Generative Design for Increased Performance on Customized Construction Parts

Gert-Jan Ditsel | Peter Champneys | Katerina Papadimitriou

BIM Manager
Dura Vermeer

Technical Specialist
Autodesk

Designated Support Specialist
Autodesk

AUTODESK. UNIVERSITY

Gert Jan Ditsel

Dura Vermeer – BIM Manager

I always want to help people! So that’s what I do in my role at Dura Vermeer I help people to change from traditional to digital. My first 6 years at Dura Vermeer I helped people understand and work with BIM. Now we are mature enough to take next steps in digitalization. And that world and future looks very promising!

Peter Champneys

Autodesk – Technical Consultant

Peter is a technical consultant working out of the Autodesk technology center in Birmingham UK. He is a specialist in additive manufacturing and generative design, and works alongside Autodesk customers to help them implement emerging make technologies into their day to day workflows

Katerina Papadimitriou

Autodesk – Customer Success Specialist

Enthusiastic architect engineer, aiming to push forward fresh perspectives and creative approaches to projects, leveraging the past combined to the future! Aiming to push the investigation of assembling new languages of architecture to the realization. Always keeping an eye on innovation and how it can influence the construction future.

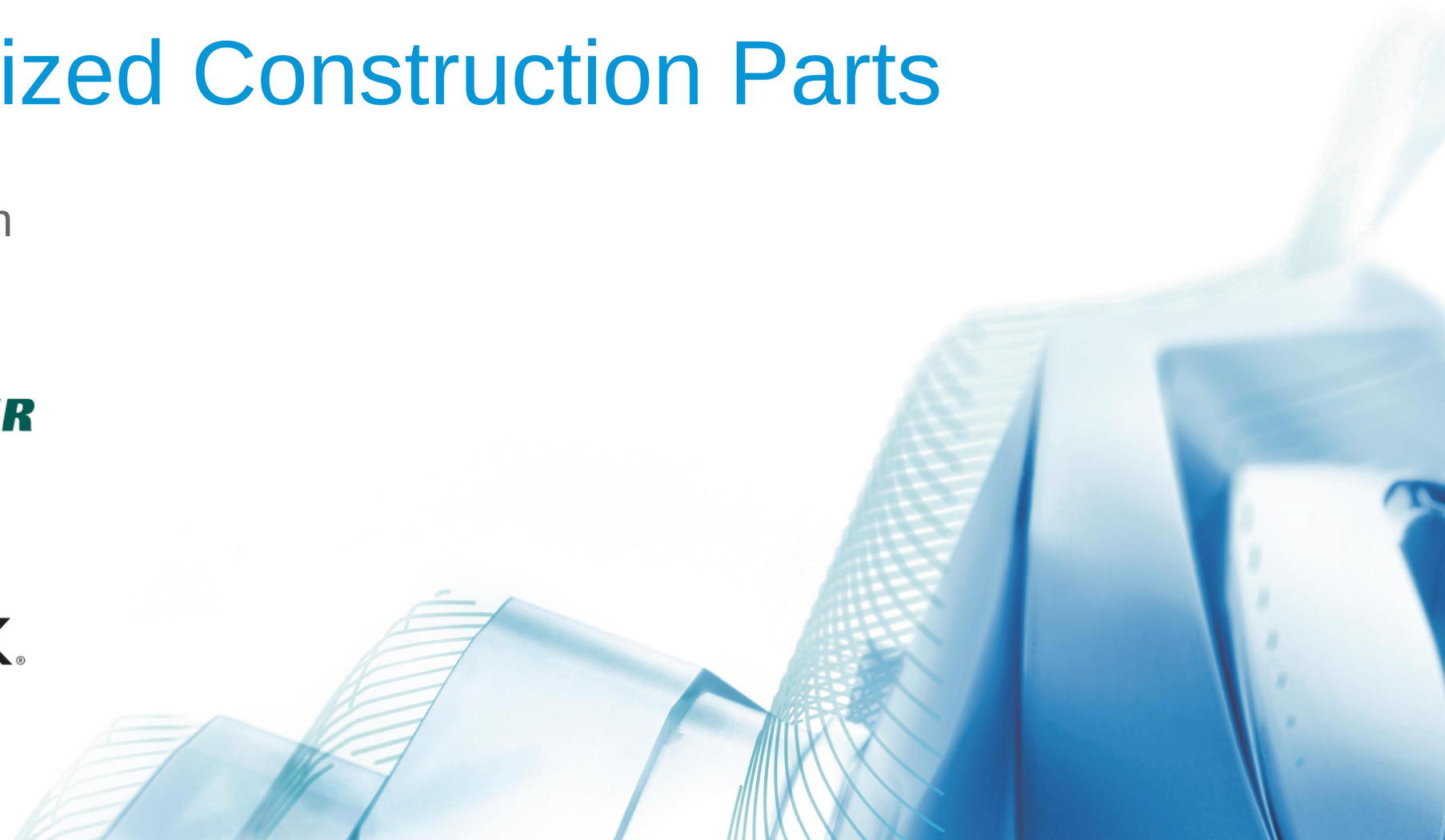
Generative Design for Increased Performance on Customized Construction Parts

A partnership between

DURA VERMEER

&

AUTODESK. UNIVERSITY



Today’s Line Up

INDUSTRIALIZED CONSTRUCTION & GENERATIVE DESIGN IN PRACTICE

How could inspire your teams on using innovative technologies?

Would you apply GD on real applications by changing your workflows?

DURA VERMEER & THE HOST OF THE SPIDER PROJECT

Company drives of innovation and objectives

The AFAS site leveraging BIM

THE CHRONICLE OF THE SPIDER

Steps to Success

Capture, Analyze, Iterate, Natural Selection, Manufacture, Test, Install, Monitor, Iterate

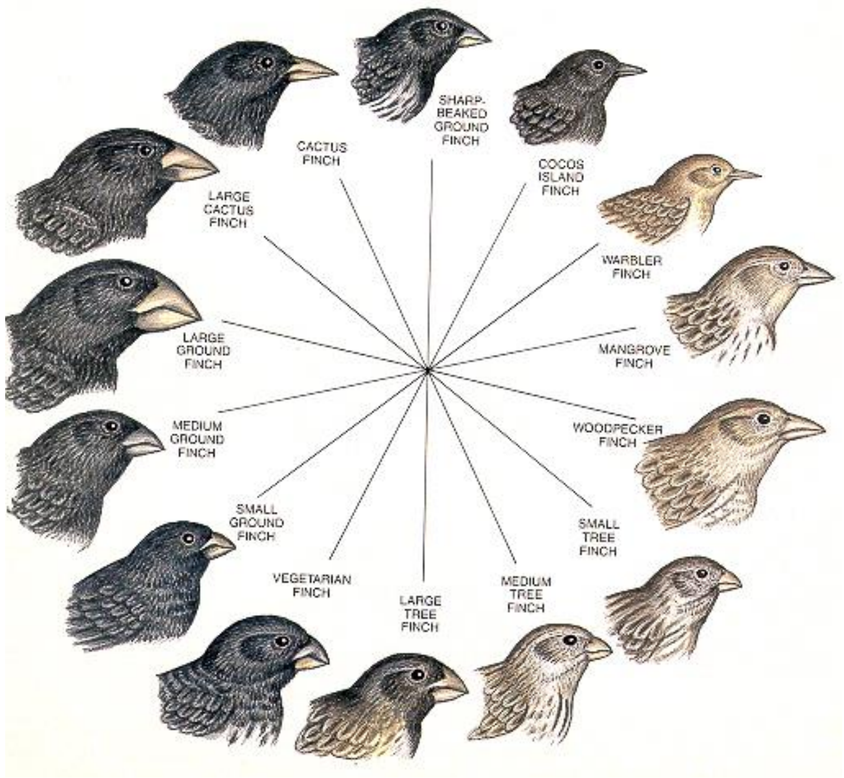
Lessons Learned

BUILDING ELEMENTS AS INTELLIGENT OBJECTS

From static to dynamic·

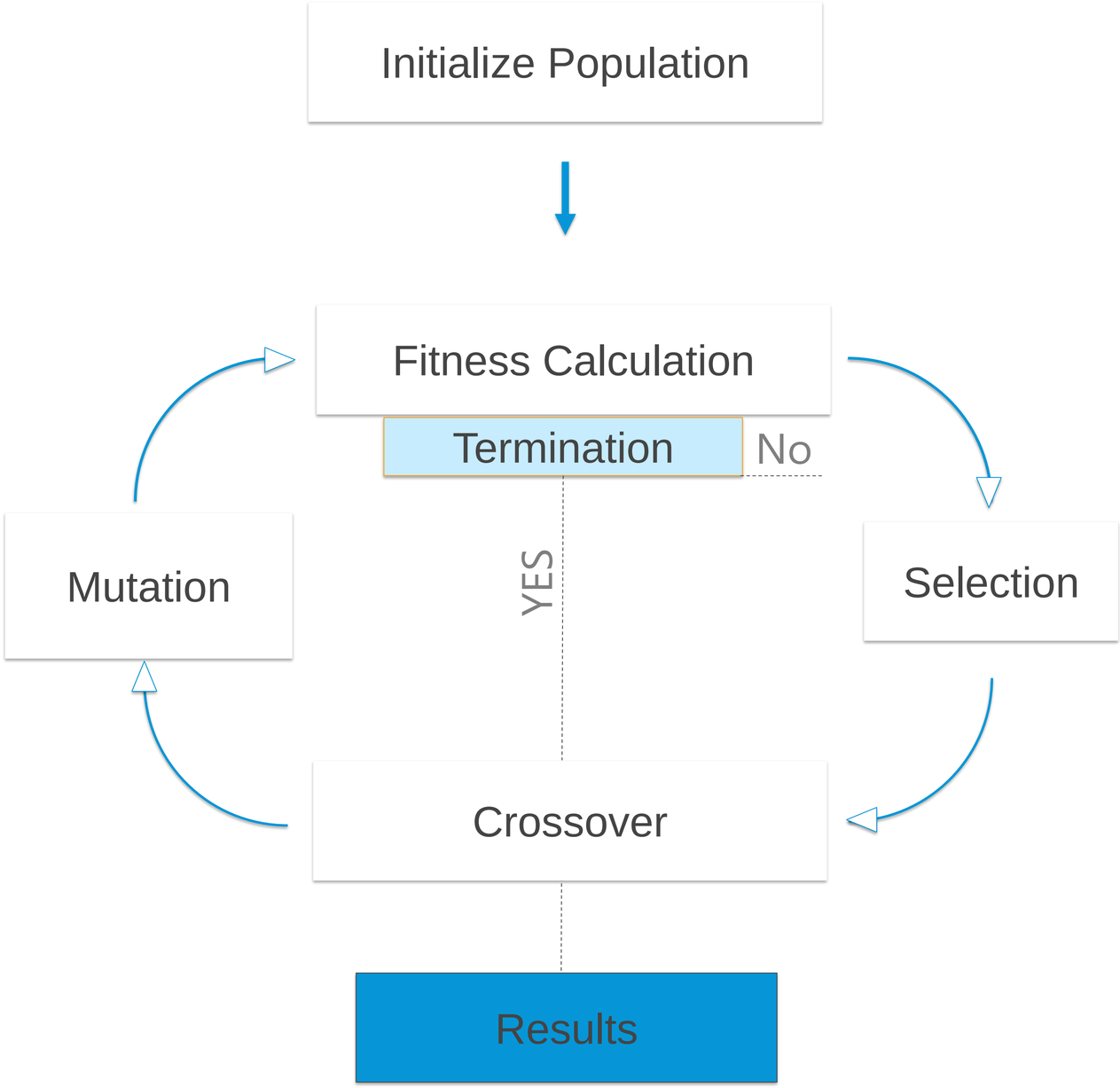
Sensors - creating intelligent objects

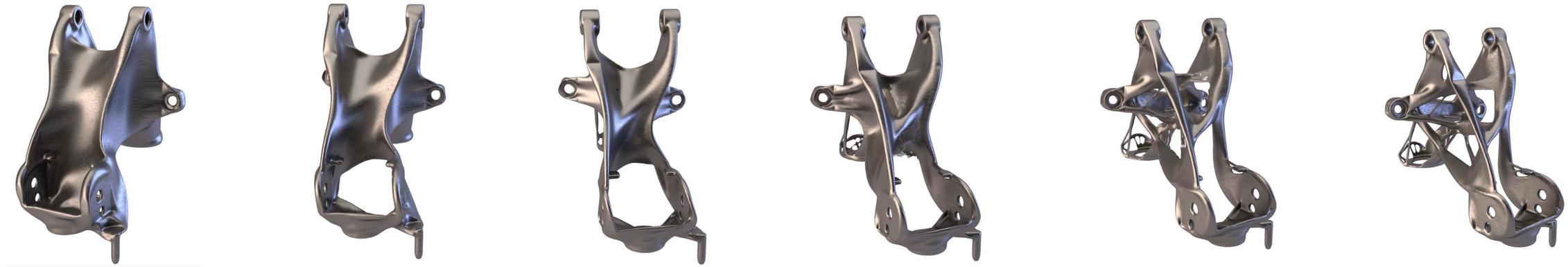
Industrialized Construction & Generative Design in Practice



Genetic Algorithms as in Nature

Evolution in nature generates solutions to problems in an optimized way. The techniques used are inheritance, mutation, selection and crossover.

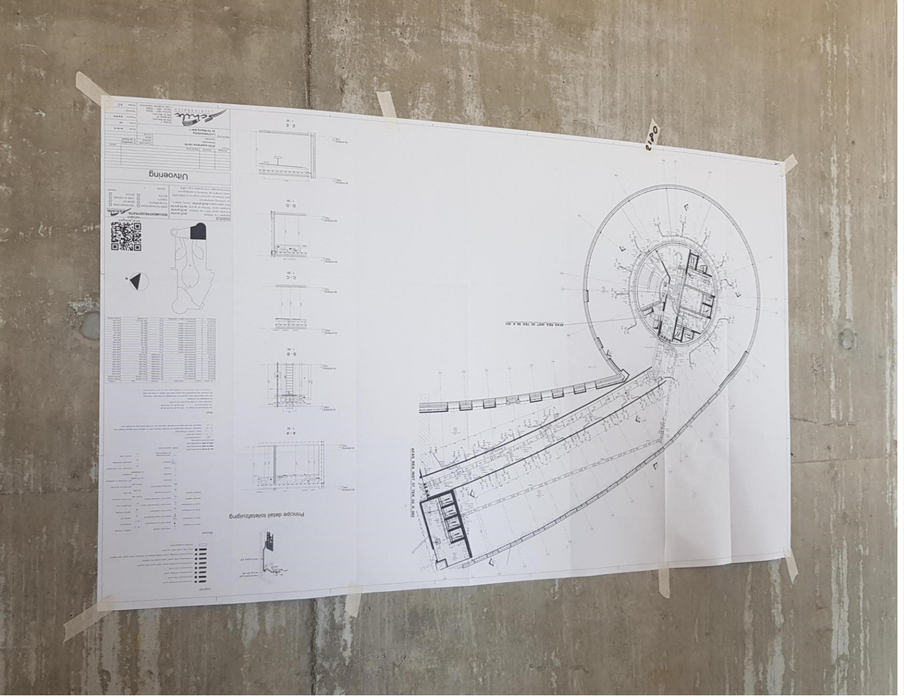


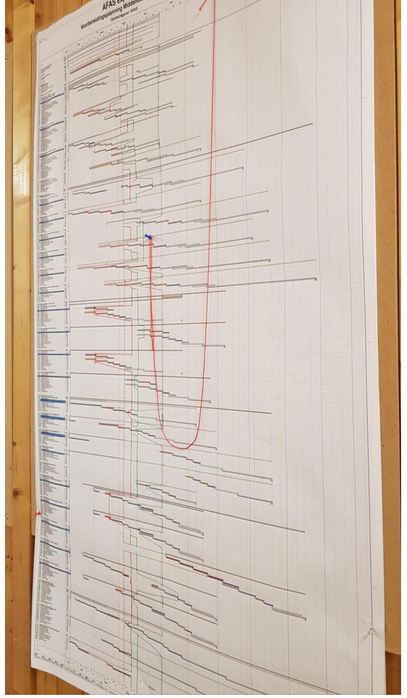


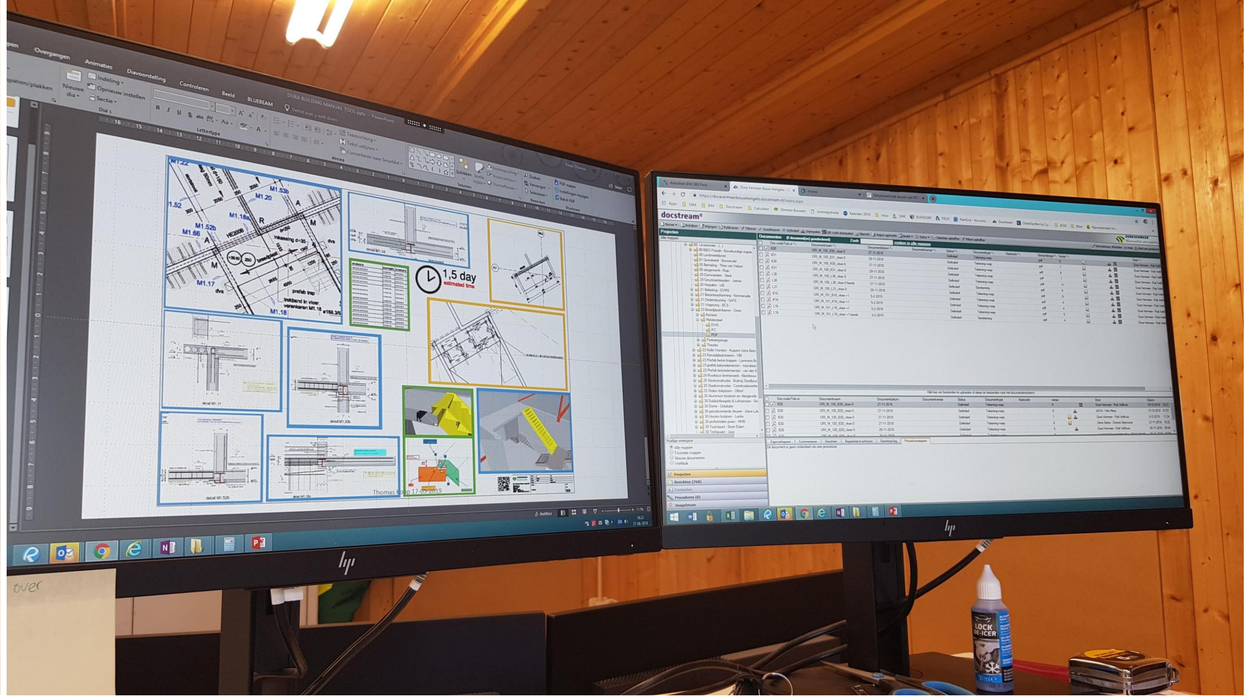
Genetic Algorithms as in Design

Generative Design is a goal-driven approach that uses automation to give designers and engineers better insights so they can make faster, more informed design decisions.

Industrialized Construction







Design & Construction then

Paper Manual

Drawings 2D

Axonometric Details

Design and Construction now

Design 3D / Algorithms

Cloud Collaboration

Generative Design

Prefab elements

Construction Principles & Increased Needs

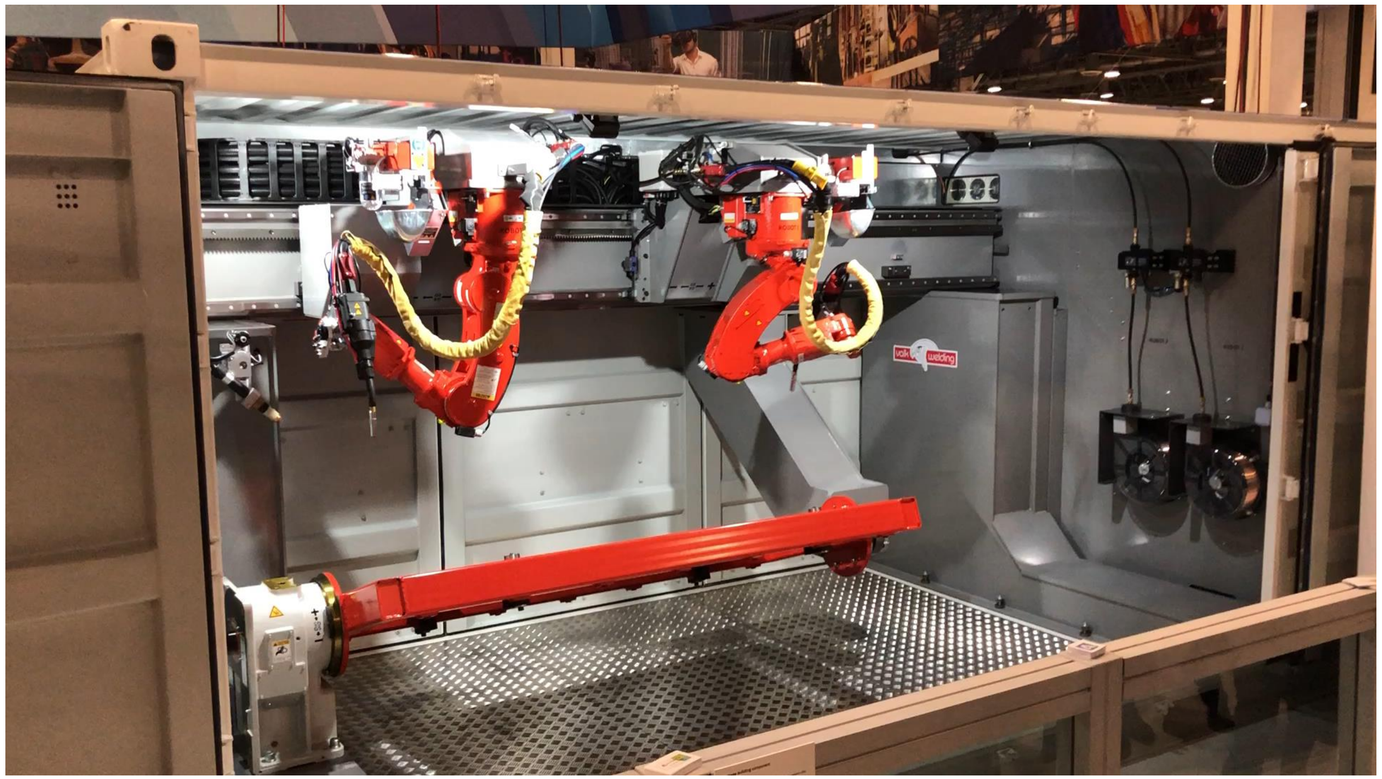
The construction industry is evolving

Robotic Toolbox · On site Production

Case Study .: Robots in a Box. How does it feel having a tool box that can make anything?

Autodesk University Las Vegas 2018

Robotic Toolbox · On site Production



Case Study .: Robots in a Box. How does it feel having a tool box that can make anything?

Autodesk University Las Vegas 2018

Scalability

Image caption goes here

Scalability

Image caption goes here

Scalability

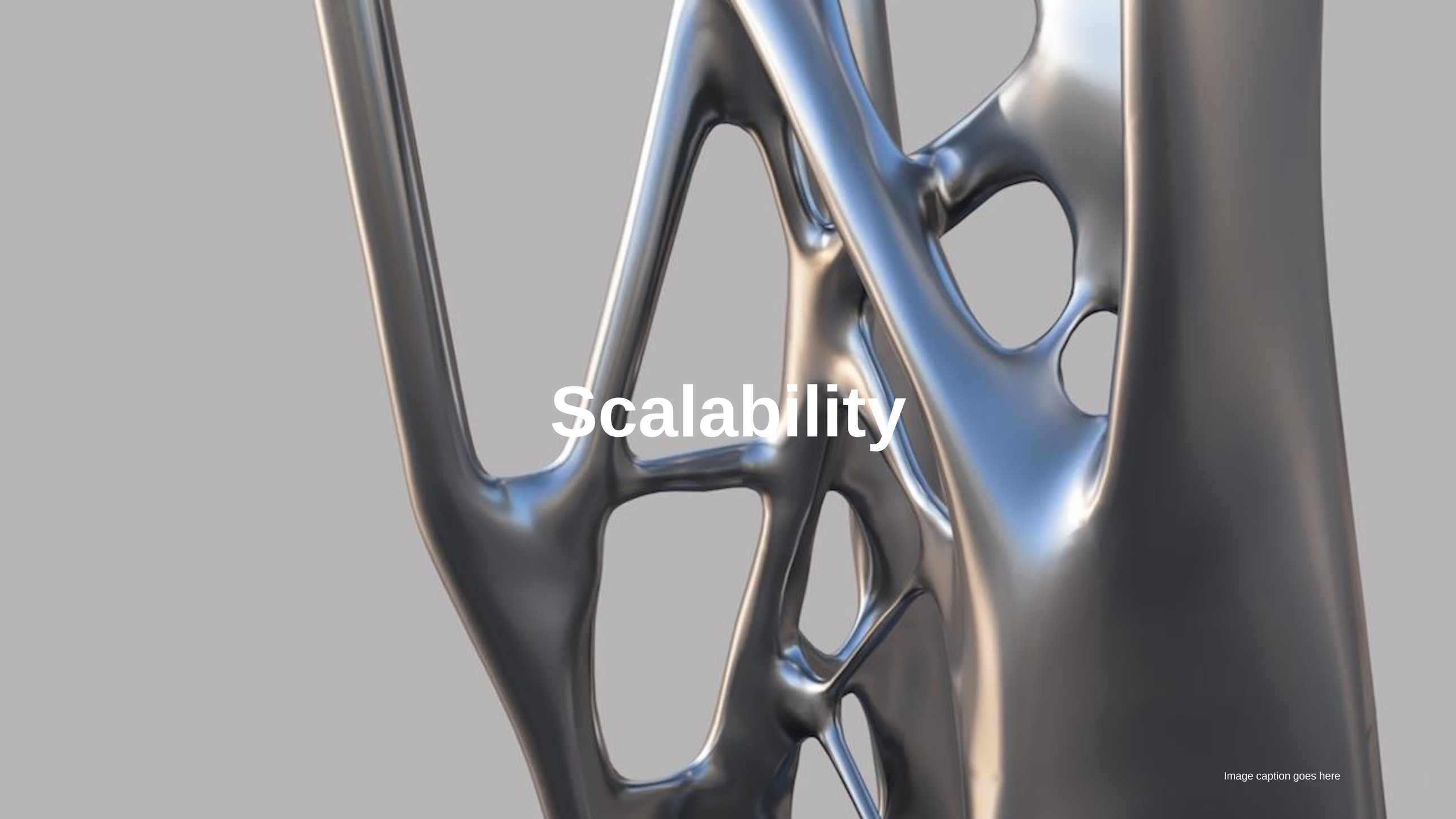


Image caption goes here

Scalability

“{…}we could have set up a unit to produce the pieces that failed in no time. Scanning, designing, producing and installing.”

Façade Engineer, Buro Happold

Dura Vermeer as Incubator


DURA VERMEER
PEOPLE ARE MORE IMPORTANT
THAN TECHNOLOGY


BHV


DIGITAL
TRADITIONAL


HORIZONTALLY ORGANIZED
FAMILY COMPANY
165 YEARS
2.700
EMPLOYEES
1,3
TURNOVER
BILLION
Division Building and Real Estate
Division Infrastructure
Division Advice and Services

OUR MISSION

MADE BY OUR OWN PEOPLE

REALIZING AMBITIONS, BY LETTING IDEAS GROW, BASED ON INSPIRATION, RESPECT AND CONNECTION.

OUR VISION

CONTRIBUTE TO INNOVATIVE SOLUTIONS AND EXTREME PREDICTABILITY, WITH THE ONLY GOAL; TO DELIVER VALUE TO OUR CUSTOMERS

AUTODESK & DURA VERMEER

DURA VERMEER


TRY
FAIL
LEARN
GROW
REPEAT
GROWTH MINDSET

LEARNING BY DOING

1

Autodesk

2

Generative Design

3

Inspired Birmingham ATC

4

Reality AFAS

MAIN BUILDING EDUCATION STUDIO'S RESTAURANT THEATER & AUDITORIUM

PARKING DECK DEMONSTRATION SPORTS ATRIUM

AFAS EXPERIENCE CENTRE

PROJECT INFO

44.000 M²
750 OFFICE WORKPLACES
820 THEATER SEATS
700 RESTAURANT PLACES
760 PARKINGSPACES

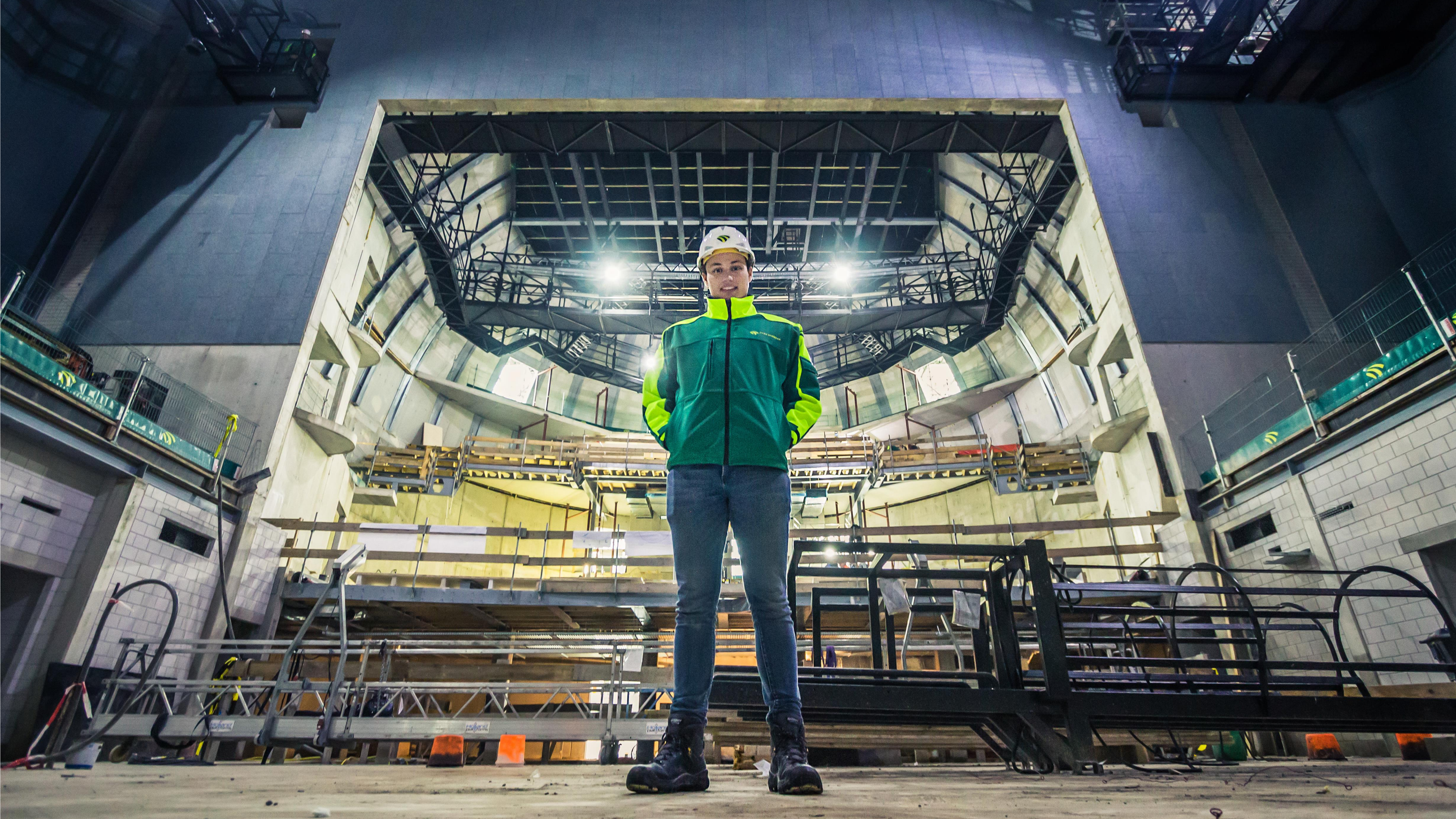
Ik kan vliegen


DURA VERMEER


ATELIER
LEUSDEN WOUDENBERG
DURAVERMEER
DURAVERMEER
DURAVERMEER

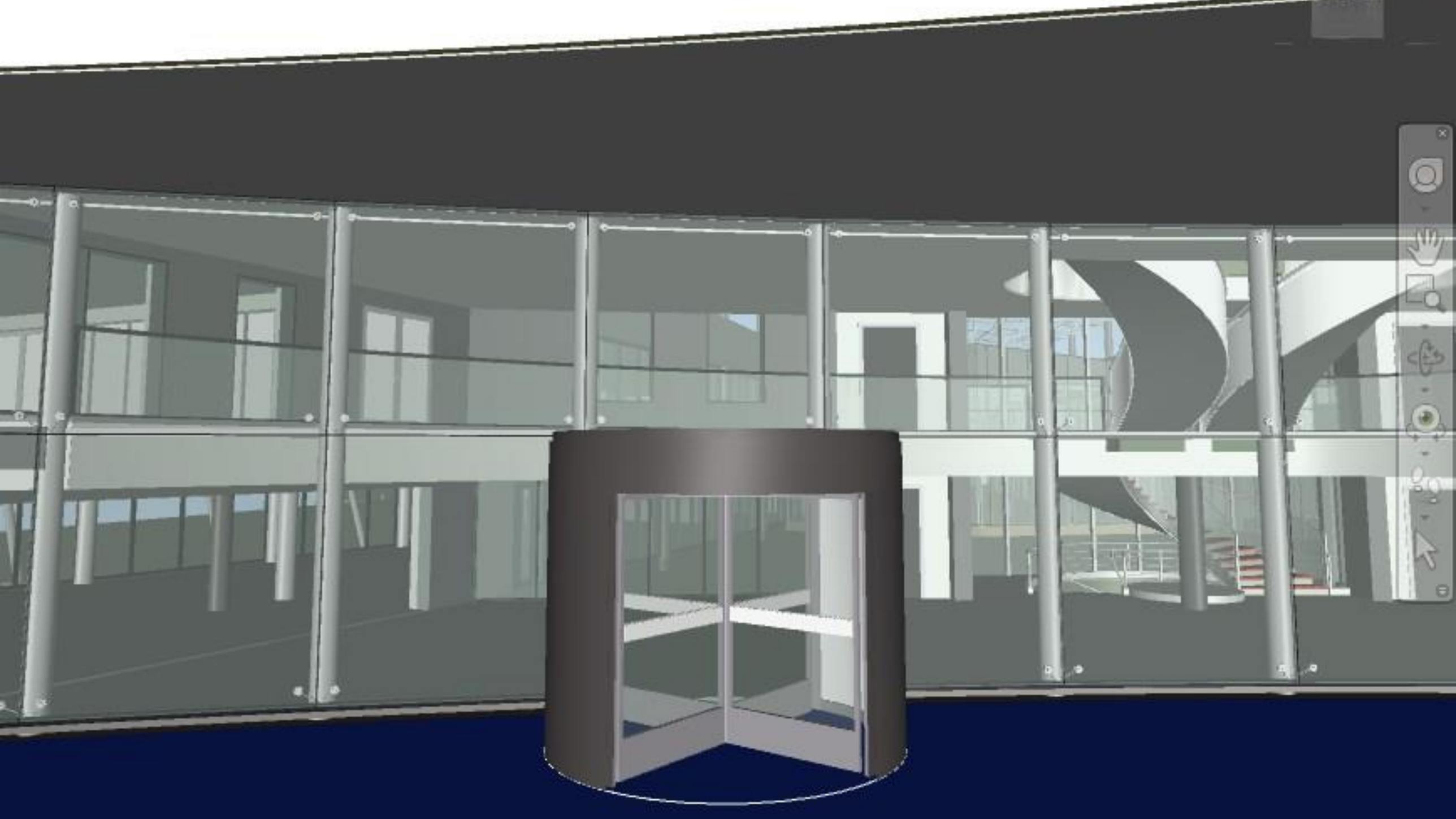

3

Image caption goes here




DURAVERMEER

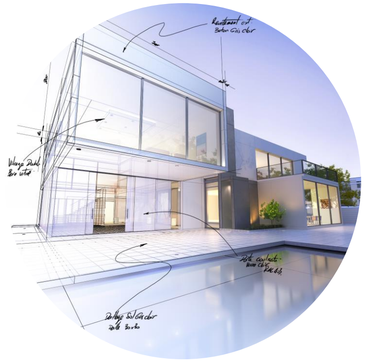

AFAS
software



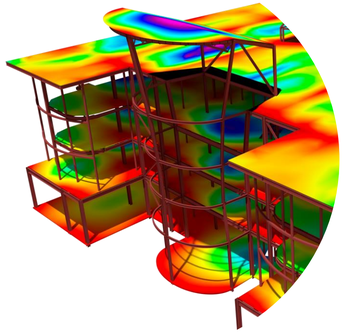
Generative Design Workflow for Construction

Traditional Design Approach

Design Problem



Idea Generation



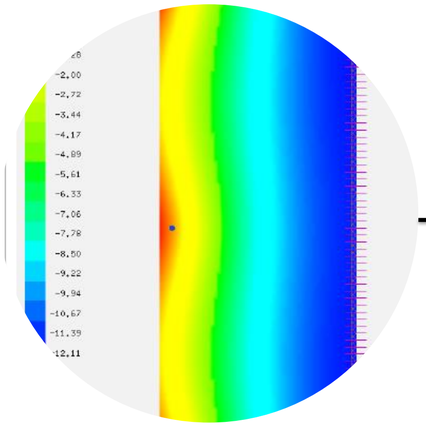
Evaluation

Production Process

Generative Design Workflow

Onsite Data

Scan data from the site captures the as built dimensions of the pillar attachment point. And allows high tolerances to be accounted for



Structural Analysis

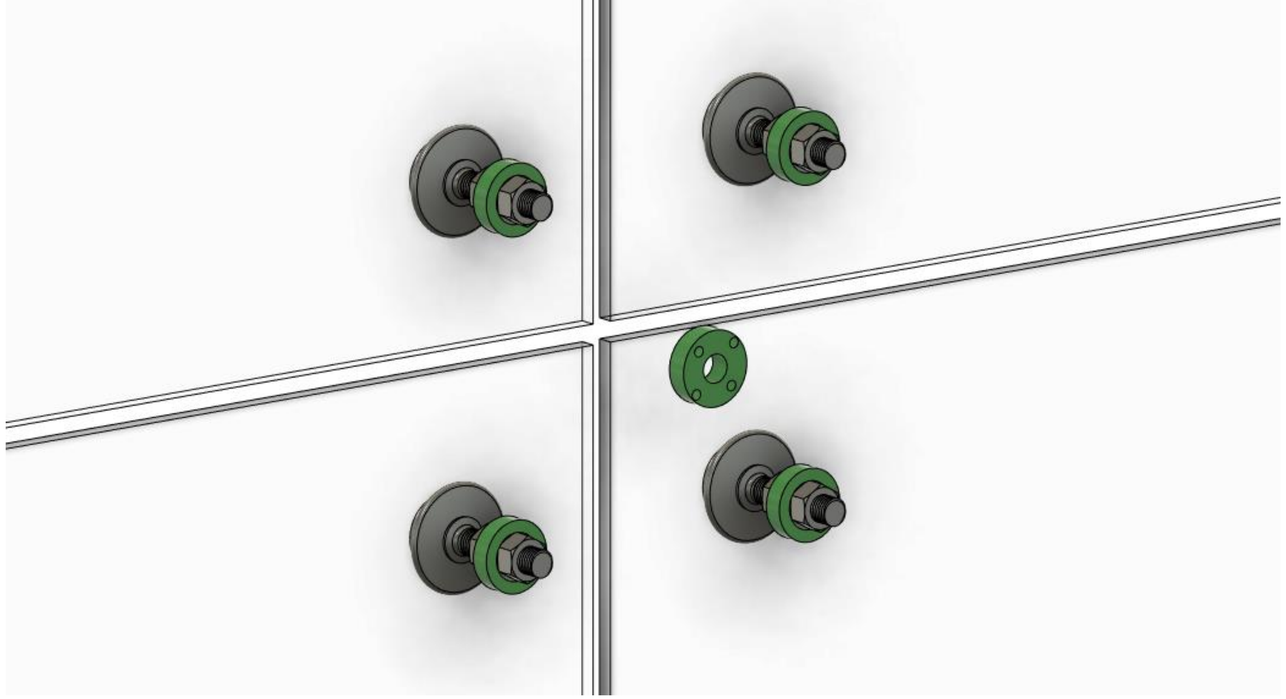
Wind, snow and point loads are calculated for each location on the facade

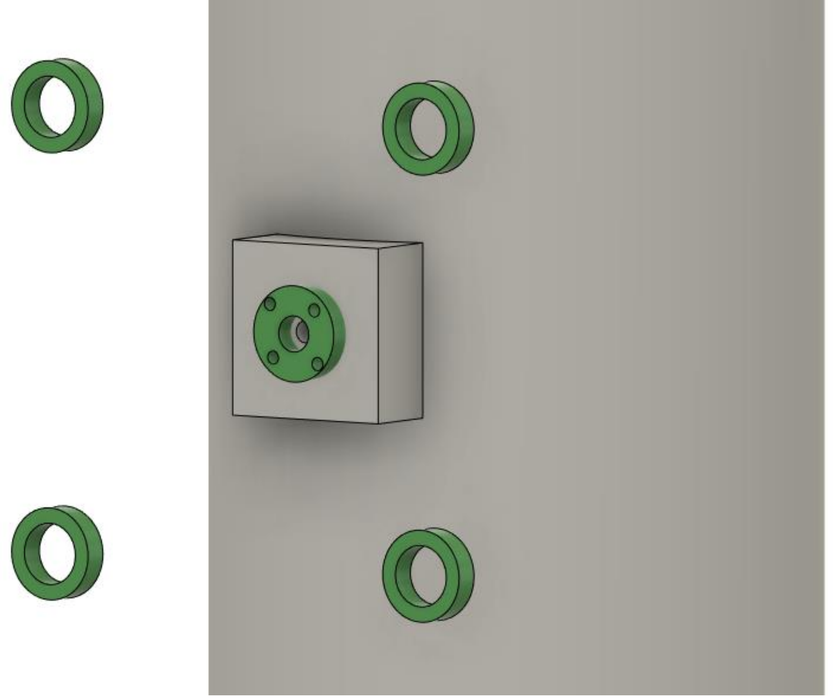
Design for Production

An understanding of what makes a good design for different on-site manufacturing processes is built into the algorithm

Generative Design

This information is sent to a generative design algorithm, which creates multiple design possibilities for us



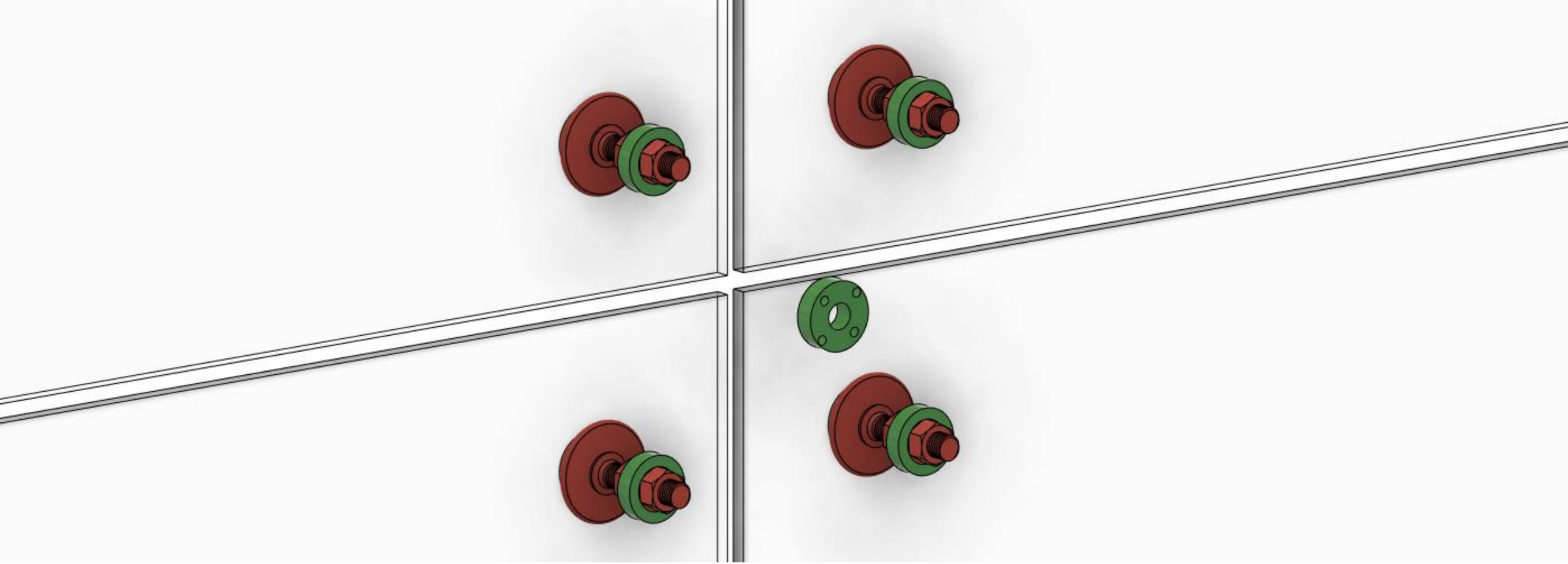


Fixation to Glass Panels

Fixation locations to the glass panels are taken from the onsite data. These let the algorithm know where to connect to the panels

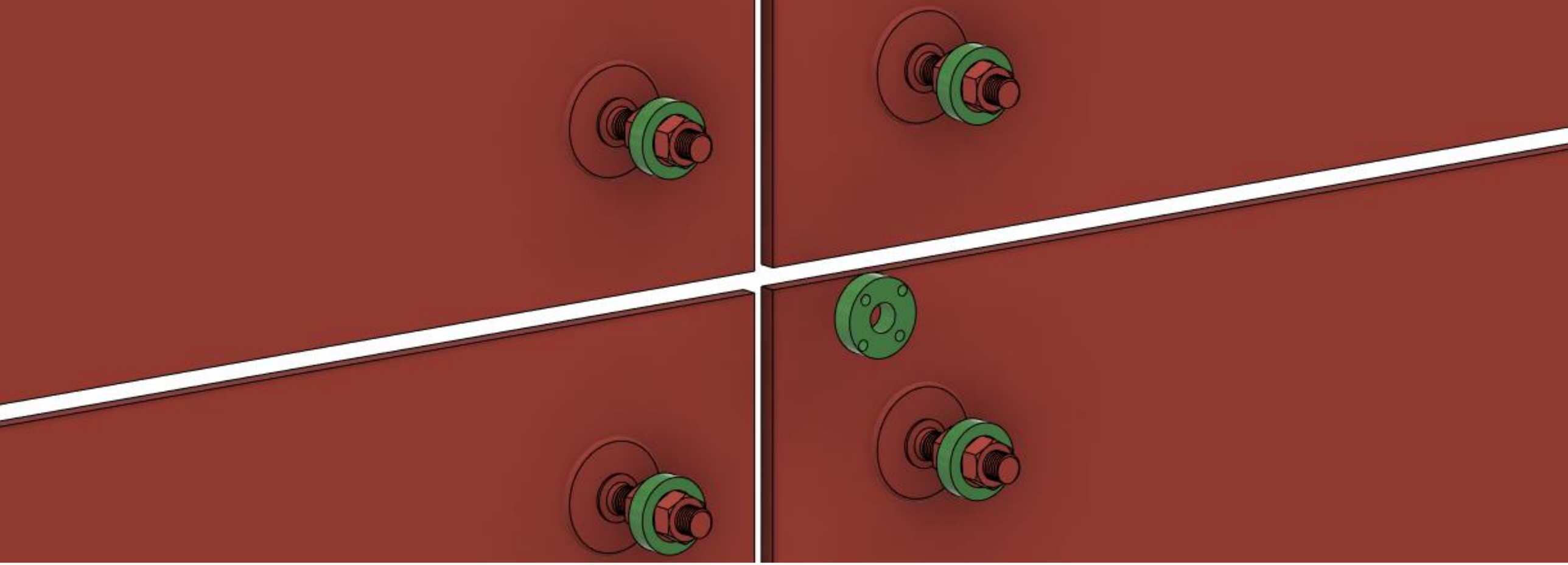
Fixation to Pillars

Geometry is also defined for the connection point to the central pillar.



Connector obstacles

An essential function of the fixture is that it should be easy to take the finished part on or off, and to install the component on-site The fixture should also be easy to fasten onto the central pillar and the glass panels. Obstacle geometry is used, to ensure adequate room is left for bolted fasteners



Assembly obstacles

Obstacle geometry is also used to represent the wider assembly of the building. This is to ensure that the spider doesn’t protrude into the rest of the façade assembly

Generative Design Workflow

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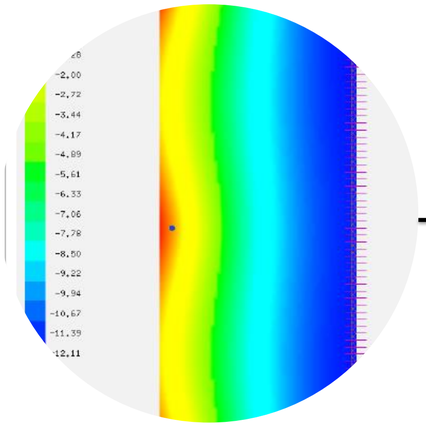

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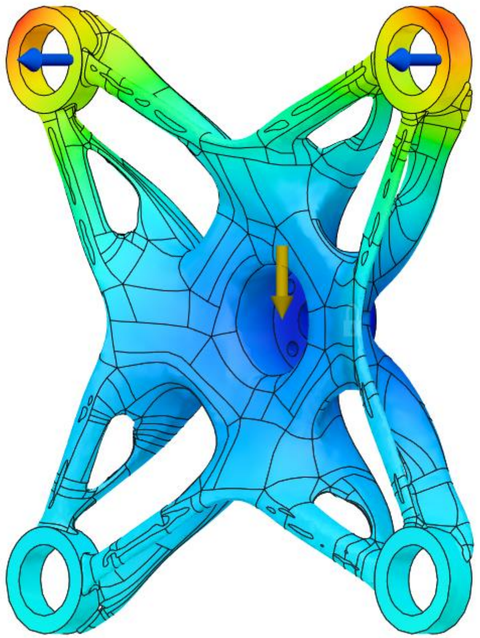

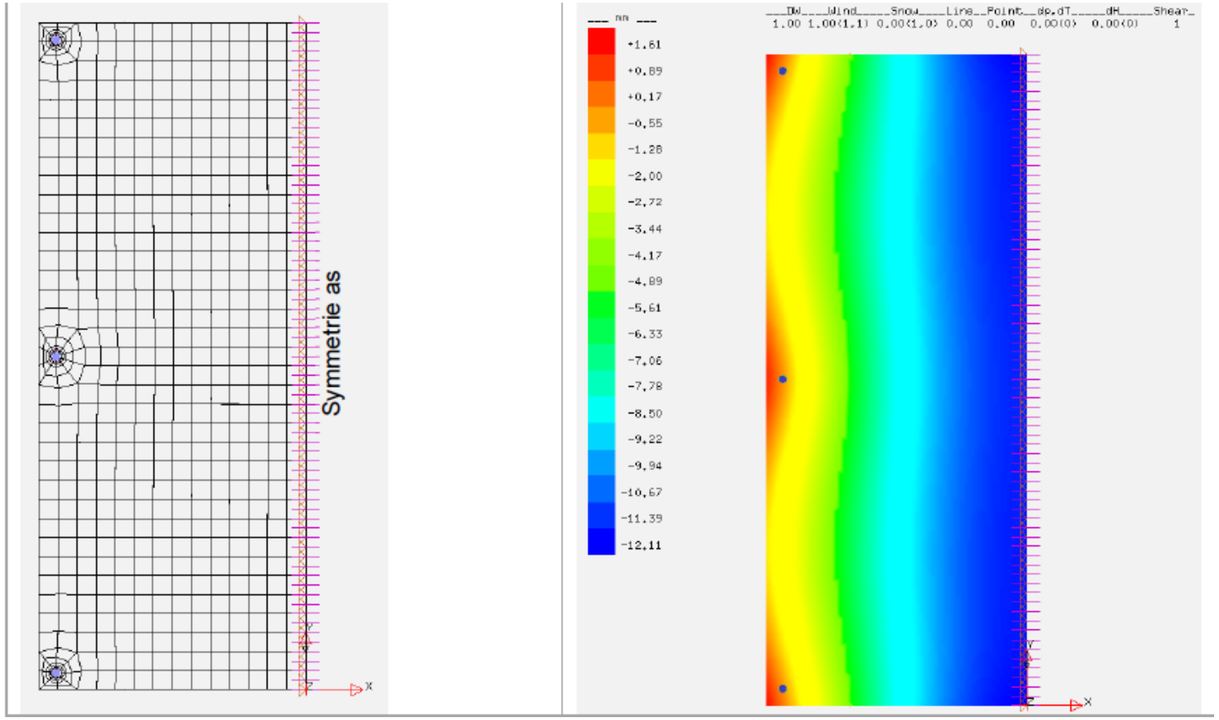

Wind, Snow and Point Loads

The forces which act on the spider during it's lifetime are represented using load cases. This allows generative design to understand the environment of the component during use, and to create design outcomes which are optimized for this environment. In this instance, an objective of maximizing stiffness has been used to maximize the structural rigidity of the fixture

Generative Design Workflow

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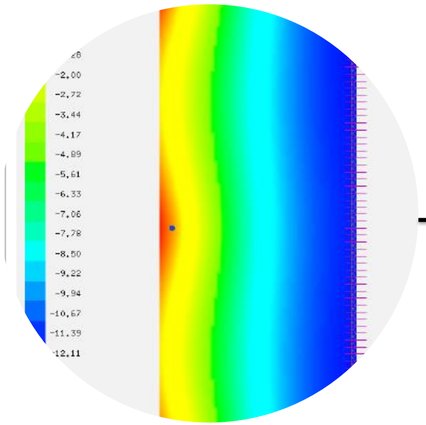

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Manufacturing Methods

The manufacturing methods which are available to the designer can be selected as constraints. Each design outcome created, will have a unique manufacturing goal in mind, the parameters of which can be customized to the users liking.

Generative Design Workflow

Onsite Data

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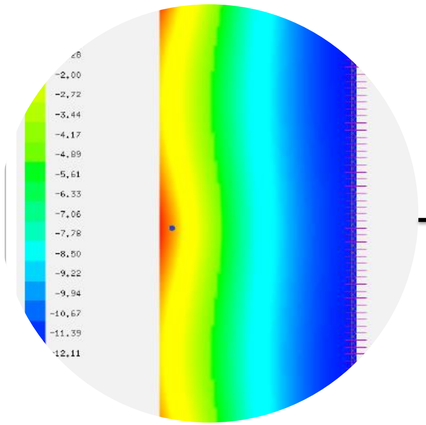

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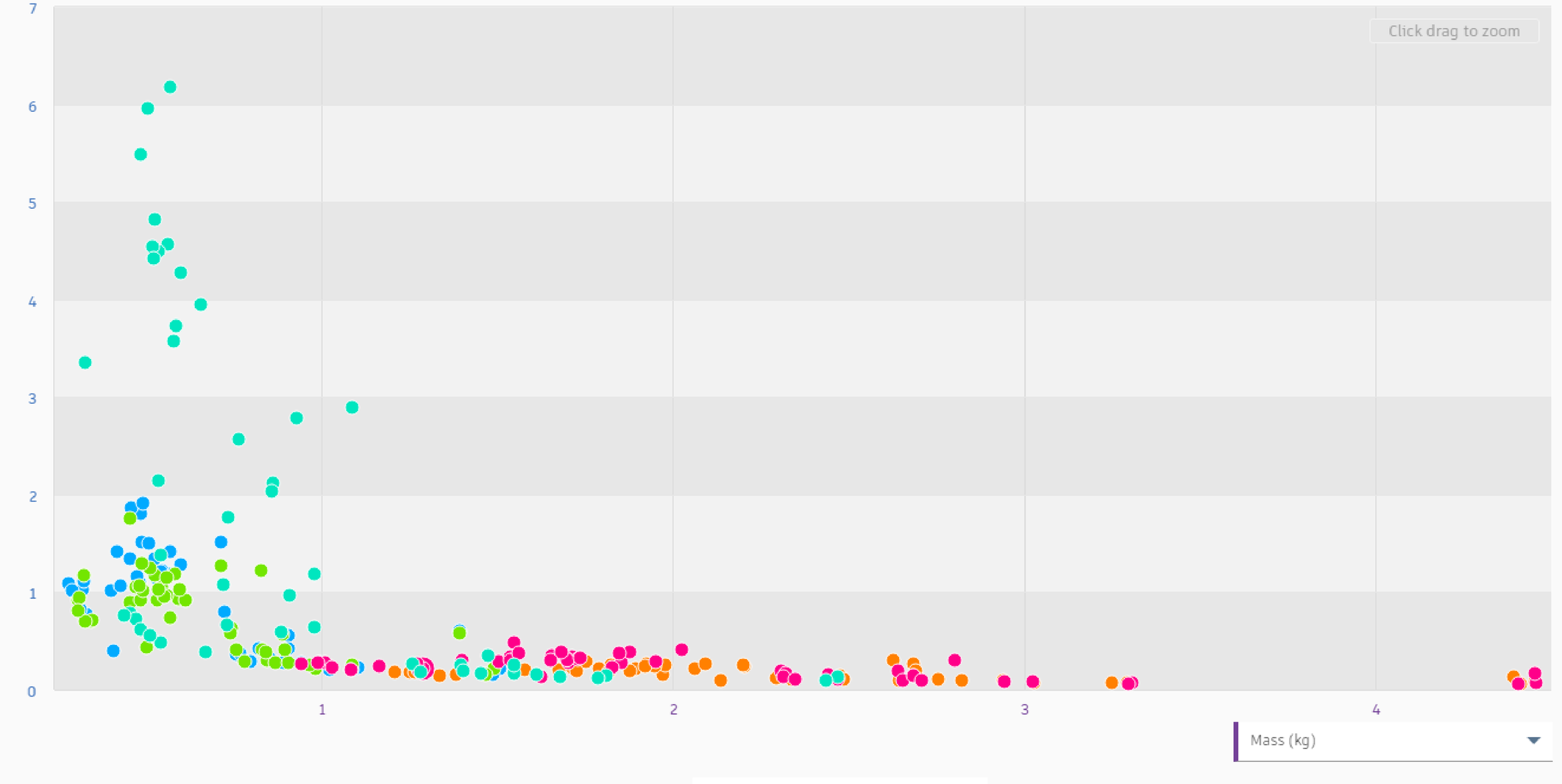
Generative Design Workflow

Design Problem

Generative
Algorithm

Multiple
outcomes



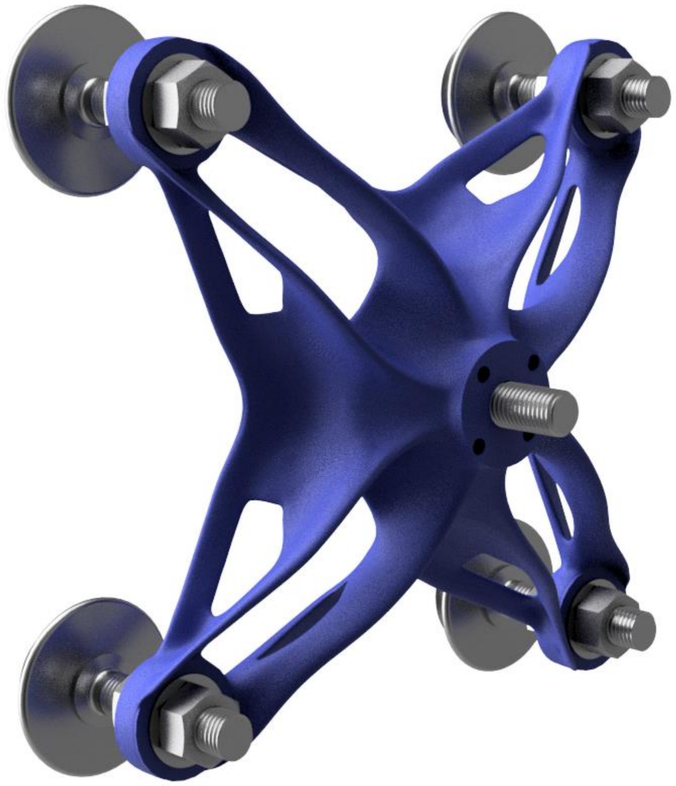
Study 3 - Generative - Outcome 7

Properties

Status	Converged
Material	Stainless Steel AISI 304
Orientation	-
Manufacturing method	Unrestricted
Visual similarity	Ungrouped
Production volume (pcs.)	-
Estimated manufacturing cost	
Range (USD)	-
Median (USD)	-
Volume (mm^3)	1.611e+5
Mass (kg)	**1.289**
Max von Mises stress (MPa)	107.4
Factor of safety limit	2
Min factor of safety	2
Max displacement global (mm)	**0.22**

Compare Outcomes

Once designs have been generated, the human engineer or designer can apply their knowledge and understanding of the design problem at hand, to compare the results against each other.



Download best outcome

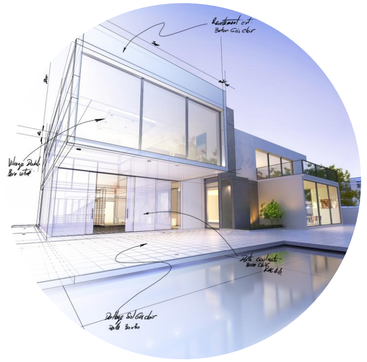
Each of the designs, in fact any iteration of any of the design outcomes, can be downloaded as a ready-to-make CAD model. This model will keep any information, such as material, associated with it; as well as the loading conditions used in the problem setup.


speedMASTER

Why Generative Design?

Traditional Design Approach

Design Problem



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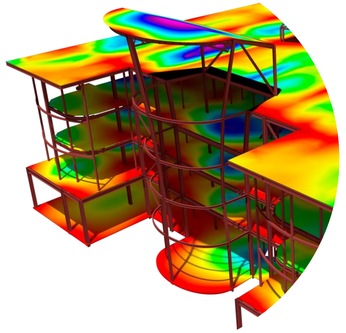
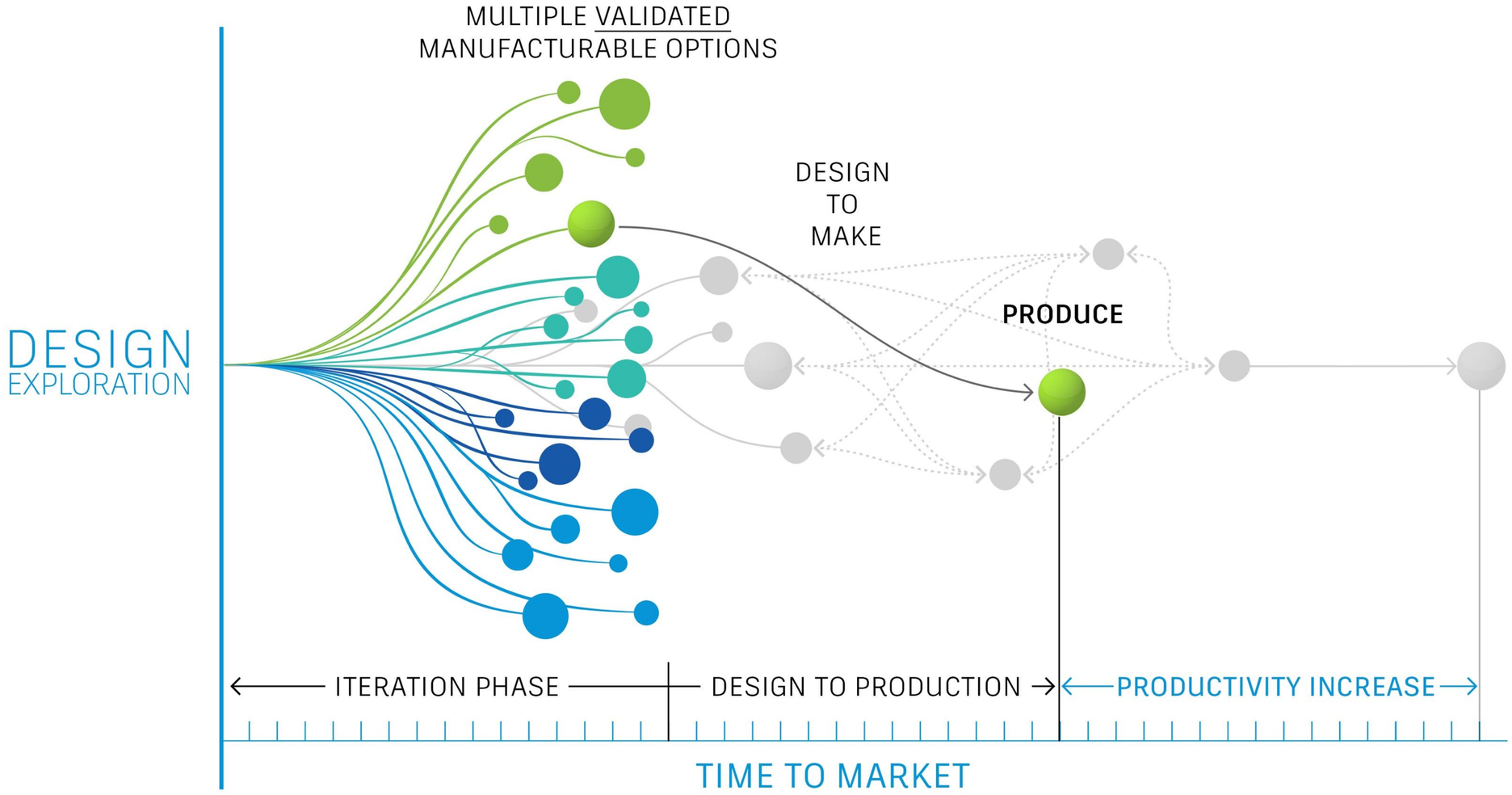


Evaluation

Production Process

Generative Design Approach



Why Generative Design

ITERATE FASTER

By offloading our design process onto the cloud using an intelligent algorithm, we are able to design more effectively and move faster than we could using traditional design processes

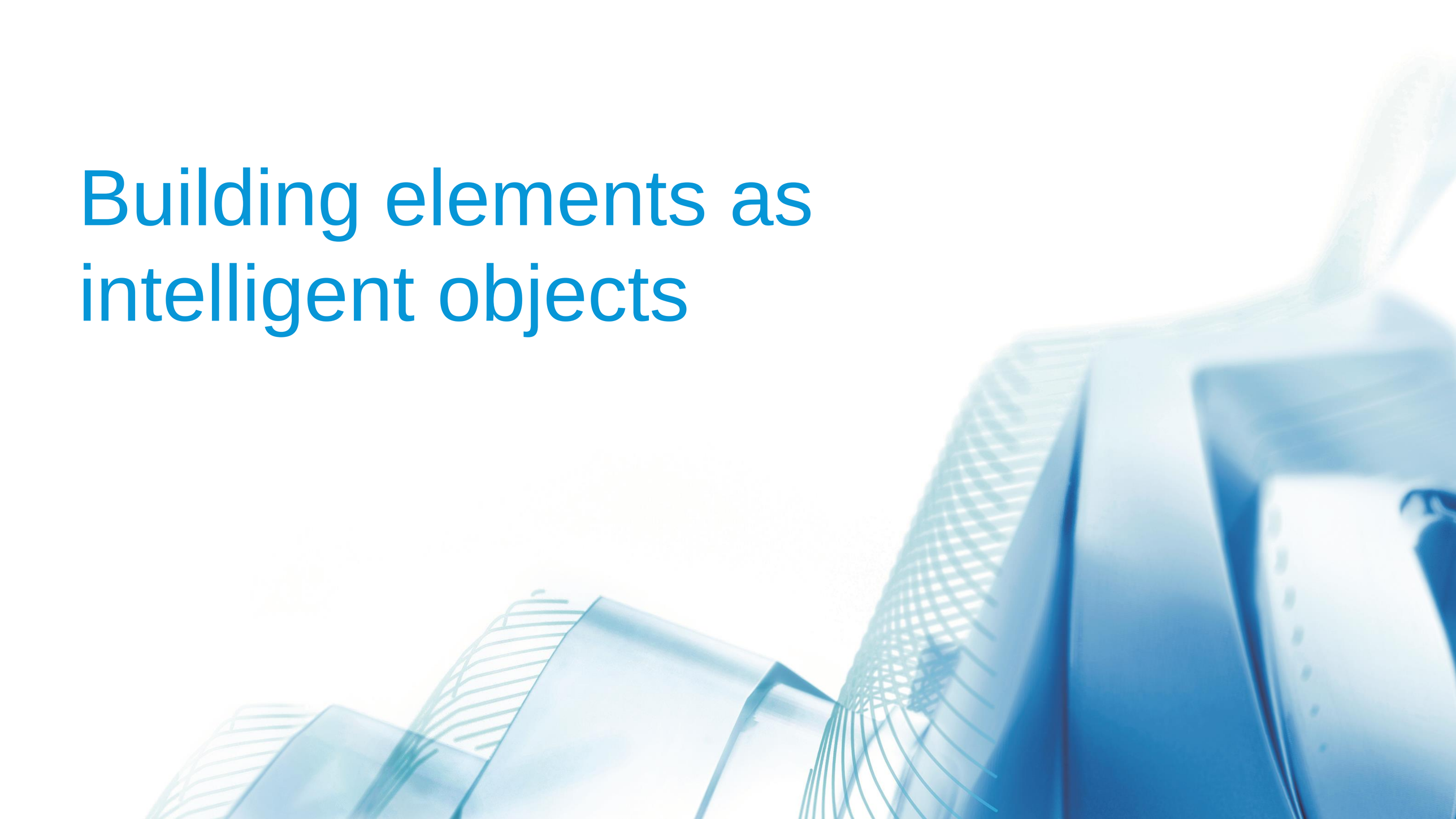
DATA DRIVEN DESIGN PROCESS

Moving more quickly allows us the freedom to design parts during the construction process using onsite data to create customized construction components which are designed with the true to life tolerances taken into account

FOLLOW THE APPROACH OF NATURE

This approach allows us to more closely follow the same design process as we see in nature, where every object is perfectly suited to it’s environment

Building elements as intelligent objects



Inhabitants : Sensors

In the horizon three the goal of this is to create a smart façade, a façade that can talk, that can give us information not only on the building occupancy but on its performance.

Data collected

1

STRUCTURAL DATA

Structural behavior of the generatively design family of spiders

2

INHABITATION

Occupants behavior on the building

3

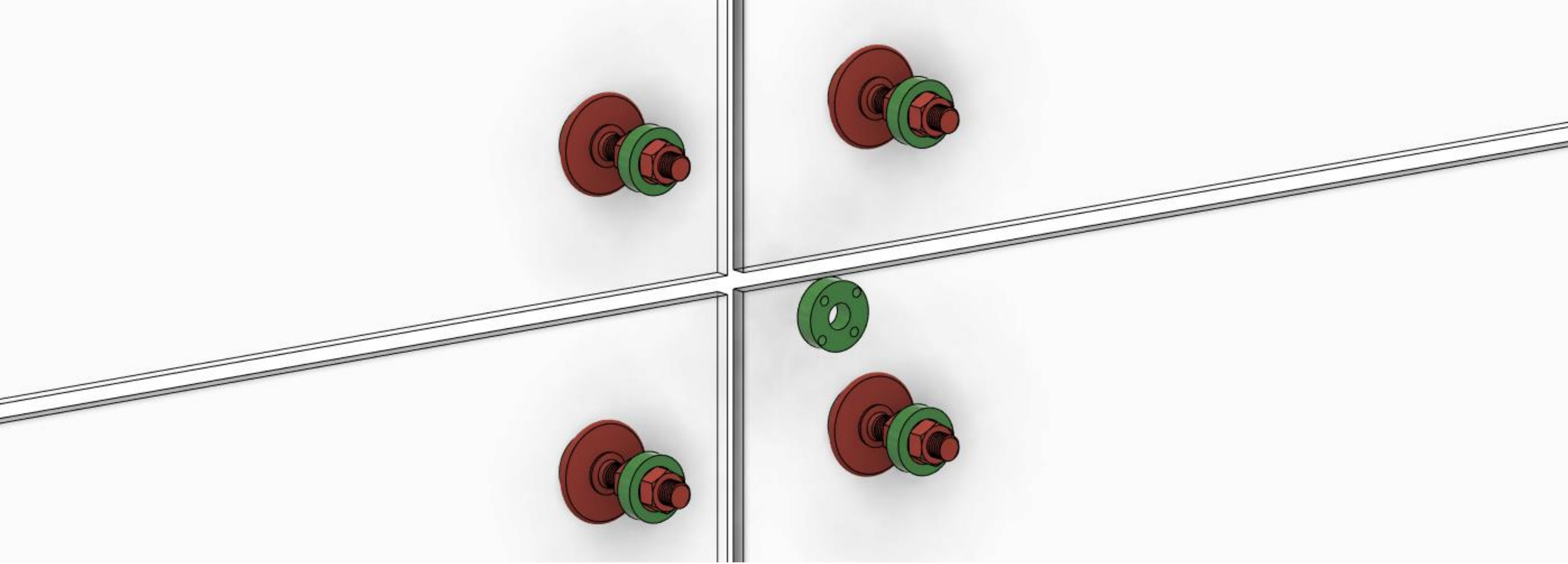
TEMPERATURES

Weather conditions that affect the lifespan of a building.

4

FLEXIBLE DATA CAPTURE

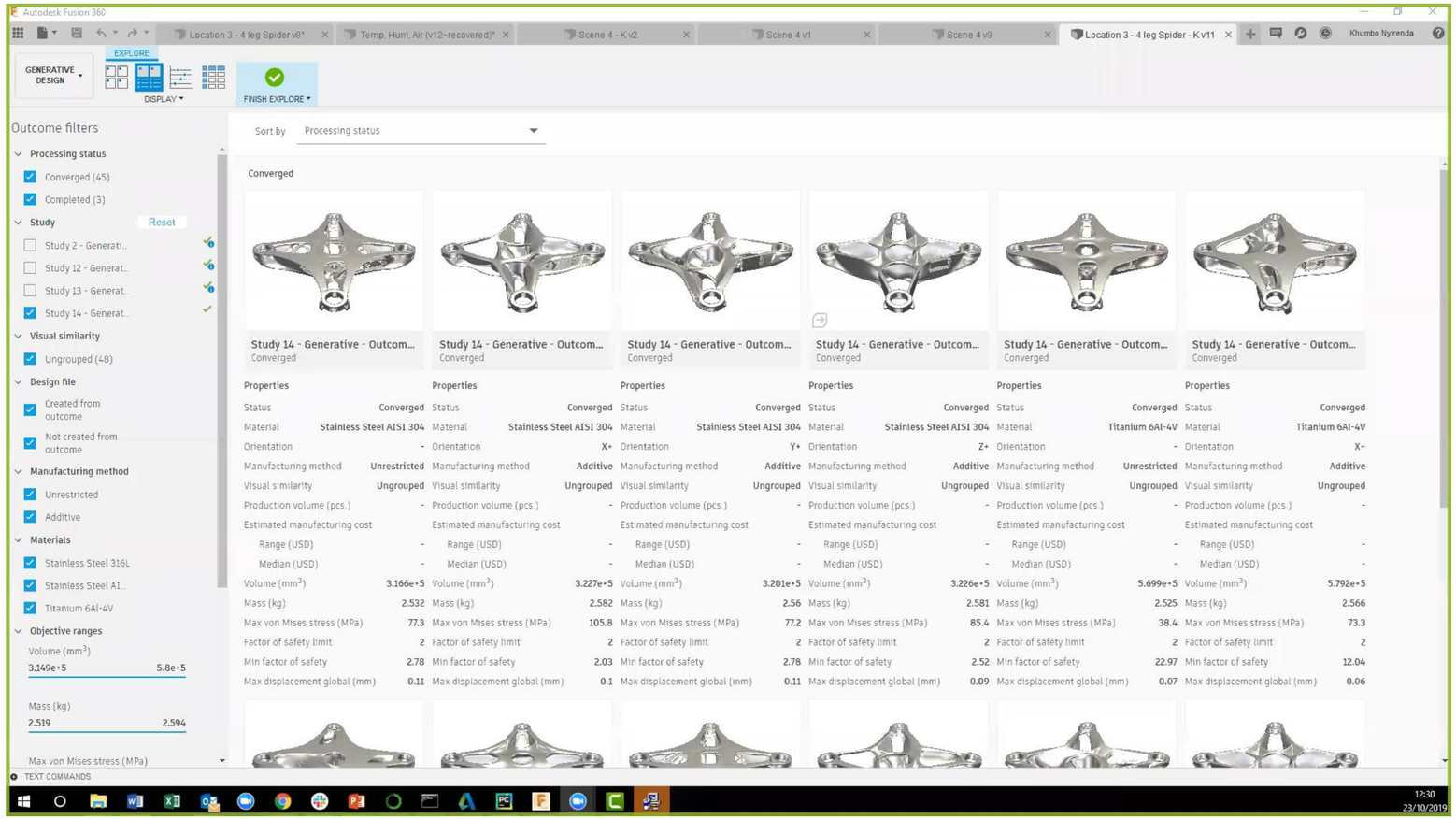
You name it!



Connector obstacles

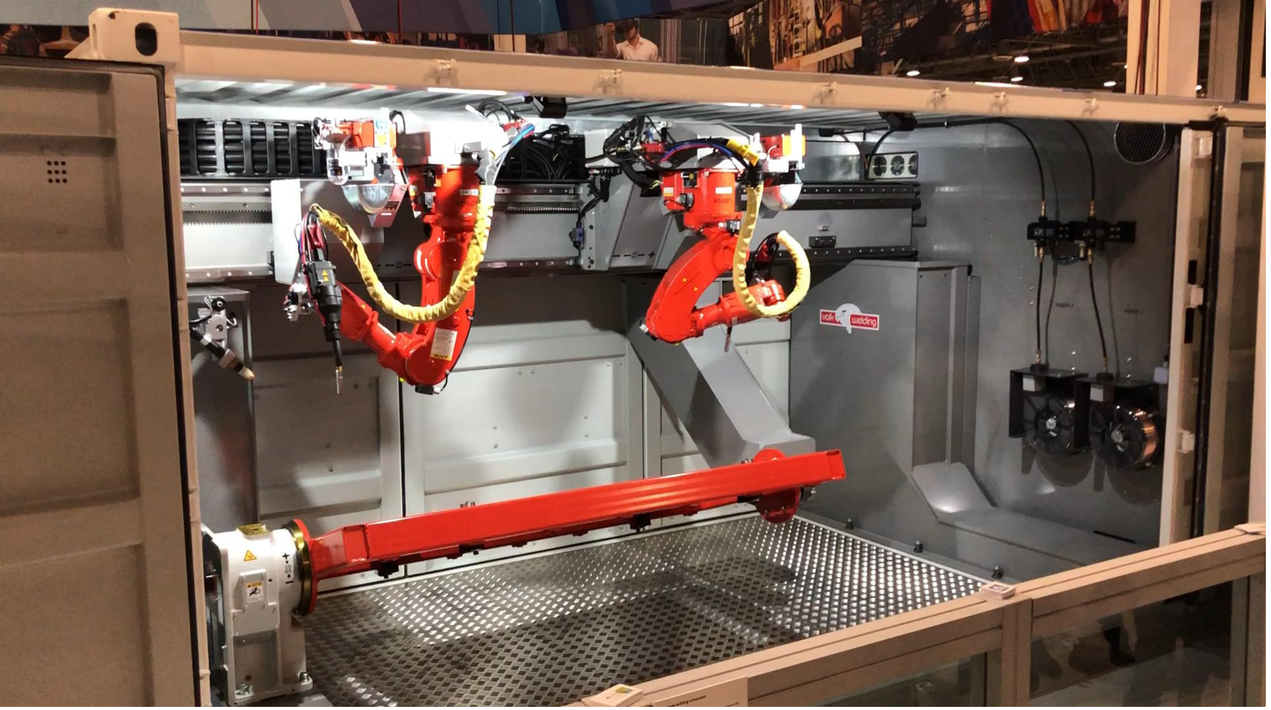
An essential function of the fixture is that it should be easy to take the finished part off, and to install new stock material. The fixture should also be easy to fasten onto the bed of the machine. Obstacle geometry is used, to ensure adequate room is left for bolted fasteners

Ease of altering an existing design



Options get generated according to the input you provide – Data, the rules you set – Constrains and the fitness criteria you prioritize.

The Wrap up



Three Horizon Journey

On Site Manufacturing

Generative Design

Data & Sensors


Internet of Things

Generative Design by Dura Vermeer
The Spider Bracketry

AUTODESK®

Make anything™

Ask anything

AUTODESK®

Make anything™