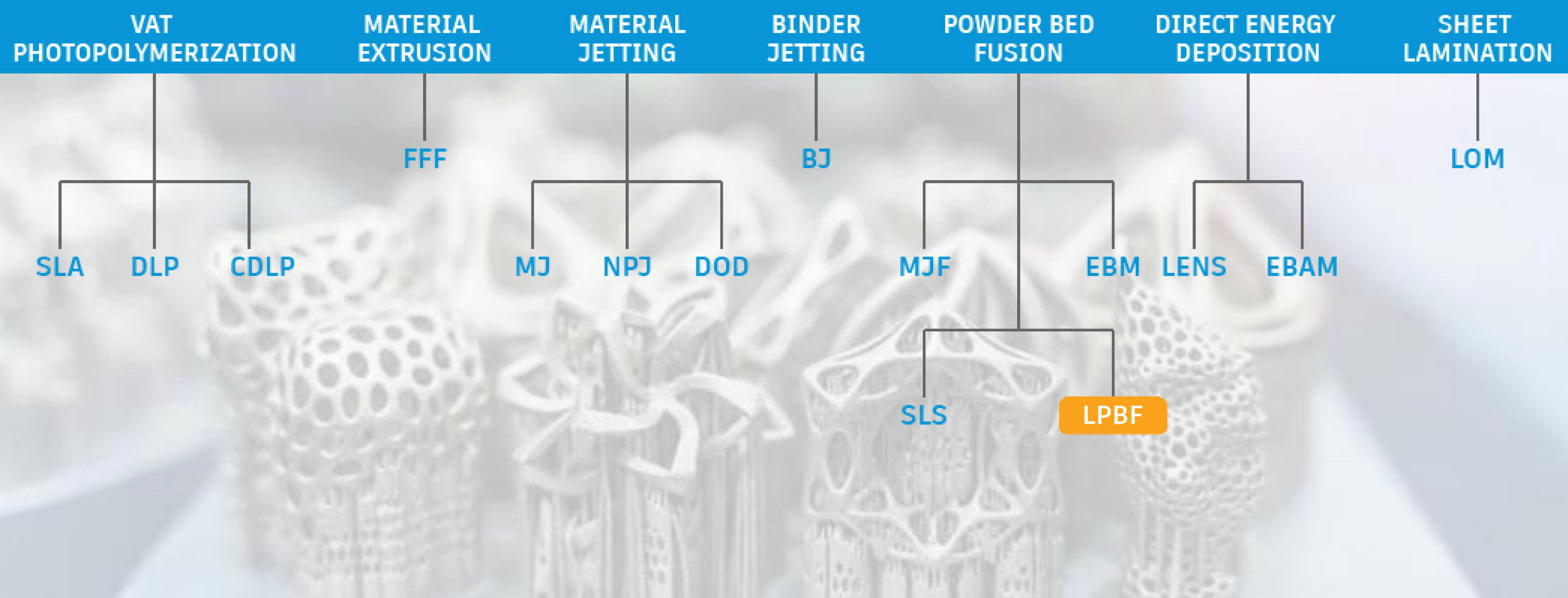
Additive Manufacturing Fundamentals



Additive Manufacturing

Process of joining materials to make objects from 3D model (CAD) data. A layer-to-layer based system that effectively uses only the raw material required - unlike subtractive.

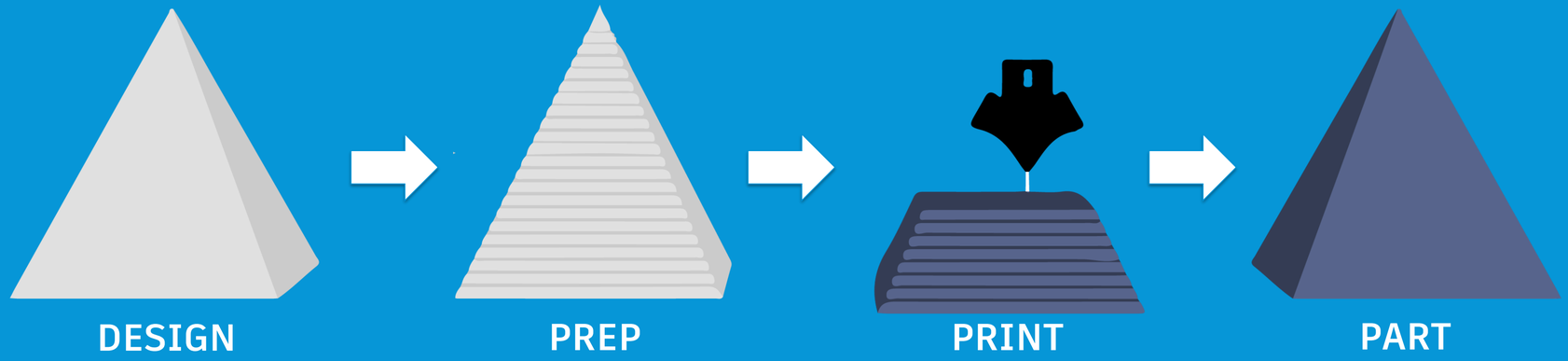
Types of AM Technologies



Laser Powder Bed Fusion

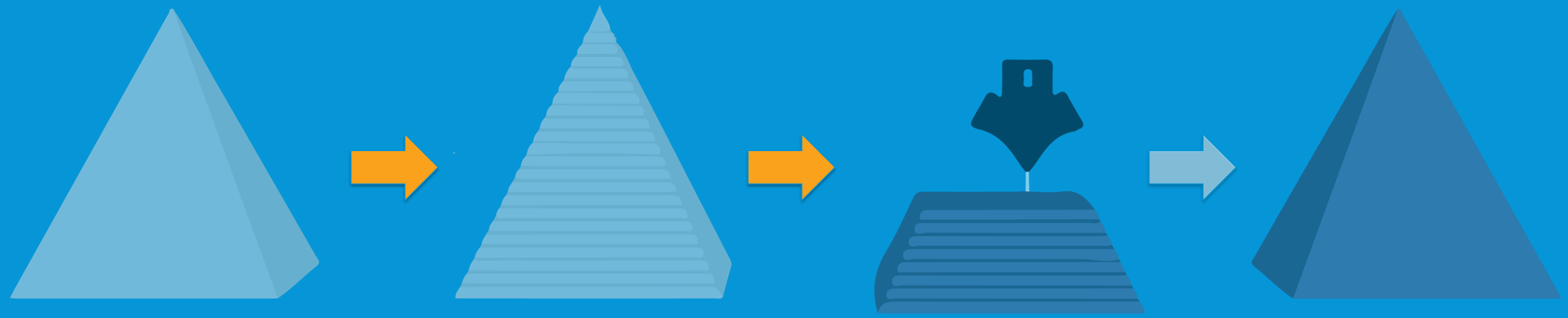
Metal powder + accurate laser + flat bed = layer-to-layer fusion

Photo Courtesy Of Javelin-Tech



General AM Workflow

From designing digitally to ending up with an end-use part, a typical additive manufacturing workflow has a couple of key phases and transitionary points.



Our Focus – ‘Key Considerations’

Obstacles that can occur during the different AM phases and can be resolved at distinct transitionary junctions. These ‘gates’ are grounded in computer-aided manufacturing, process simulation and sustainability.

Gated approach

1. SUSTAINABILITY

2. DfAM

3. LPBF VARIABLES

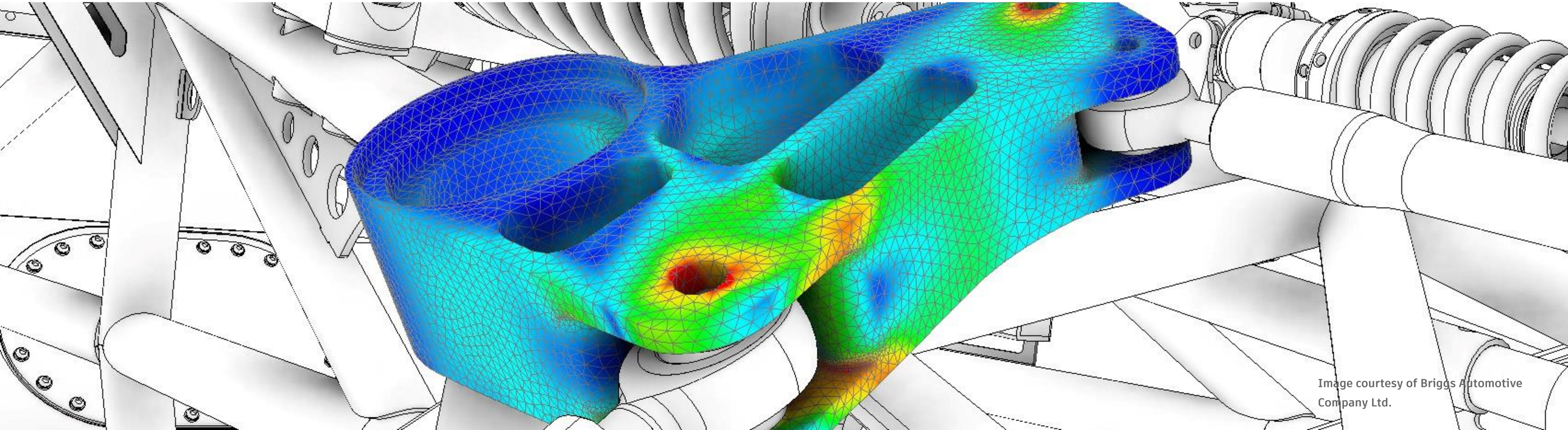
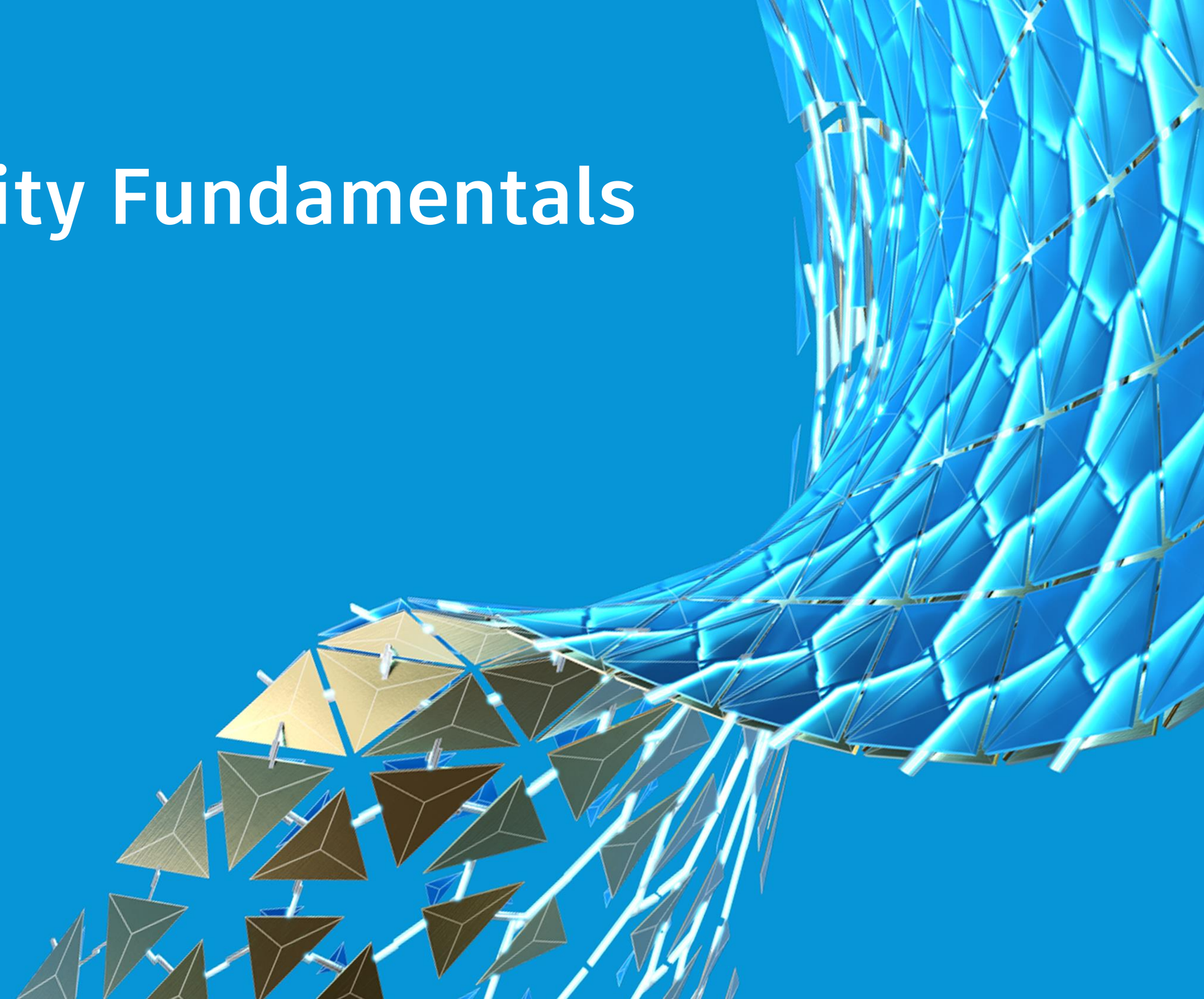


Image courtesy of Briggs Automotive Company Ltd.

Sustainability Fundamentals



Sustainability

Ability for a system to maintain and thrive indefinitely. In manufacturing, this means limiting materials, energy consumption, and embodied carbon.

Sustainability in AM

SUSTAINABILITY

Failed prints = Cost

Carbon Emissions

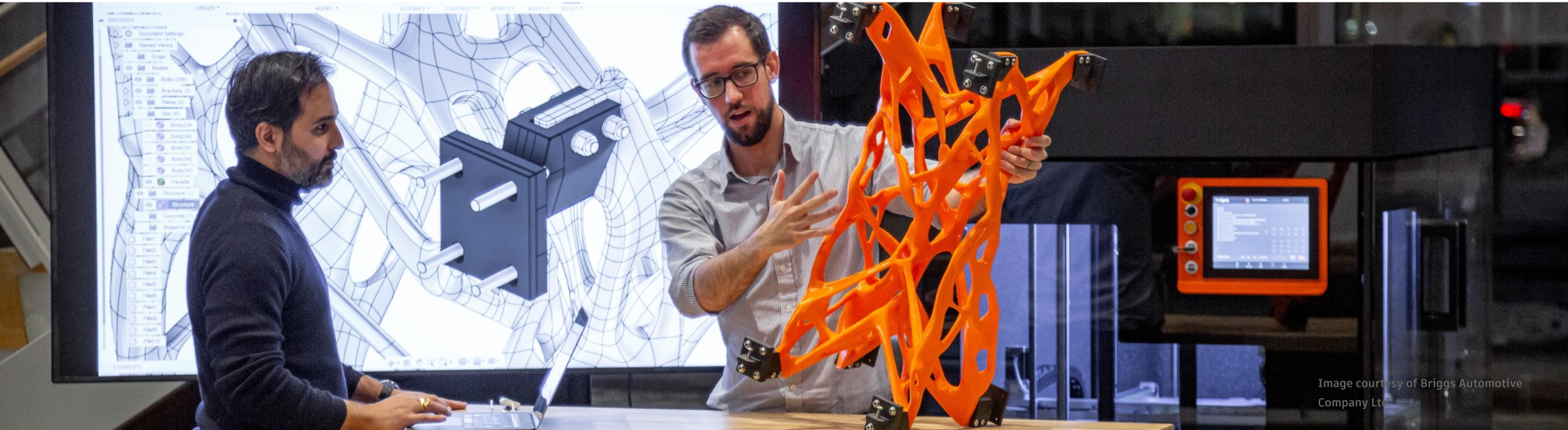
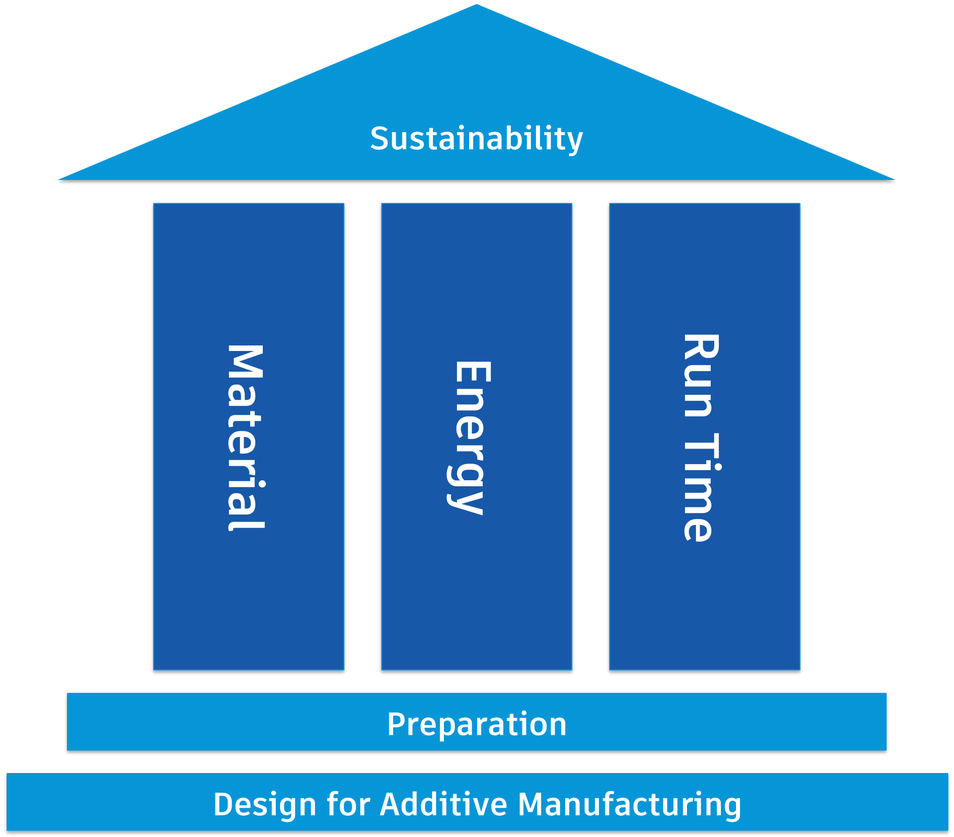
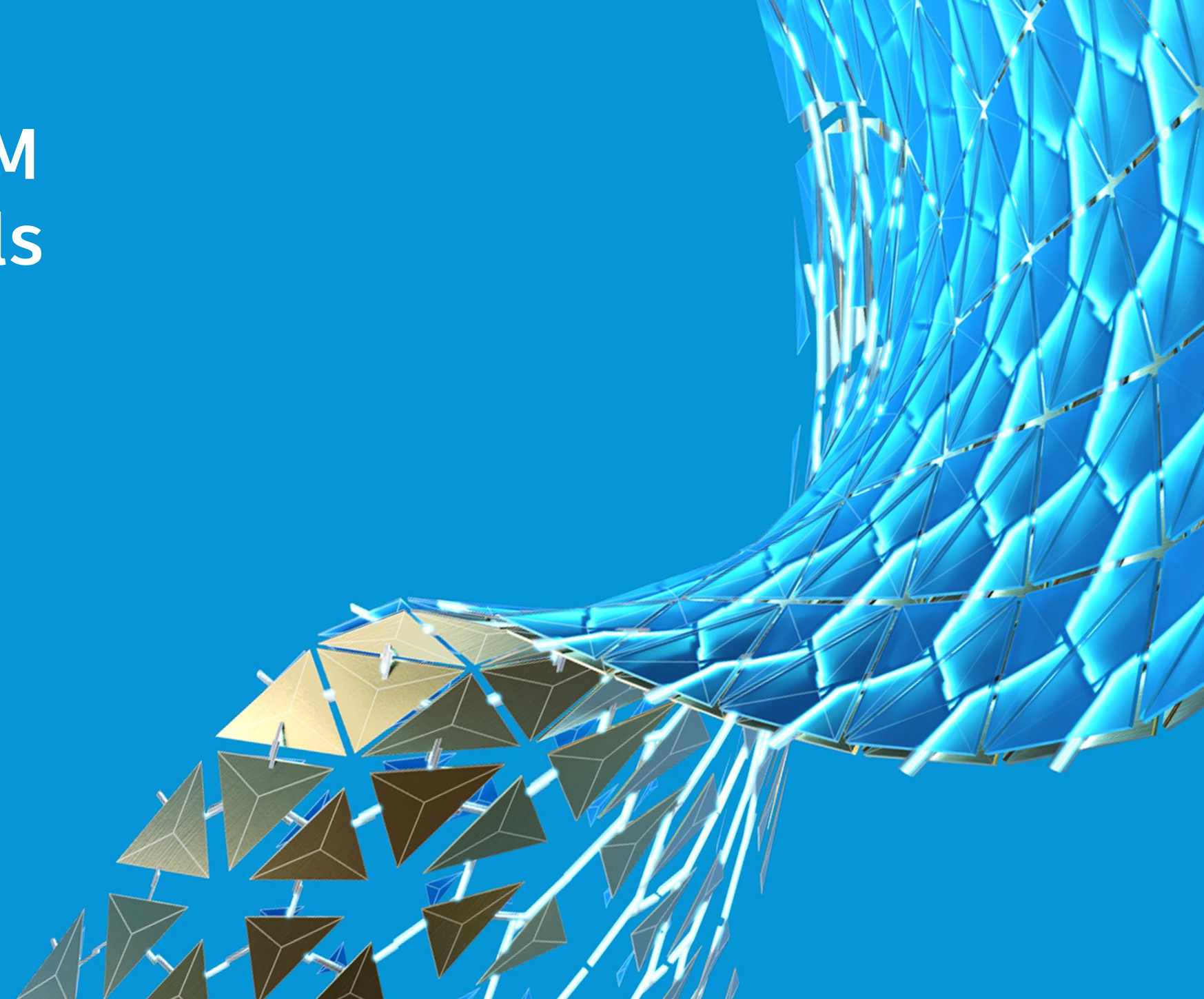


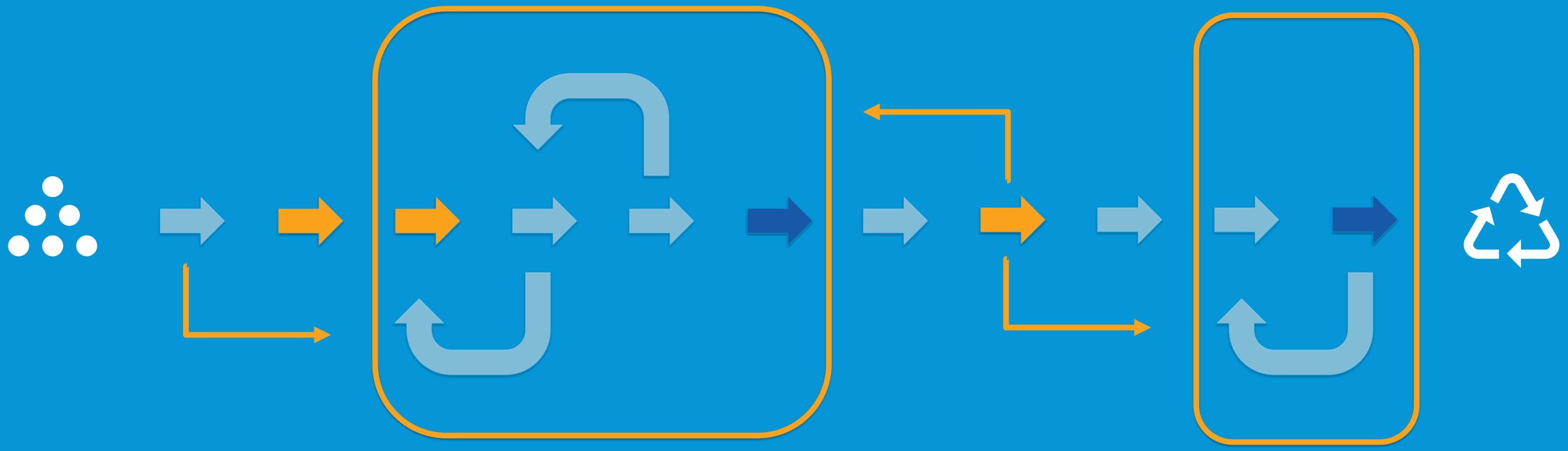
Image courtesy of Briggs Automotive Company Ltd.

Sustainability in AM



Design for AM Fundamentals

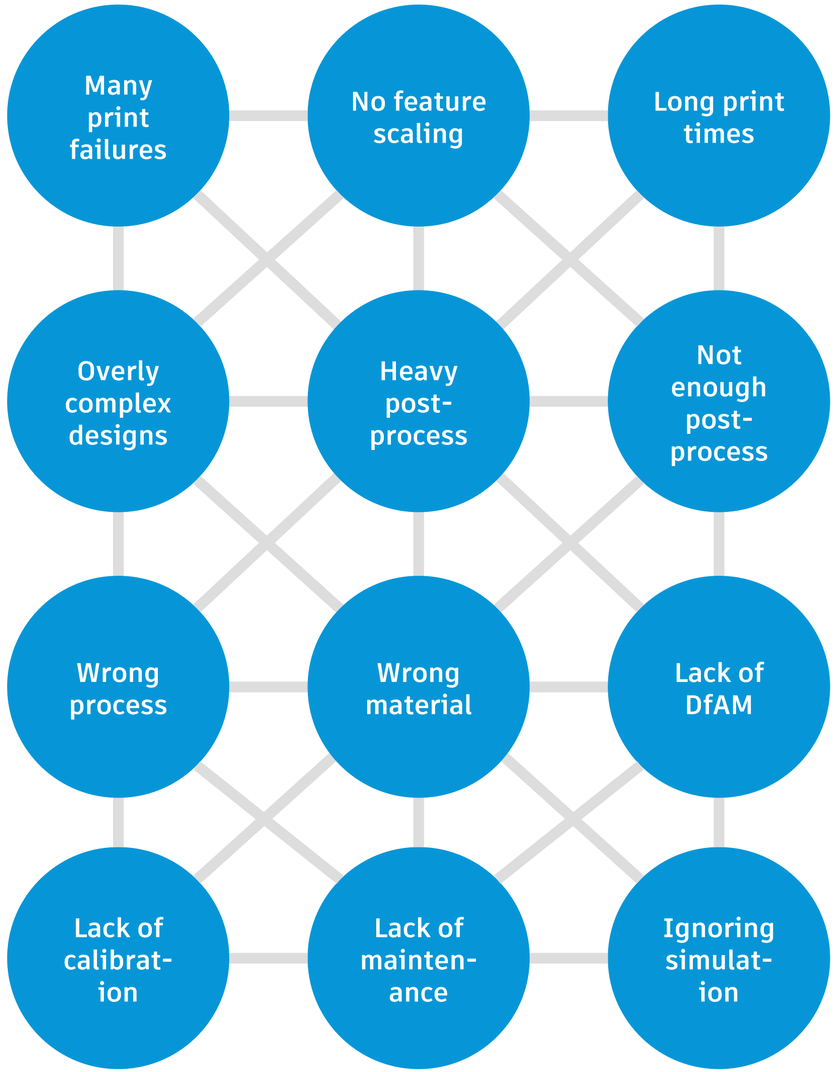




Design for Additive Manufacturing

Synthesis of shapes, sizes, geometric meso-structures, material compositions and microstructures to best utilize manufacturing process capabilities to achieve desired performance and even to maximize product performance (Rosen 2007)

AM Pitfalls



• Photo courtesy of Alexander Liu

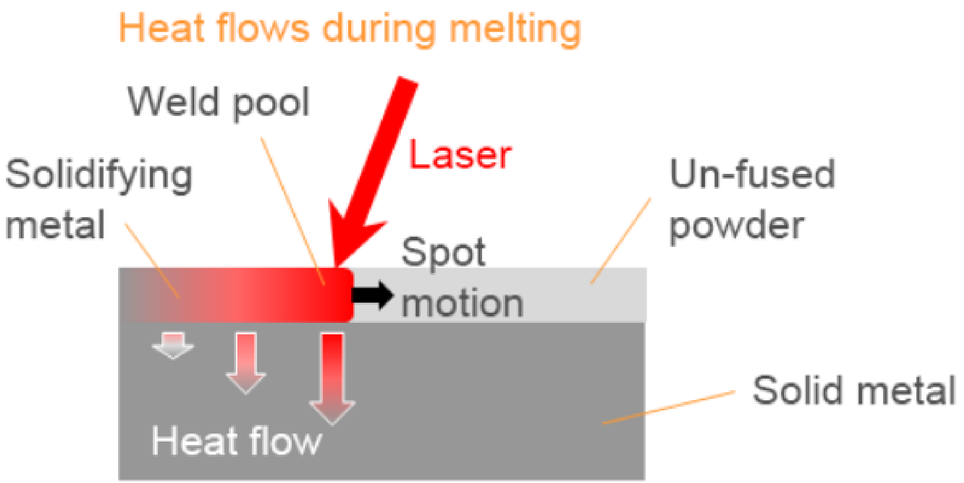
Key Considerations in LPBF

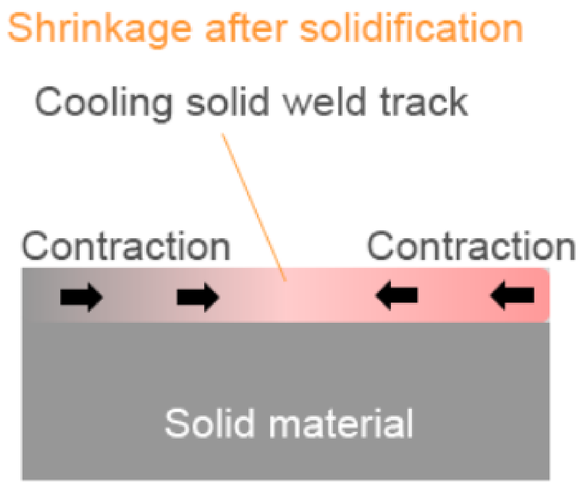
RESIDUAL STRESS

SUPPORT STRUCTURES

PART ORIENTATION

Residual Stress





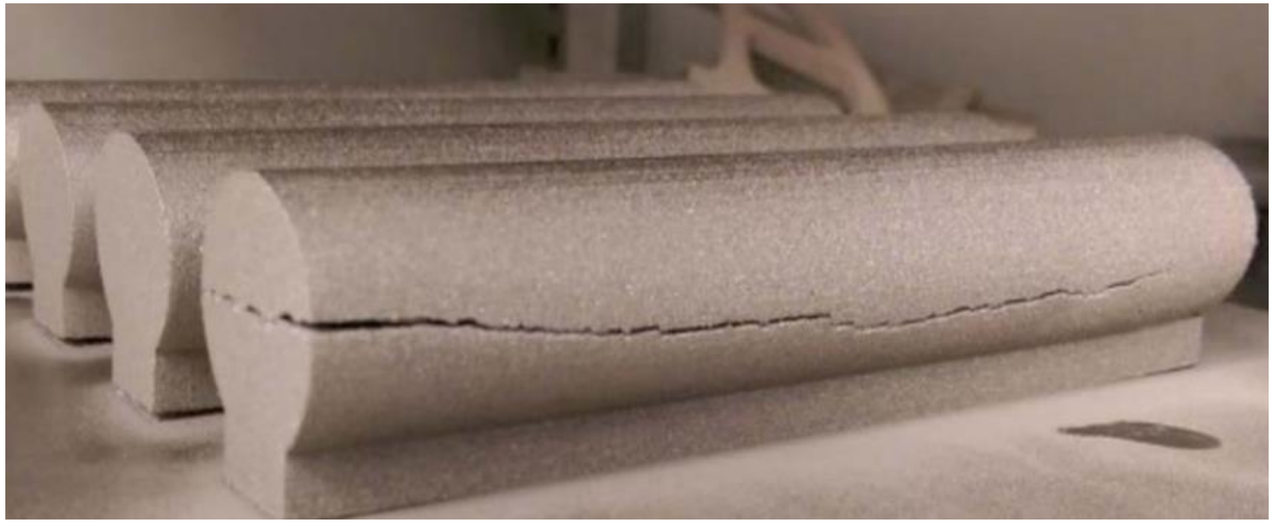


Photo Courtesy Of Renishaw Inc.

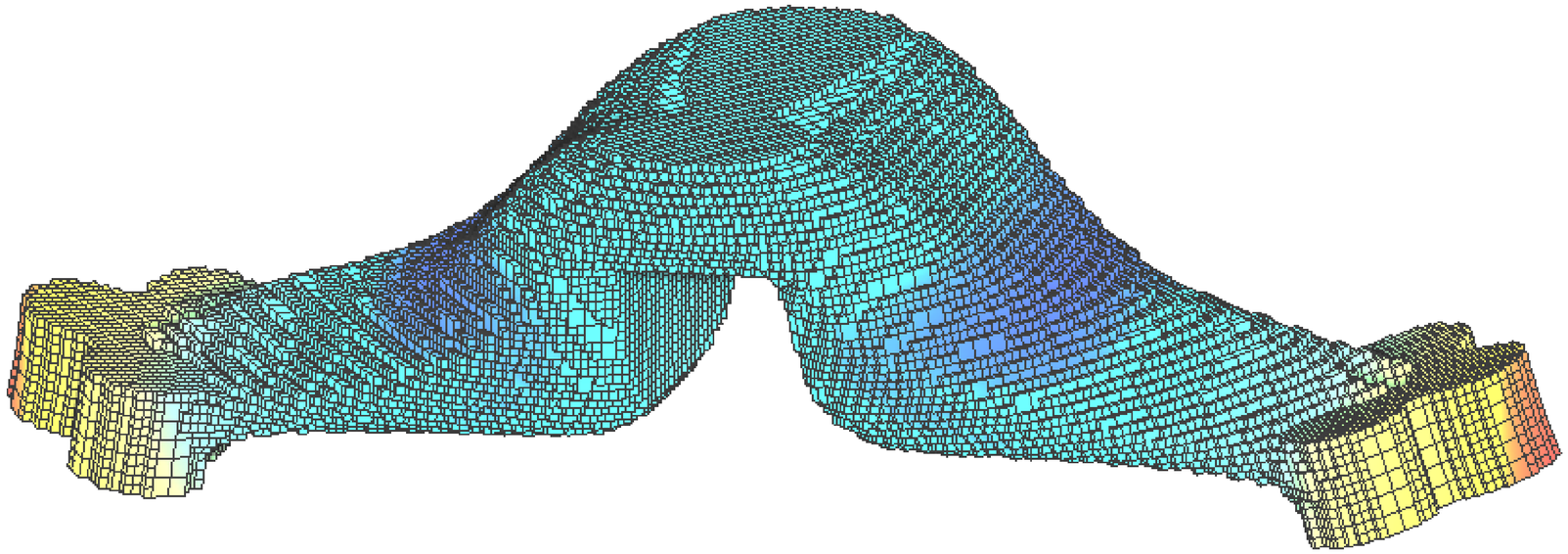
Netfabb Simulation Demo

LPBF VARIABLES

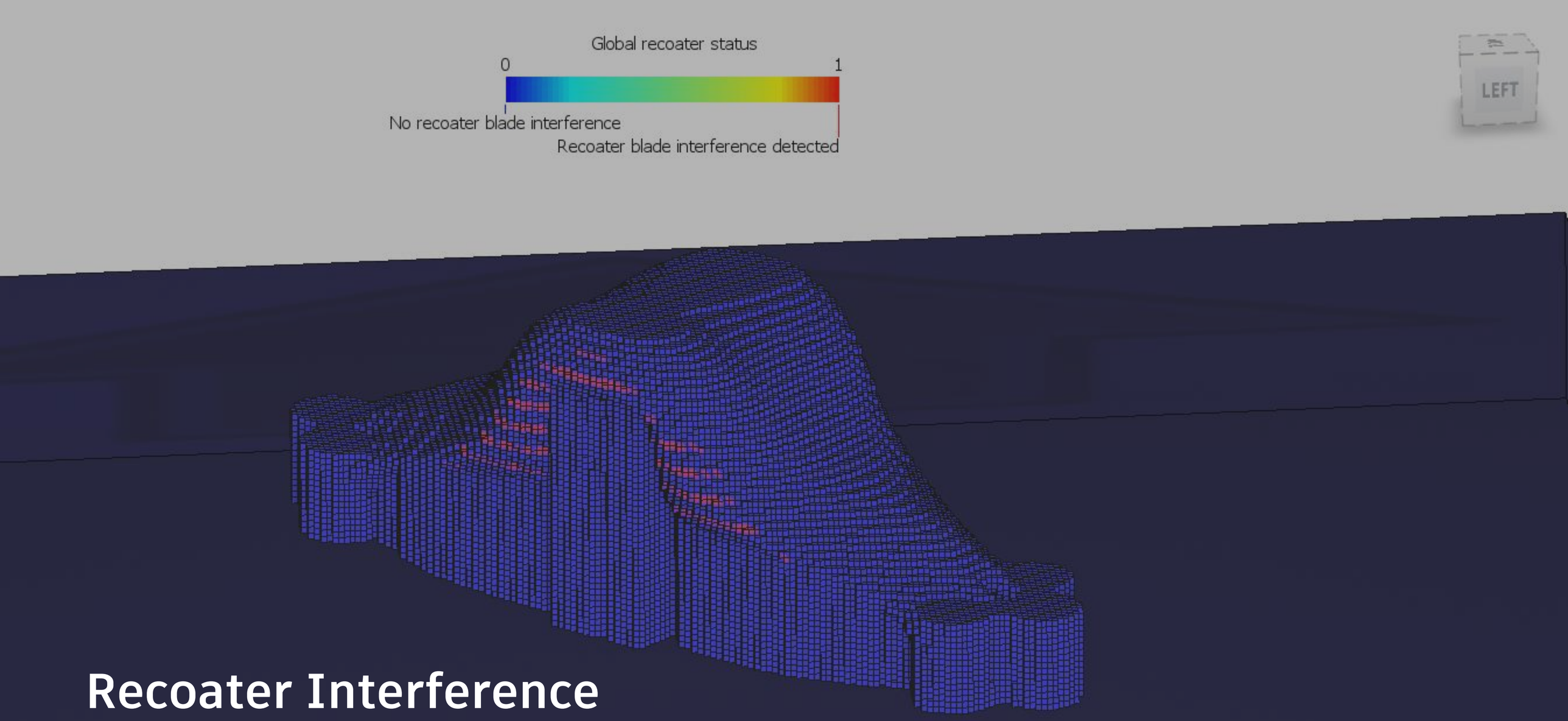
1. RECOATER

2. SUPPORT STRUCTURE

3. PART DISTORTION



AUTODESK® SIMULATION
UTILITY FOR NETFABB®

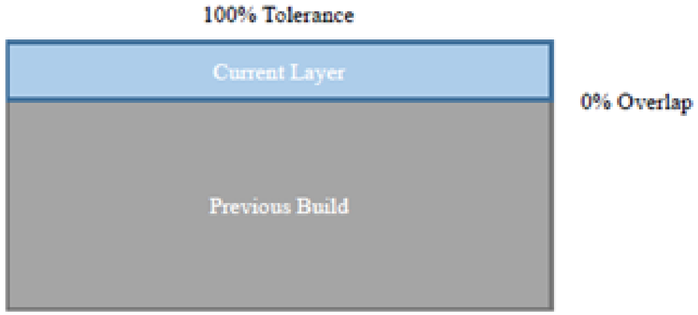


Recoater Interference

Residual stresses during print can cause parts to distort upwards, colliding with the recoater

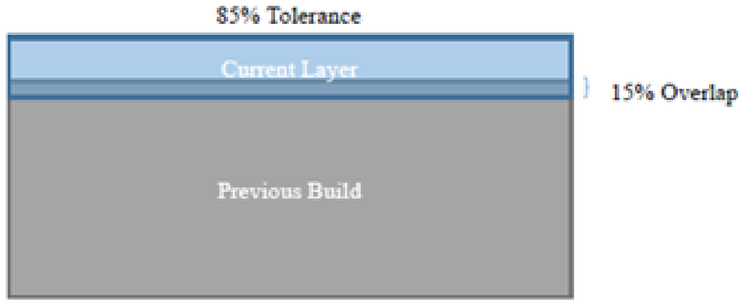
Recoater Tolerance

A)



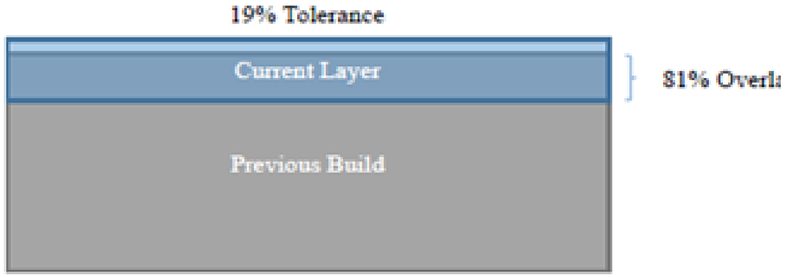
(a) 100% Recoater tolerance

B)



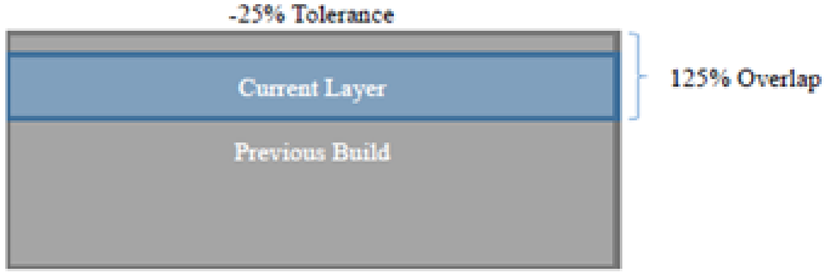
(b) 85% Recoater tolerance

C)



(c) 19% Recoater tolerance

D)

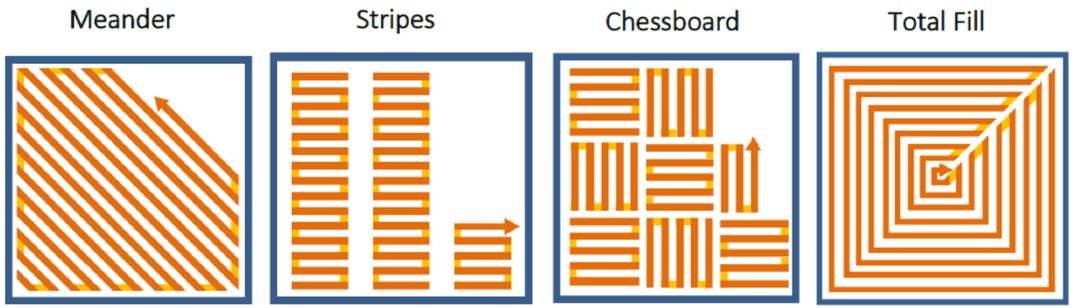


(d) -25% Recoater tolerance

NETFABB DEMO:
PREDICTING RECOATER TOLERANCE

AUTODESK® NETFABB®

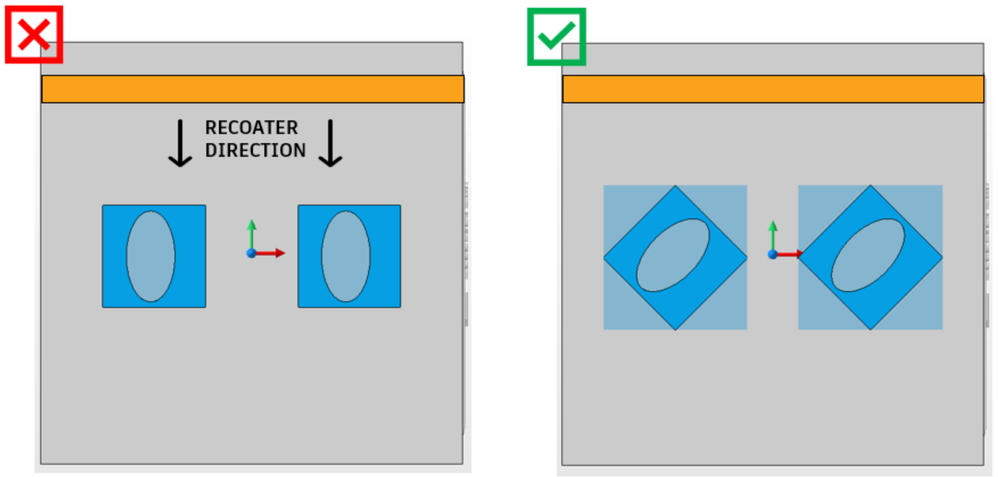
Avoiding Recoater Interference



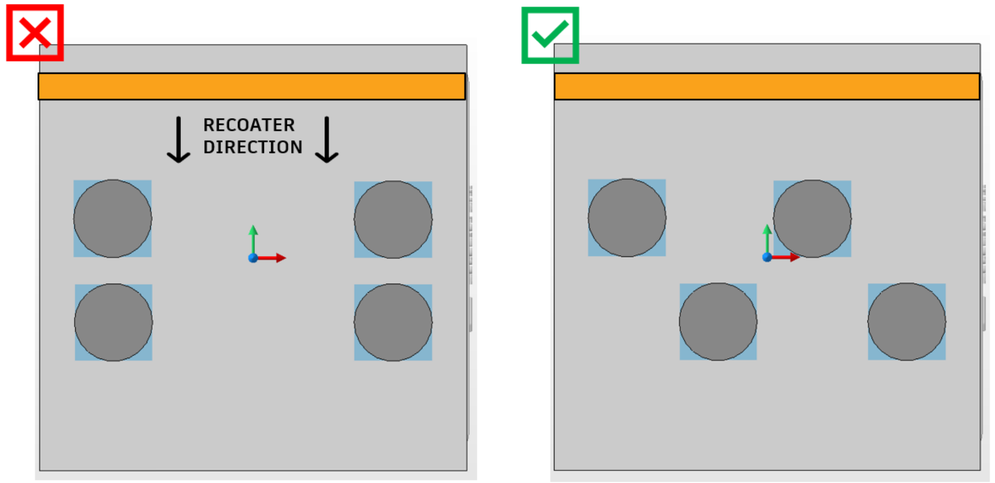
SELECT APPROPRIATE SCANNING STRATEGIES

HEATED BUILD PLATE

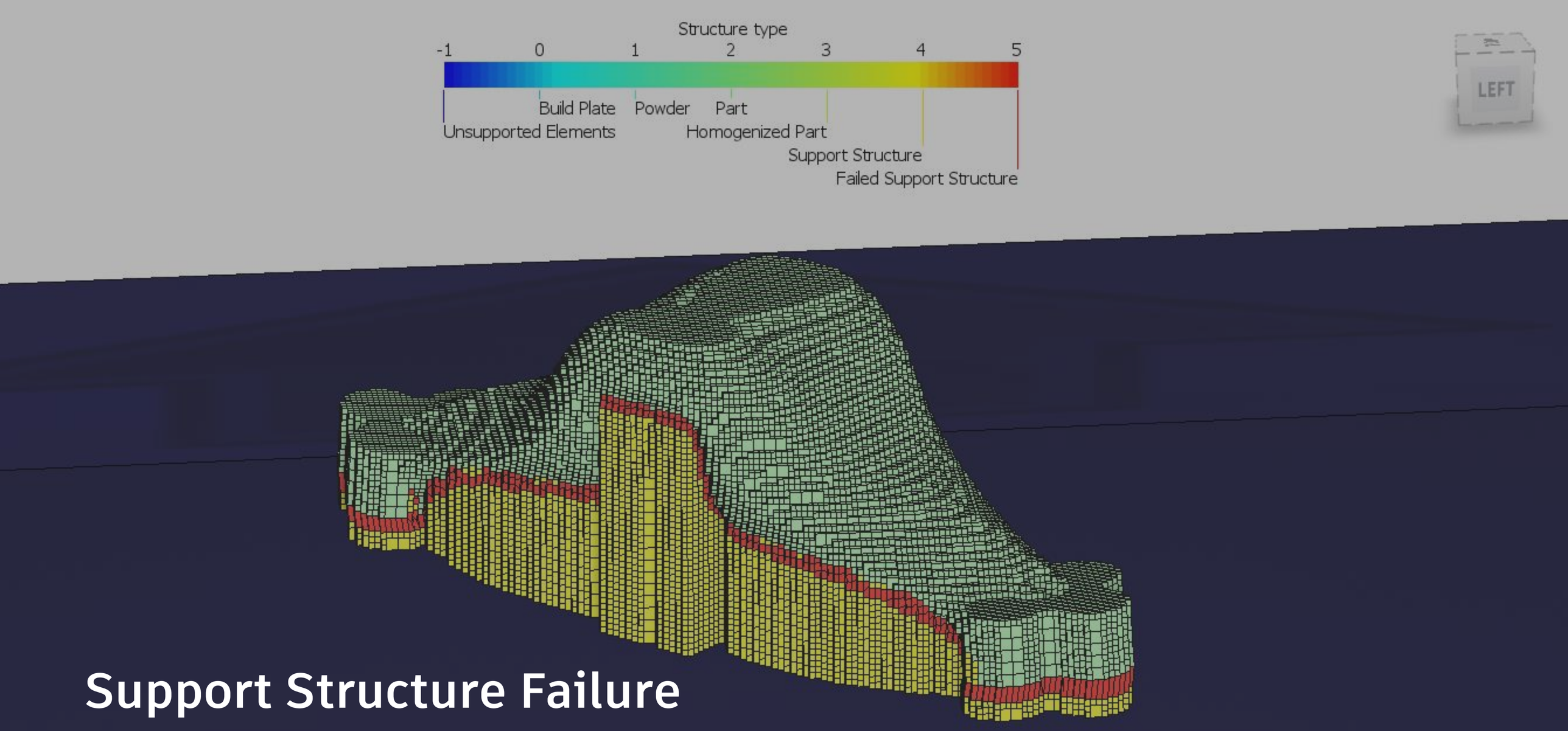
Avoiding Recoater Interference



PART ORIENTATION



PART PLACEMENT



Support Structure Failure

Residual stresses during print can cause parts to distort upwards, causing the support structure underneath to yield to the forces of distortion

Support Structure

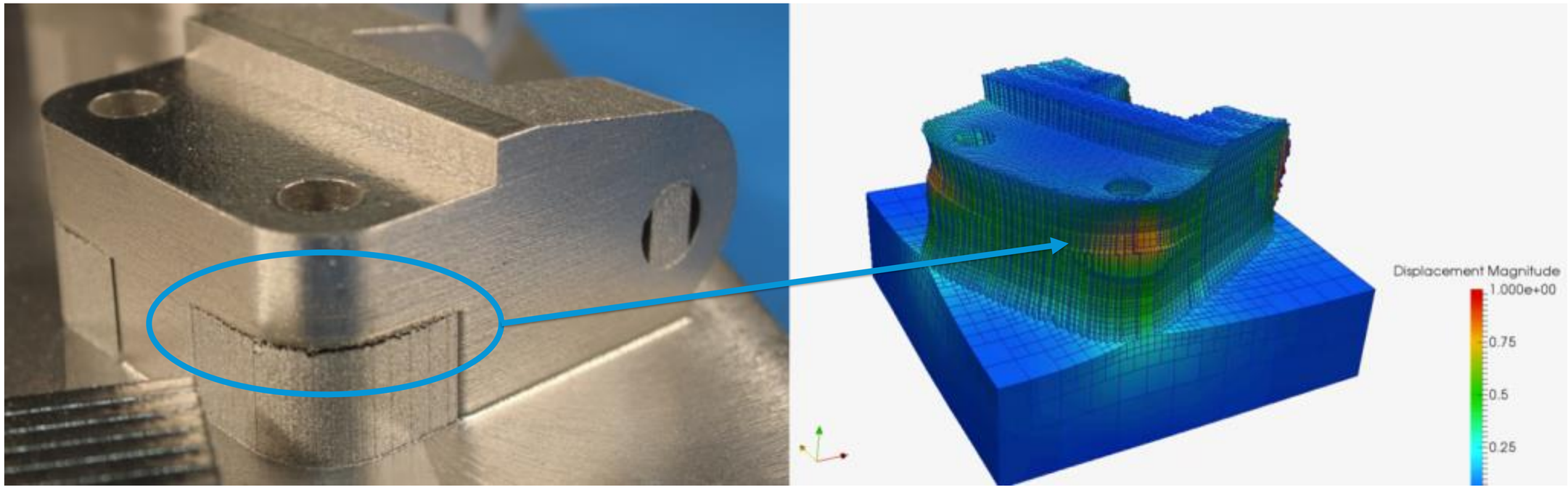
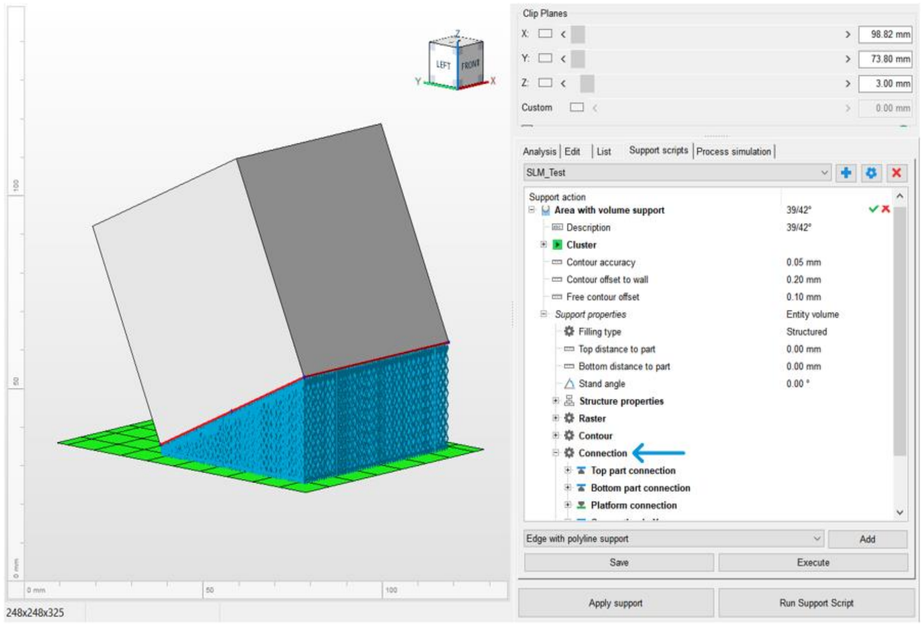


Photo Courtesy Of Dr. Ed De Meter

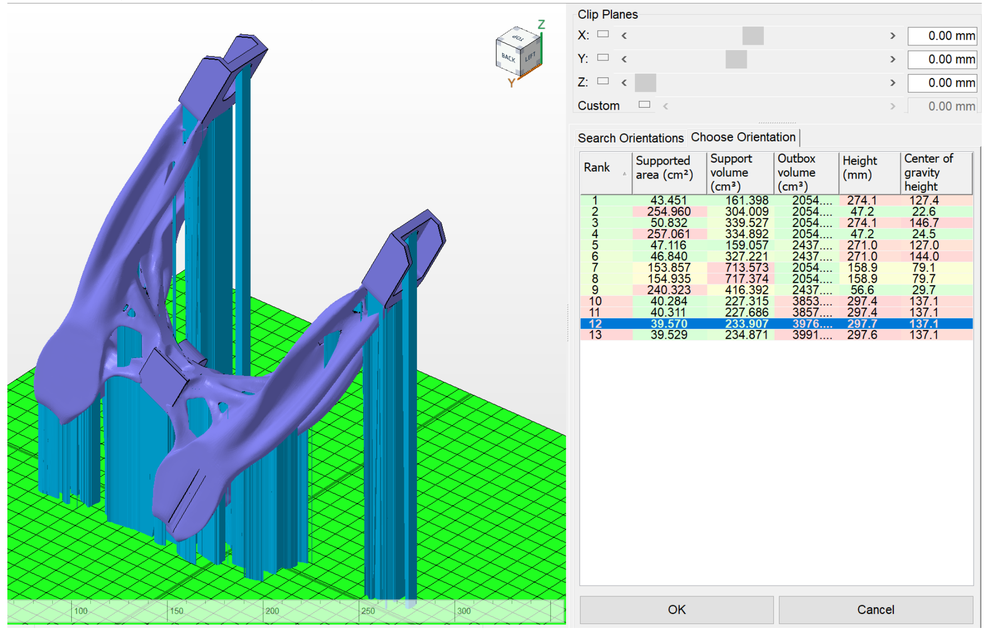
NETFABB DEMO:
PREDICTING SUPPORT FAILURE

AUTODESK® **NETFABB®**

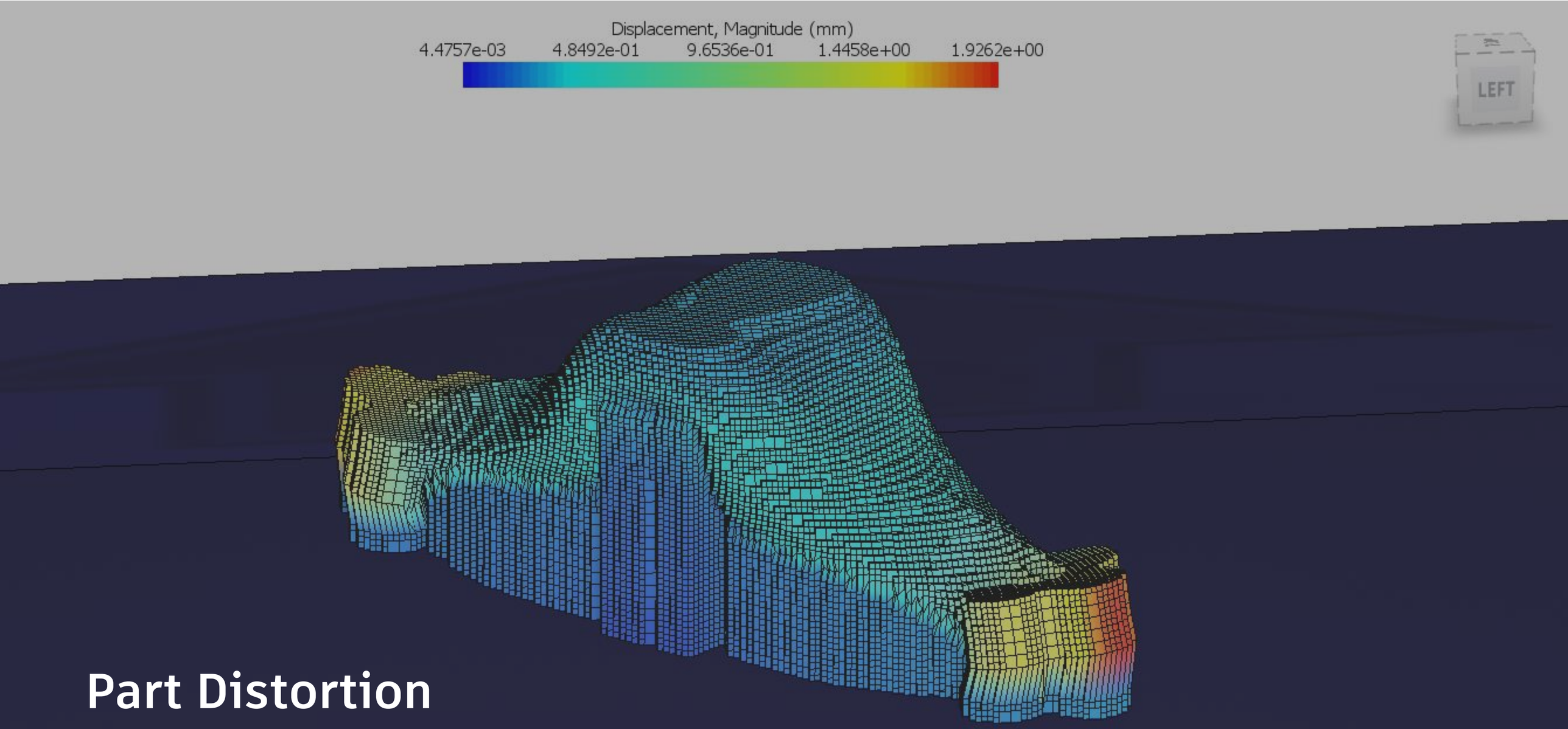
Avoiding Support Failure



RE-DESIGN SUPPORTS



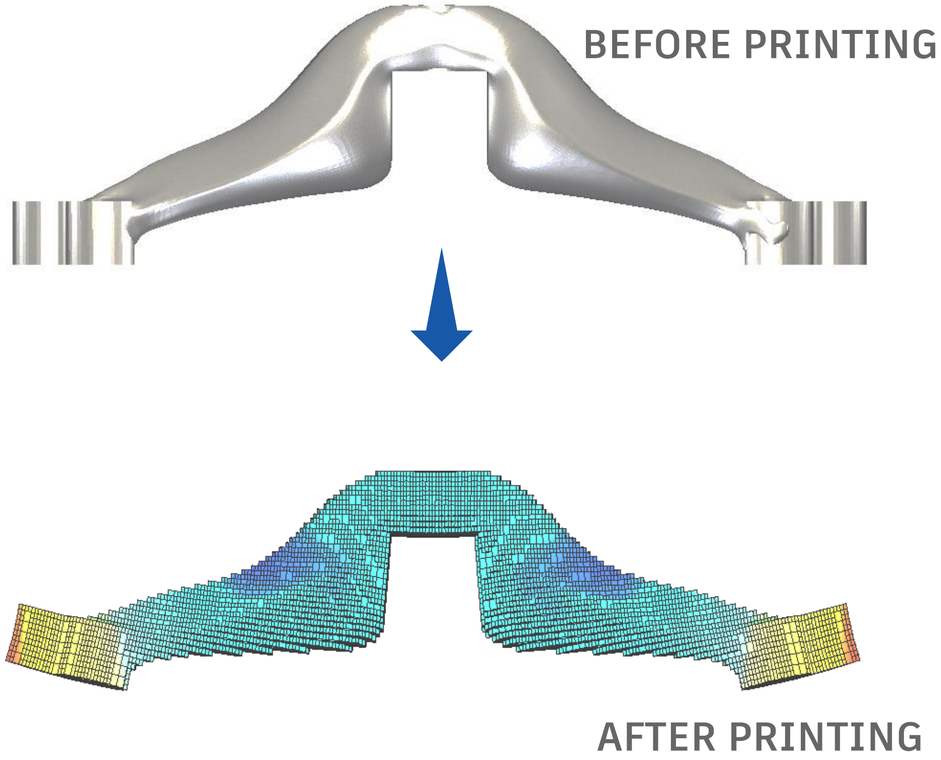
RE-ORIENT PART



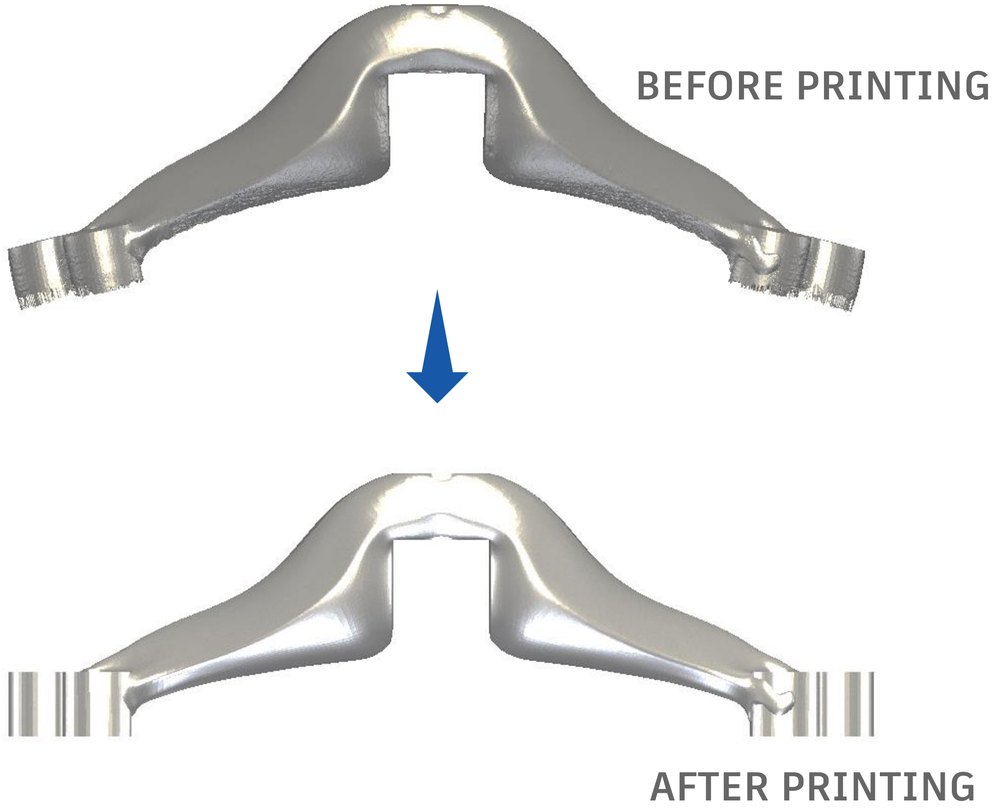
Part Distortion

Part distortion is unavoidable due to residual stresses during print. Predicting distortion and applying corrected geometric compensation.

Part Distortion



Geometry Compensation



NETFABB DEMO:
PART DISTORTION & APPLYING
GEOMETRY COMPENSATION

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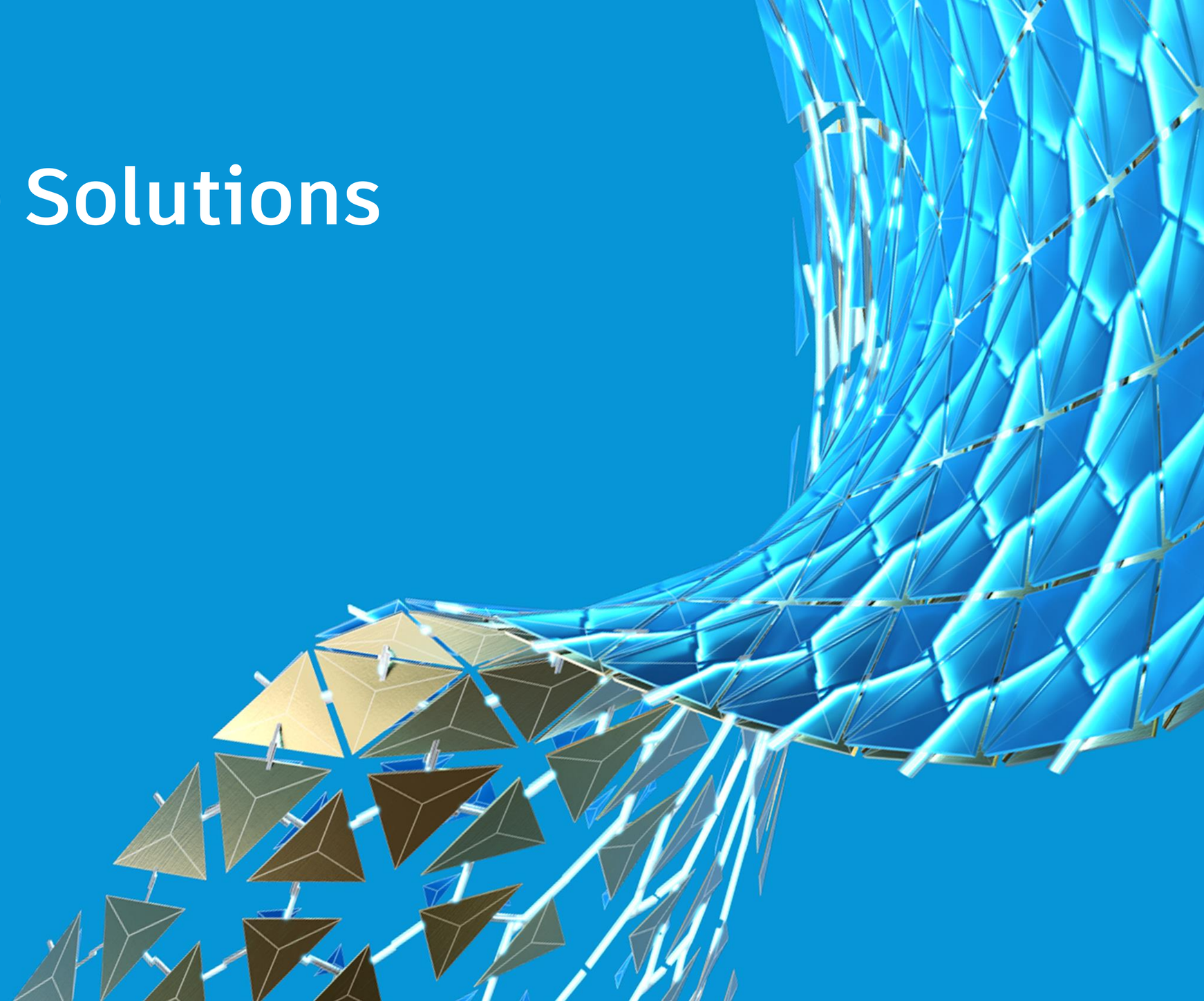
Sustainable Solutions



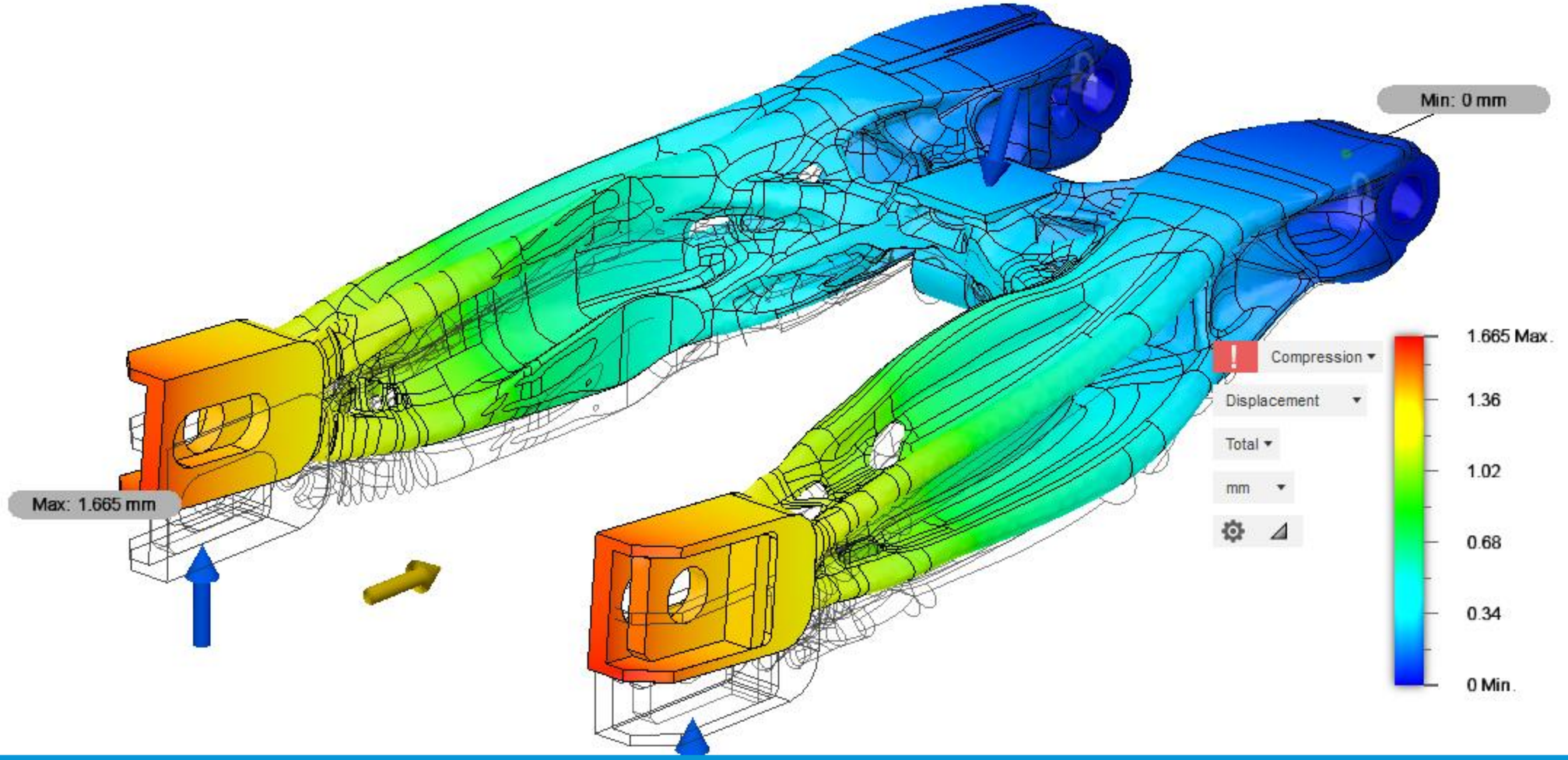
Sustainable Solutions

DESIGN

- Generative Design
- (Dis)Assembly
- Parameters
- Packing
- Simulation

MAKE

- In-machine Data
- Material Graduation
- Post-processing
- Prototype Scaling
- Process Selection



Simulation

Complications stem from a lack of foresight. The inability to project downstream pitfalls can cause error to compound incrementally.

PART vs. PROCESS

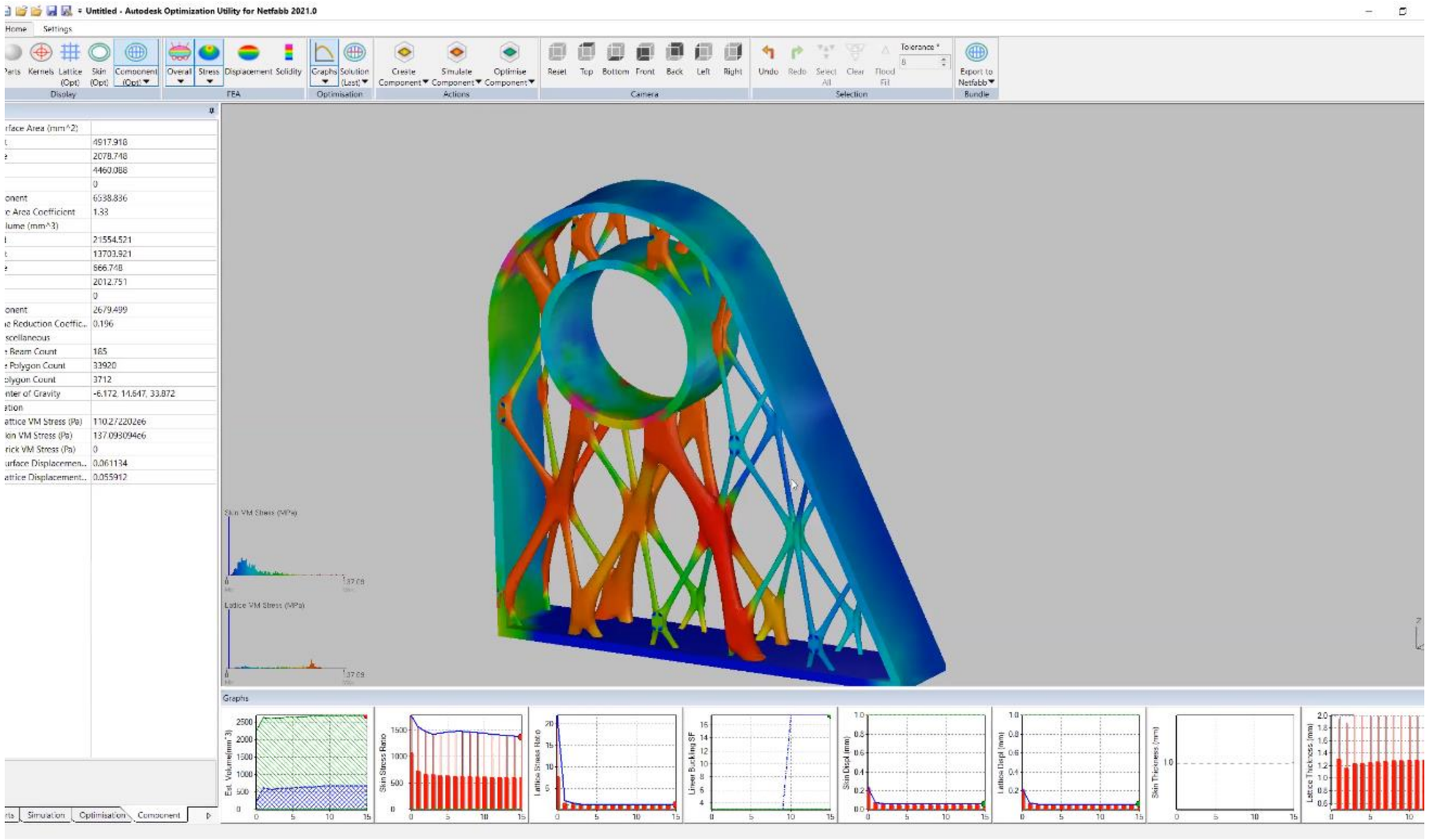
Image of Swing Arm bracket in Fusion Simulation

Generative Design (Fusion 360)

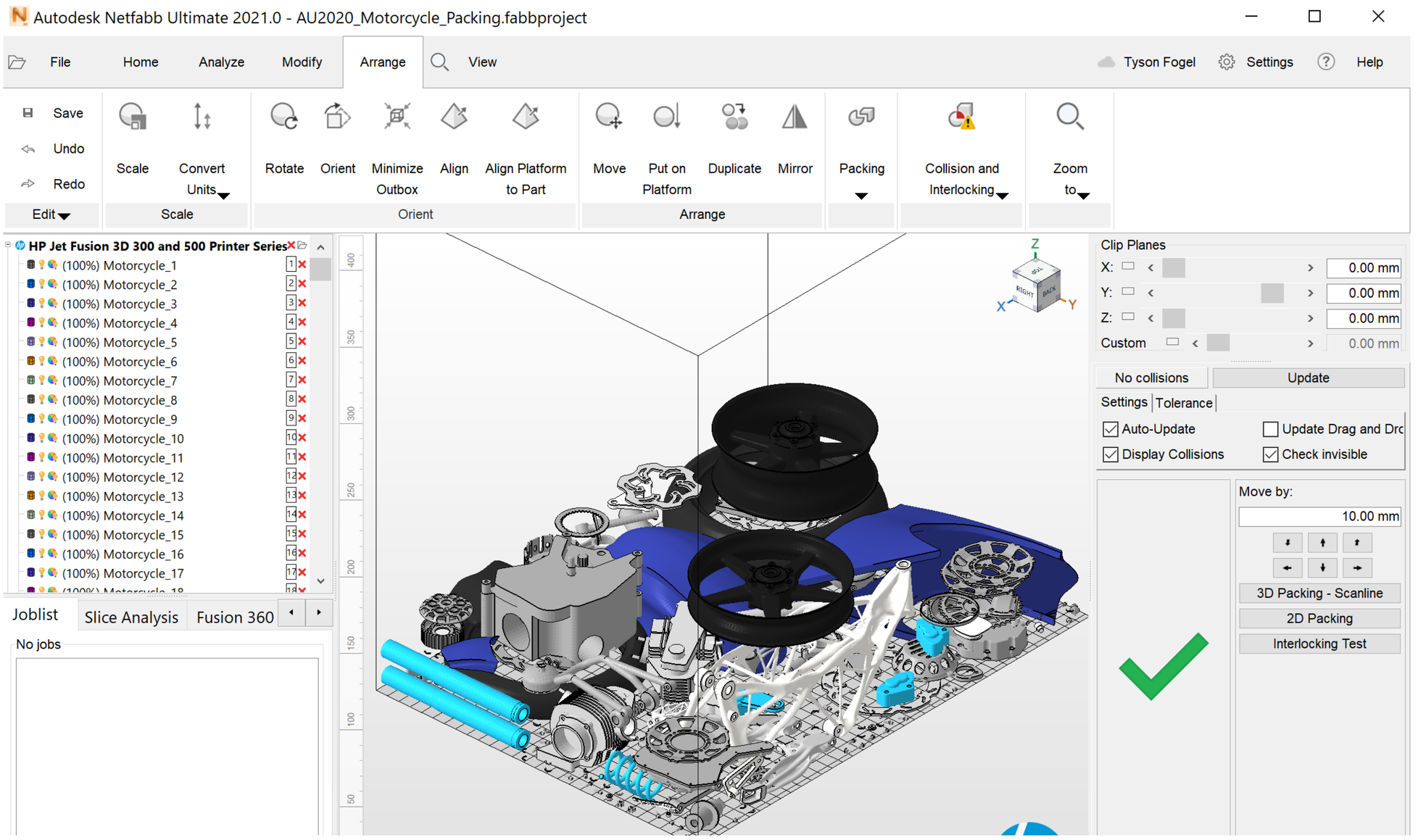
Design exploration technology. Simultaneously generate multiple CAD-ready solutions based on real-world manufacturing constraints and product performance requirements.

Image of Generative Design – JPL Lander

Lattice Optimization



Packing


Autodesk Netfabb Ultimate 2021.0 - AU2020_Motorcycle_Packing.fabbproject
File
Home
Analyze
Modify
Arrange
View
Tyson Fogel
Settings
Help
Save
Undo
Redo
Edit
Scale
Convert Units
Scale
Rotate
Orient
Minimize Outbox
Align
Align Platform to Part
Orient
Move
Put on Platform
Duplicate
Mirror
Arrange
Packing
Collision and Interlocking
Zoom to
HP Jet Fusion 3D 300 and 500 Printer Series
(100%) Motorcycle_1
(100%) Motorcycle_2
(100%) Motorcycle_3
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(100%) Motorcycle_16
(100%) Motorcycle_17
Joblist
Slice Analysis
Fusion 360
No jobs
Clip Planes
X:
Y:
Z:
Custom
0.00 mm
No collisions
Update
Settings
Tolerance
Auto-Update
Update Drag and Drc
Display Collisions
Check invisible
Move by:
10.00 mm
3D Packing - Scanline
2D Packing
Interlocking Test

List of Resources

Autodesk Netfabb

Autodesk Fusion 360

Generative Design

Sustainability

Find these resources & more in the handout!

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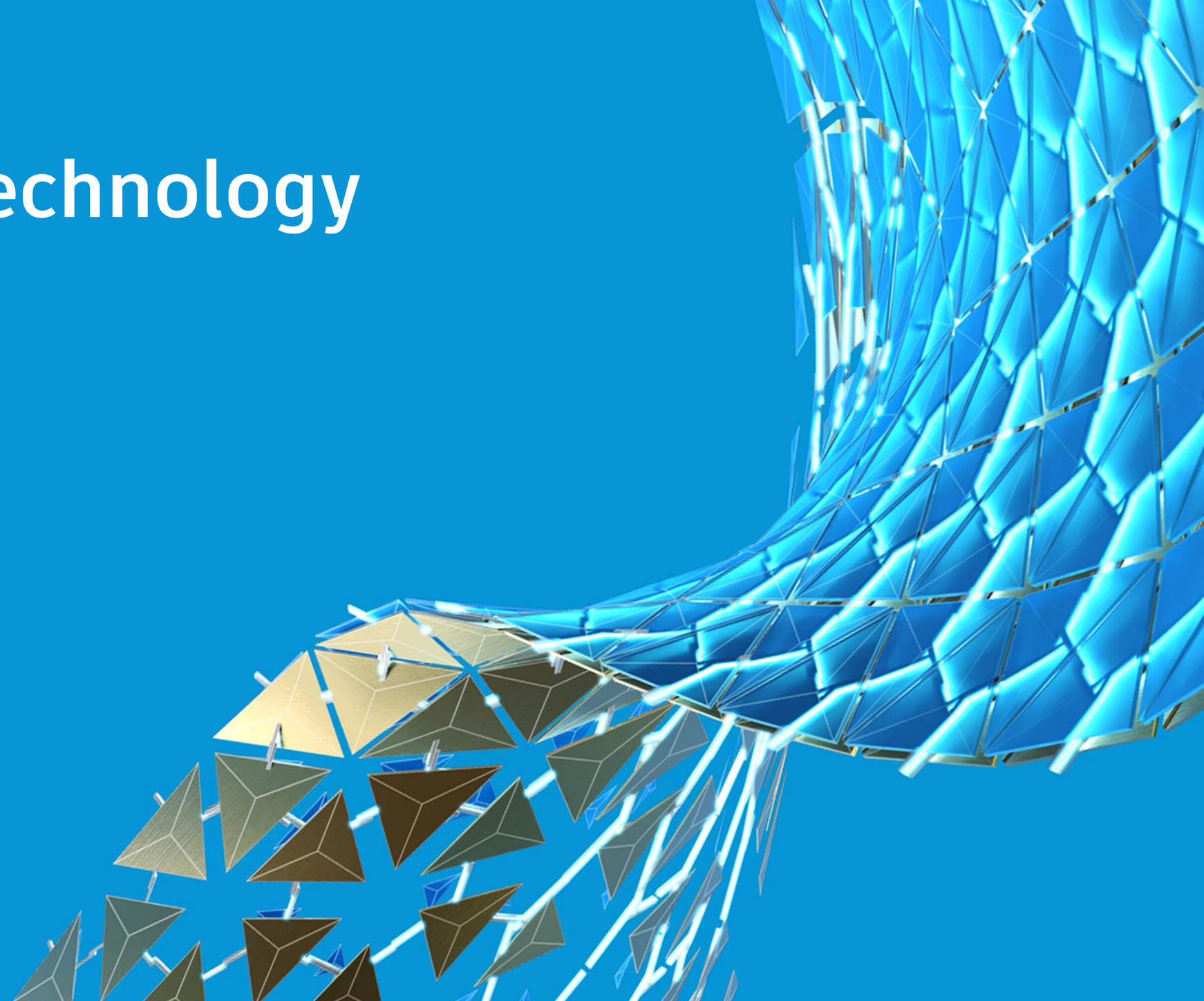

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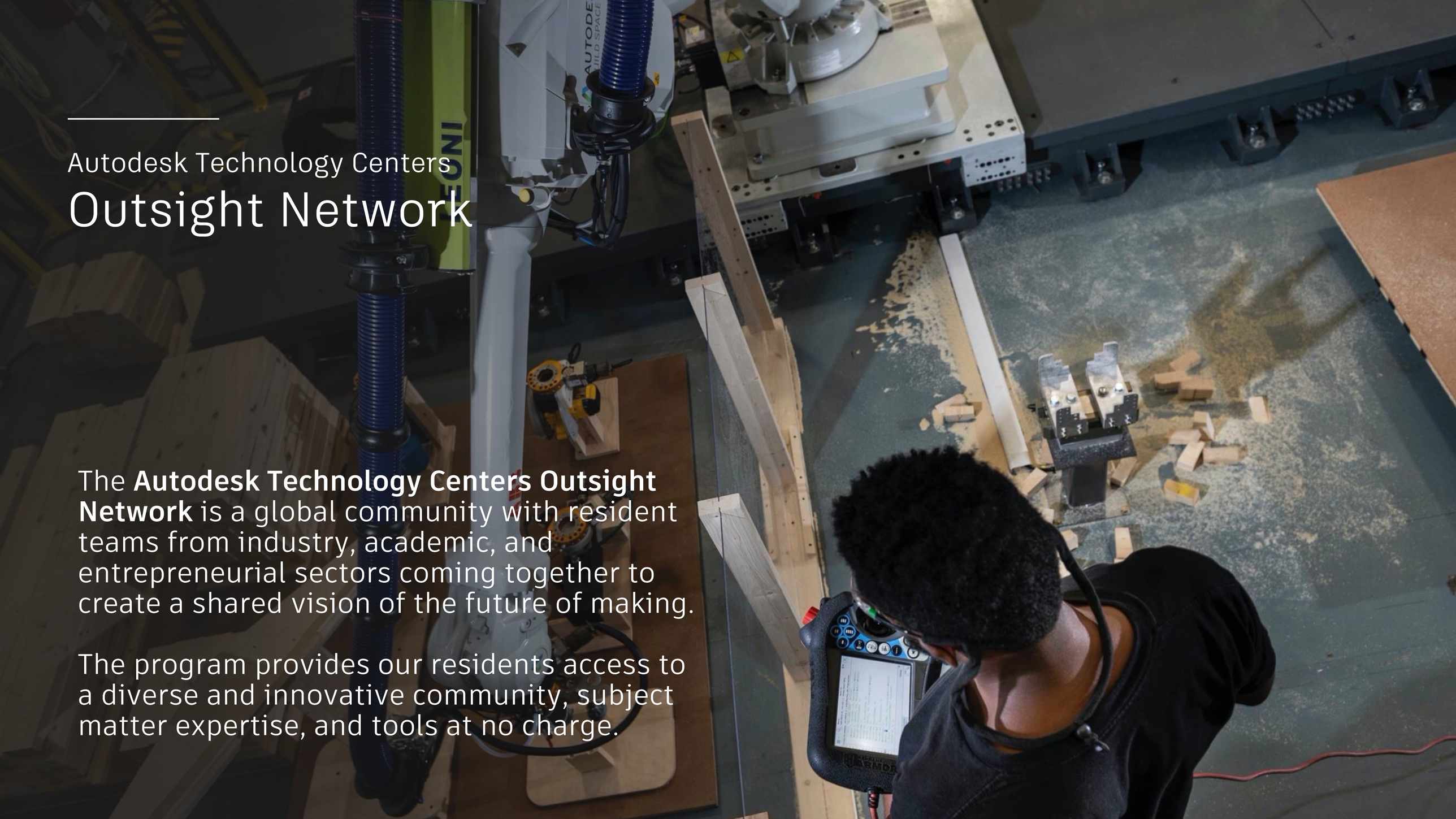
Outsight Network



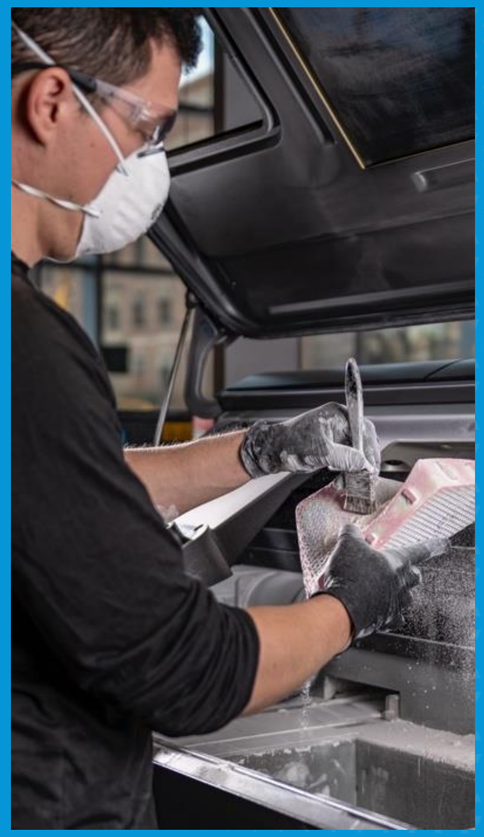
The **Autodesk Technology Centers Outsight Network** is a global community with resident teams from industry, academic, and entrepreneurial sectors coming together to create a shared vision of the future of making.

The program provides our residents access to a diverse and innovative community, subject matter expertise, and tools at no charge.

Autodesk Technology Centers

Our Technology Centers are equipped with state-of-the-art equipment and machinery to aid our residents as they prototype new ideas. Our facilities are available for use by all of our Outsight Network residents.

San Francisco, California



Toronto, Ontario, Canada

Boston, Massachusetts

All our facilities offer:

Inspiring workspaces

- Desks and office amenities
- Project space for fabrication and assembly

Advanced machinery

- 3D Printing, CNC, Robotics
- Wood/Metal workshops, Electronics and more...

Training and support

- Expert Consultation
- Software and Equipment training

Join the Outsight Network

Connect

Our team is available to assist in proposal development and to answer questions.

Contact us at:
technology.centers@autodesk.com

Apply

Visit our website below to fill out a proposal form. We request that you provide us background on your team and your proposed project. Proposals are reviewed on a rolling basis.

Become a Resident

Once accepted, we will contact you to schedule an introductory meeting and work with you to ensure your team is well positioned for success.

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