

Digitale Planung komplexer Fassaden- und Dachkonstruktionen

Dr.-Ing. Alamir Mohsen





Li3

Lithium Architects
GmbH

JUN 2020

Digitale Planung komplexer Fassaden- und
Dachkonstruktionen
“Parametric Planning of Complex Facades and
shell-structures”

Presented by Dr.-Ing. **Alamir Mohsen & Hilmar Wanner**

Introduction

Problem statement - Projects

- Munch Museum, Oslo
- Mainzero, Frankfurt
- Hangar 8, Salzburg



© Bollinger + Grohmann Ingenieure, Frankfurt

Introduction

- Stick system.
 - High technical demands.
- Highly customized.
- Highly engineered.

Munch Museum



Munch Museum, Oslo © Bollinger + Grohmann Ingenieure, Frankfurt

Introduction

- Geometrical challenges.
 - Load cases challenges.
- Customized solution.

Munch Museum



Munch Museum, Oslo © Bollinger + Grohmann Ingenieure, Frankfurt

Introduction

- Unitized system.
 - High technical demands.
- Highly customized.
- Highly engineered.

Mainzero



Mainzero, Frankfurt © Bollinger + Grohmann Ingenieure, Frankfurt

Introduction

- Design challenge.
 - Assembly challenge.
- Customized solution.

Mainzero



Mainzero, Frankfurt © Bollinger + Grohmann Ingenieure, Frankfurt

Introduction

- Dome structure.
 - High geometrical demands.
- Highly customized.
- Highly engineered.

Hangar 8



Hangar 8, Salzburg © Bollinger + Grohmann Ingenieure, Frankfurt

Introduction

- Geometrical challenge.
- Manufacturing challenge.

- Customized solution.
- Intense amount of labor in planning and realization.

Hangar 8



Hangar 8, Salzburg © Bollinger + Grohmann Ingenieure, Frankfurt

Li3 Vision

- Crystalized Architecture.
- Utilization of Standard Façade Systems.
- Expanding Architects' vision.
- More Transparency.
- Economical unique solutions.
- 3D printed Façade Node "N-AM_Li3".

Application in Architecture



Li3 Vision

- Crystalized Architecture.
- Utilization of Standard Façade Systems.
- Expanding Architects' vision.
- More Transparency.
- Economical unique solutions.
- 3D printed Façade Node "N-AM_Li3".

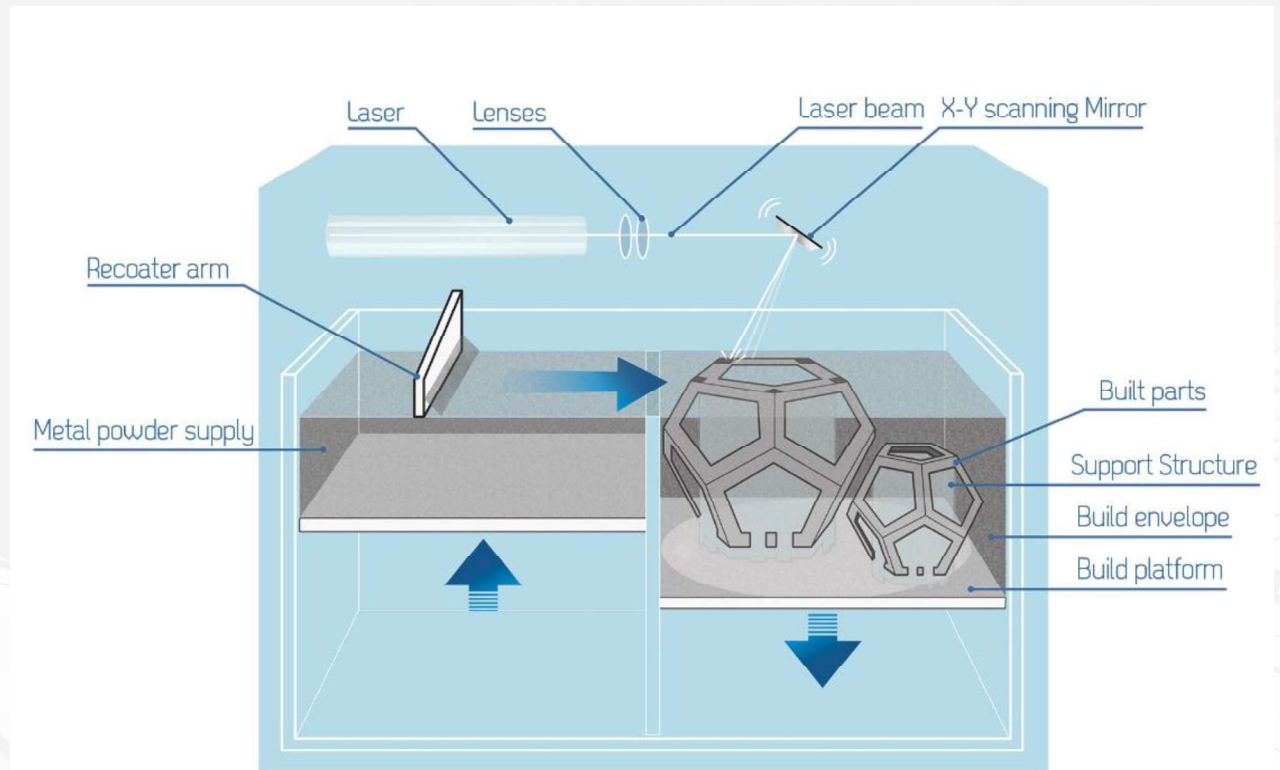
Application in Architecture



State of the Art

- Additive Manufacturing of Metals (SLM).
- Direct Modelling vs. Parametric Modelling.

Additive Manufacturing of Metals

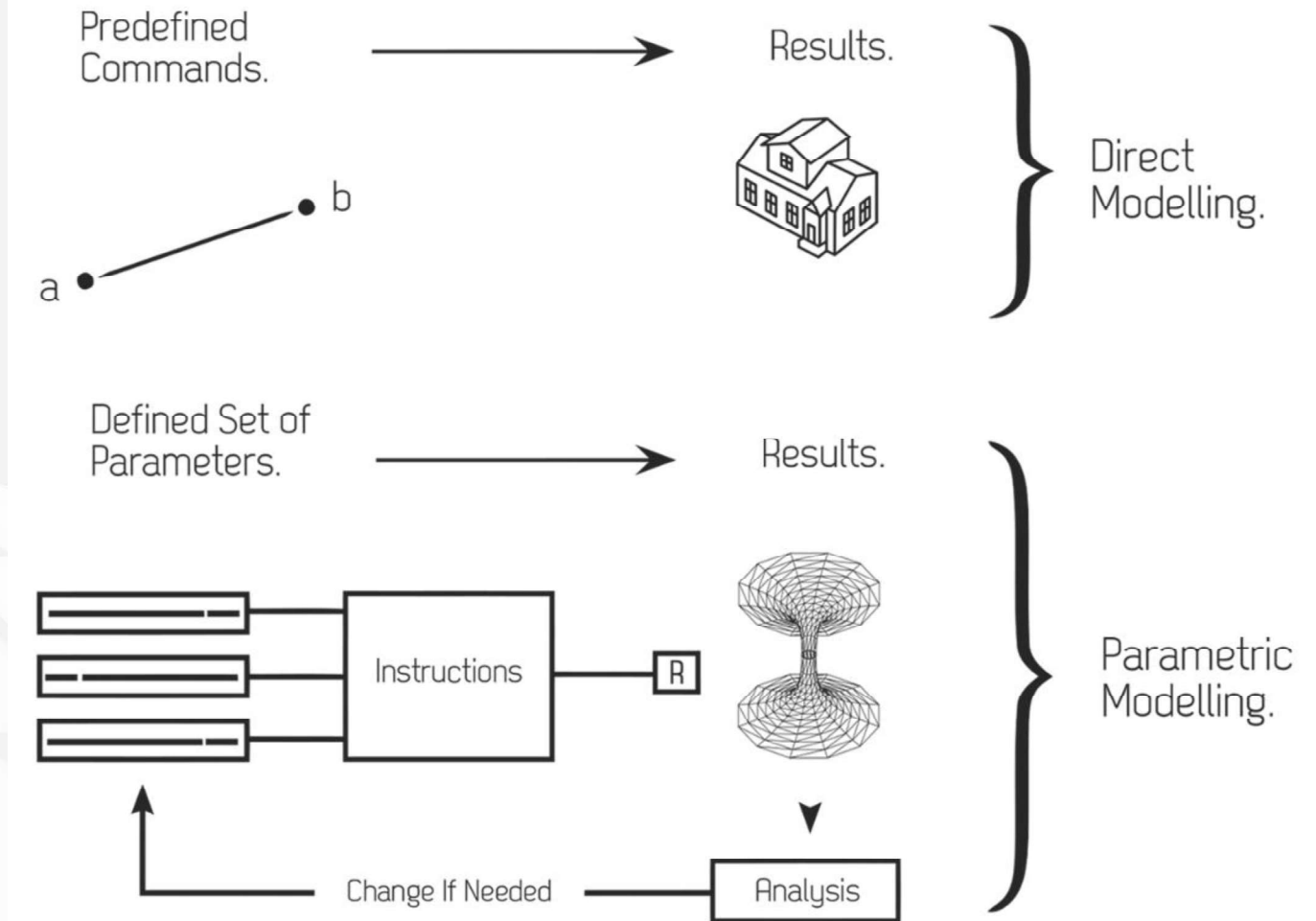


Selective Laser Melting (SLM).

State of the Art

- Additive Manufacturing of Metals (SLM).
- Direct Modelling vs. Parametric Modelling.

Direct- vs. Parametric-Modelling



Proof of Concept

- **Li3_Method:**

- > Digital Planning concept.
- > Manufacturing Planning concept.
- > N-AM_Li3

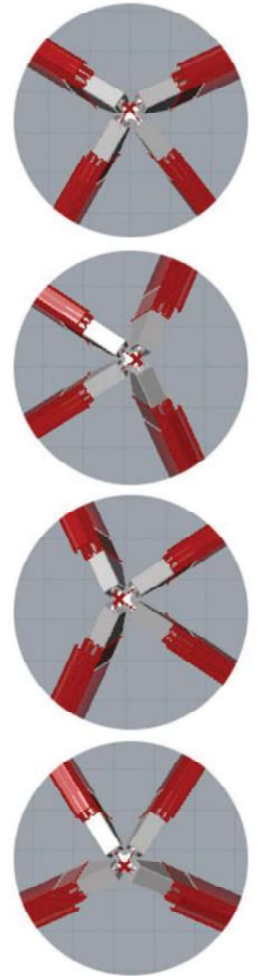
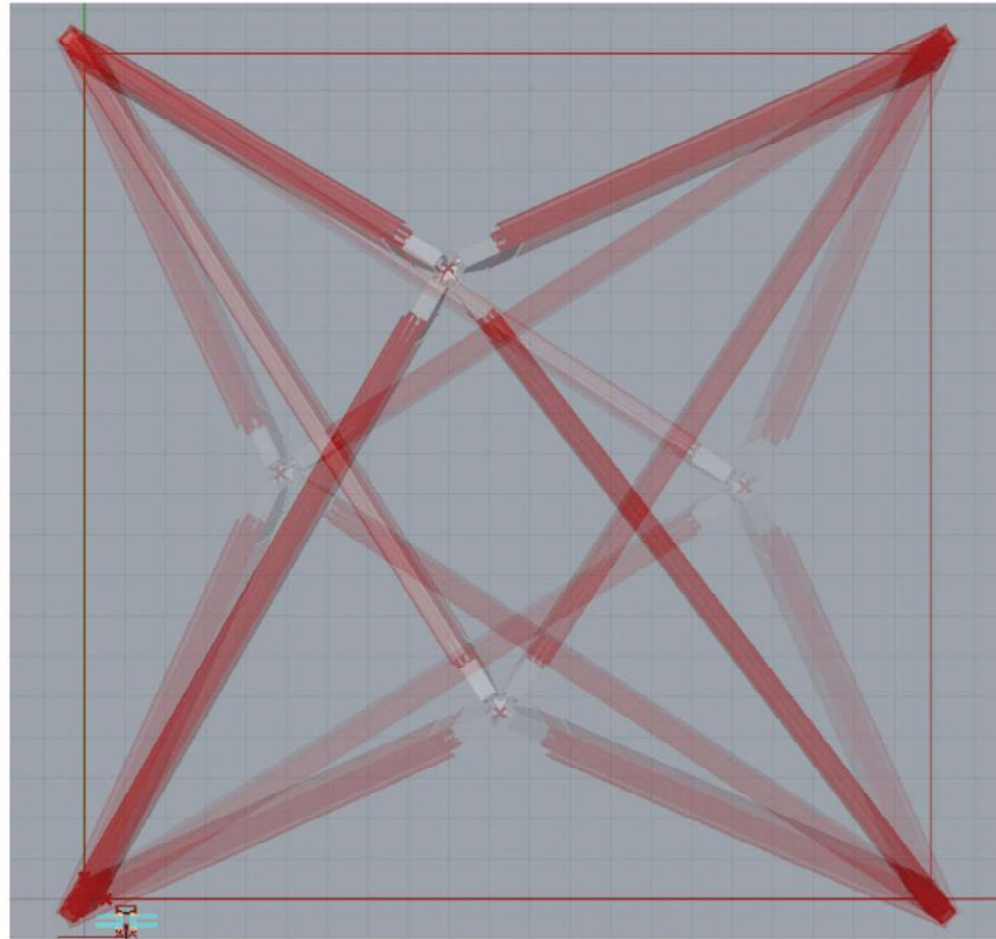
Digital Planning concept

- N-AM 1st Generation
- N-AM 2nd Generation
- Voronoi Facade
- Paneling Free-form
- Voronoi Shell Structure

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

N-AM 1st generation



Design scenarios of N-AM 04.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

N-AM 2nd generation

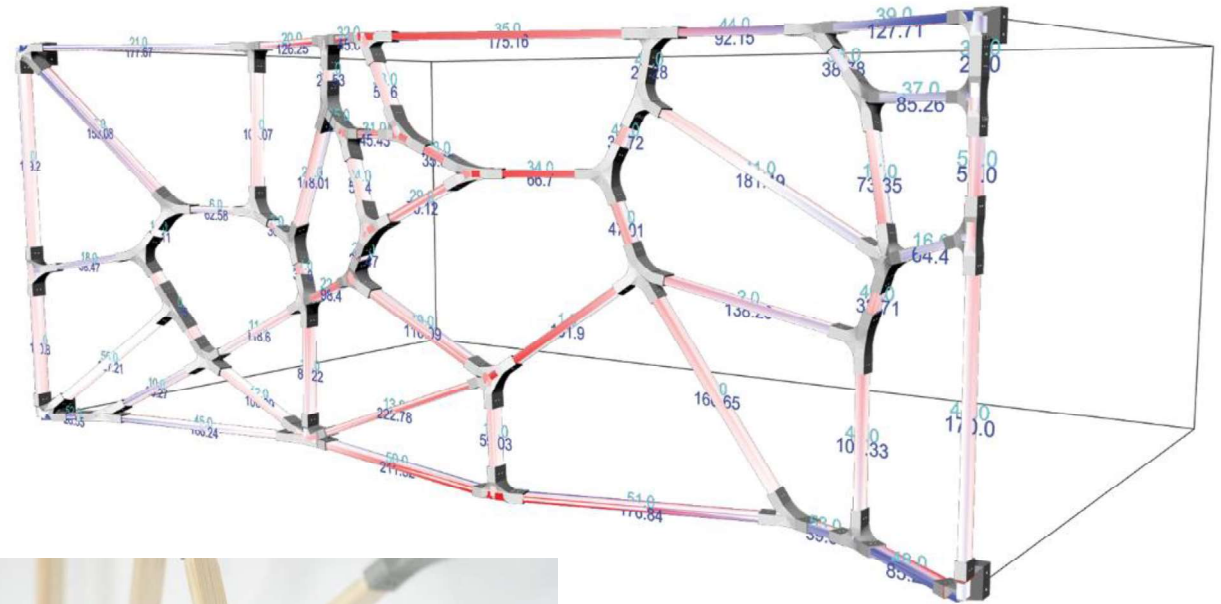


N-AM 10 - Topology optimized Steel Node.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Voronoi Facade



Structural Model of Voronoi Facade

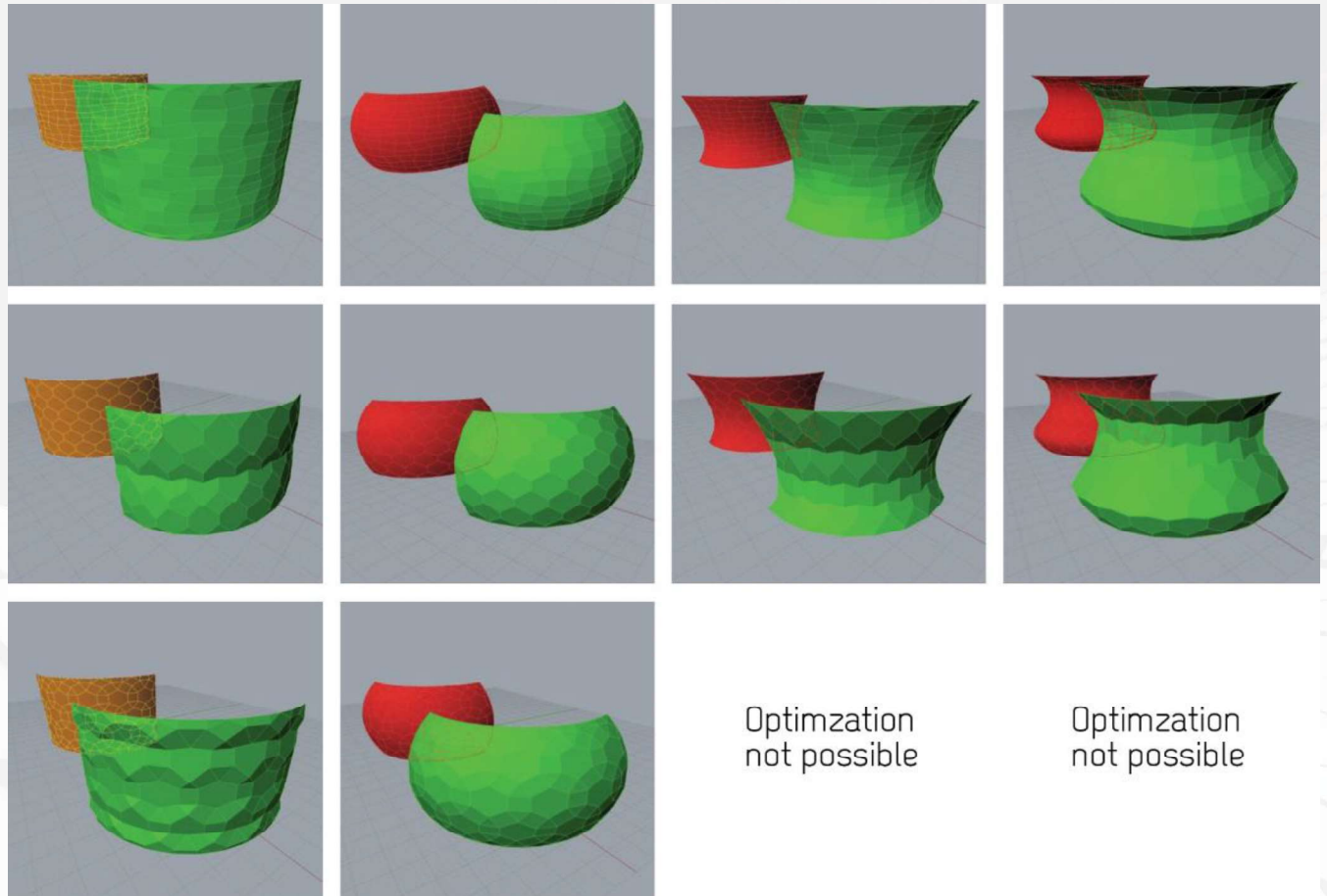


Zoom-In of the 1:20 model. The model is made of wooden sticks and 3D-printed FDM plastic nodes.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Paneling Free-Form

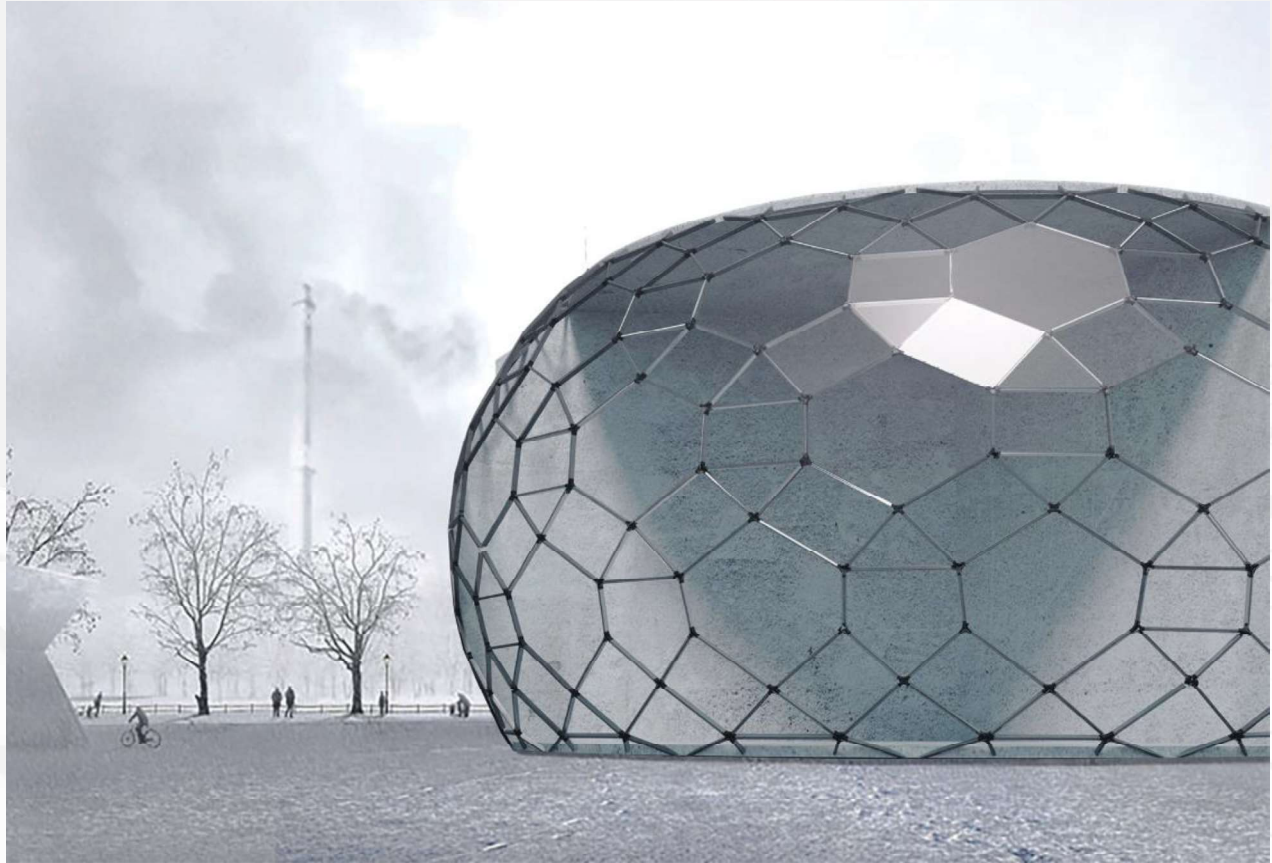


Form finding of planar glass surfaces out of Free-Form surface.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Paneling Free-Form

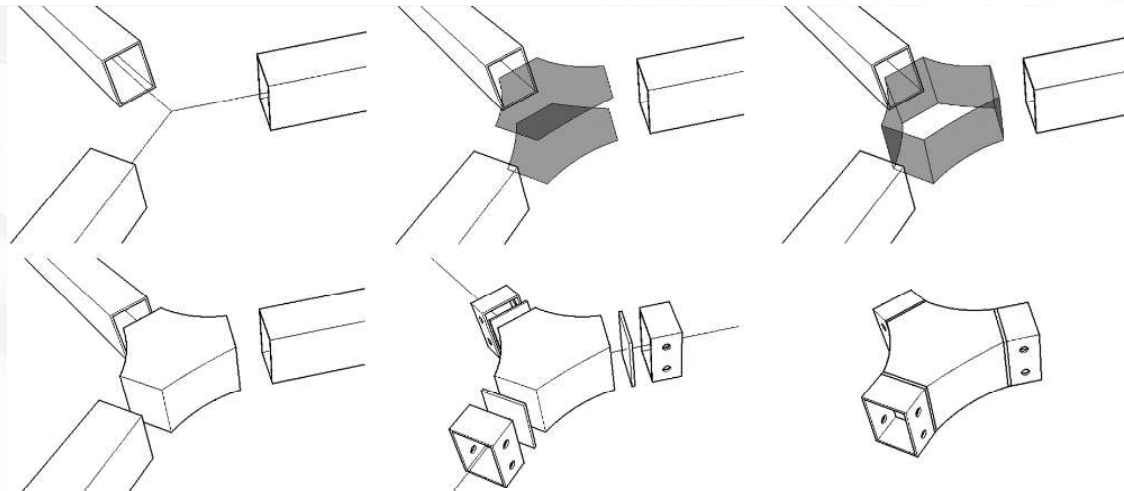
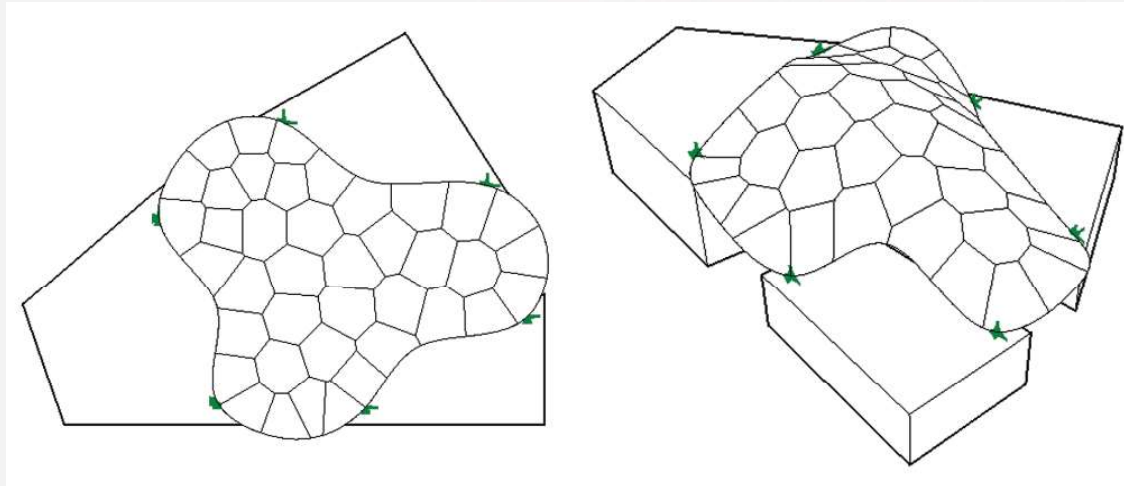


Visualization of an optimized Dome that is made of planar glass surfaces, straight profiles and 3D-printed nodes.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

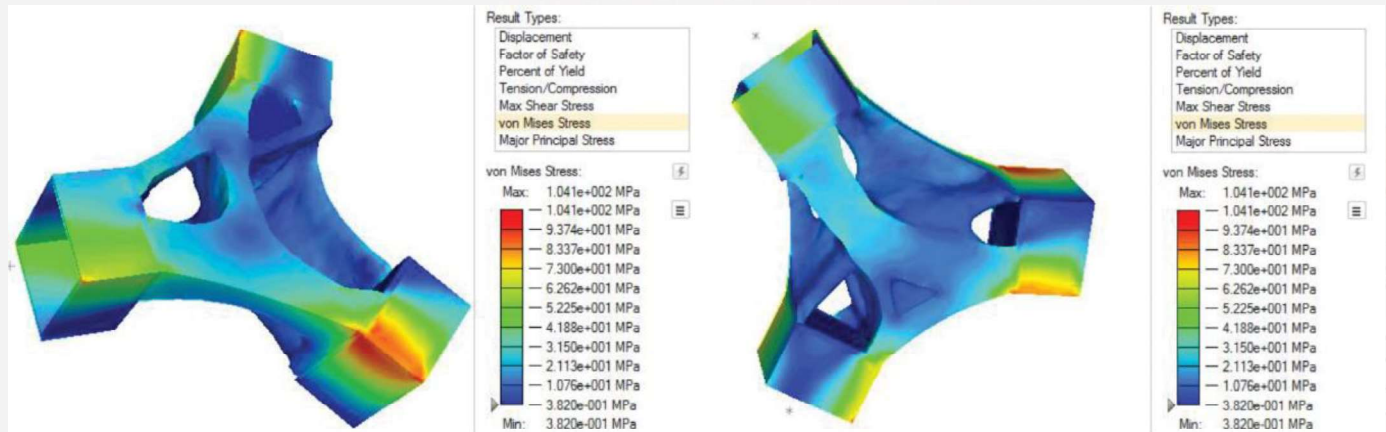
Voronoi Shell Structure



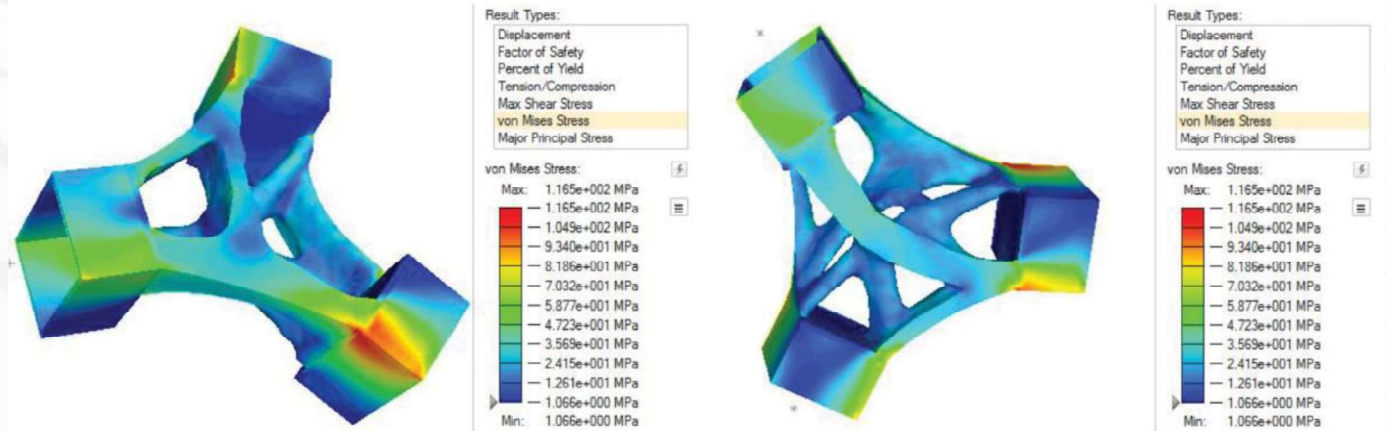
Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Voronoi Shell Structure



Topology optimization of a Welded connection at 30% Mass target.



Topology optimization of a Welded connection at 20% Mass target.

Proof of Concept

- **Li3_Method:**
 - > Digital Planning concept.
 - > Manufacturing Planning concept.
 - > N-AM_Li3.

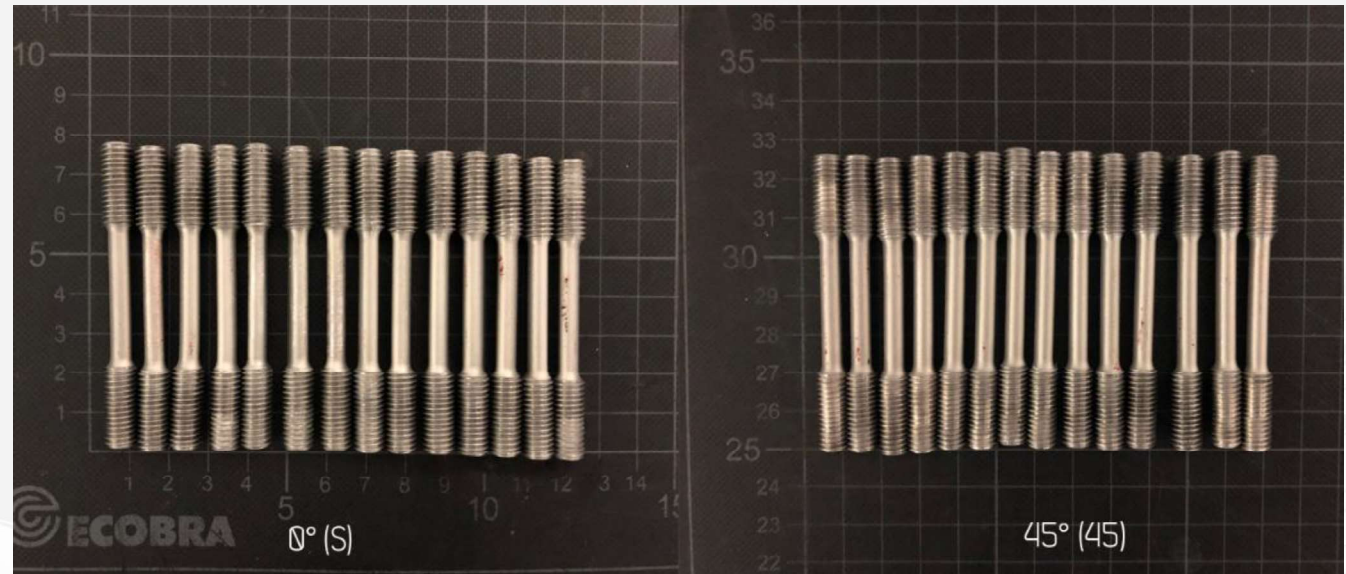
Manufacturing Planning Concept

- Tensile Tests
- Validation Tests

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Tensile Tests



Tensile specimens and breaking pattern of AlSi10Mg

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Validation Tests



Validation Tests of X-form specimens made of Stainless-steel 316L

Proof of Concept

- Li3_Method:

- > Digital Planning concept.
- > Manufacturing Planning concept.
- > N-AM_Li3.

N-AM_Li3

- Façade Element Design.
- Structural Analysis.
- Connection design.
- Topology optimization.
- Building Component test.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Façade Element Design

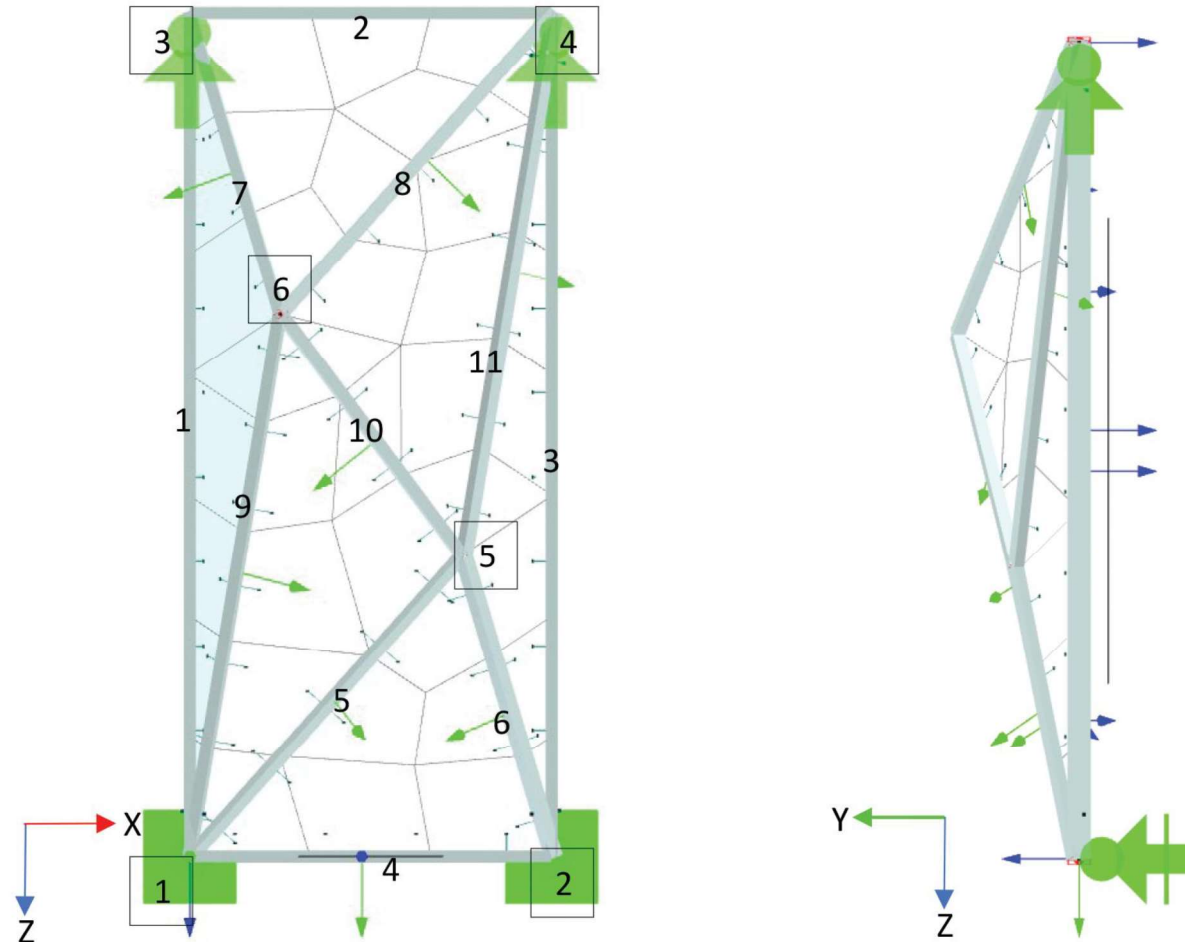


Conception of 1:1 Mockup (1,5*3,0 m Façade element)

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Structural Analysis

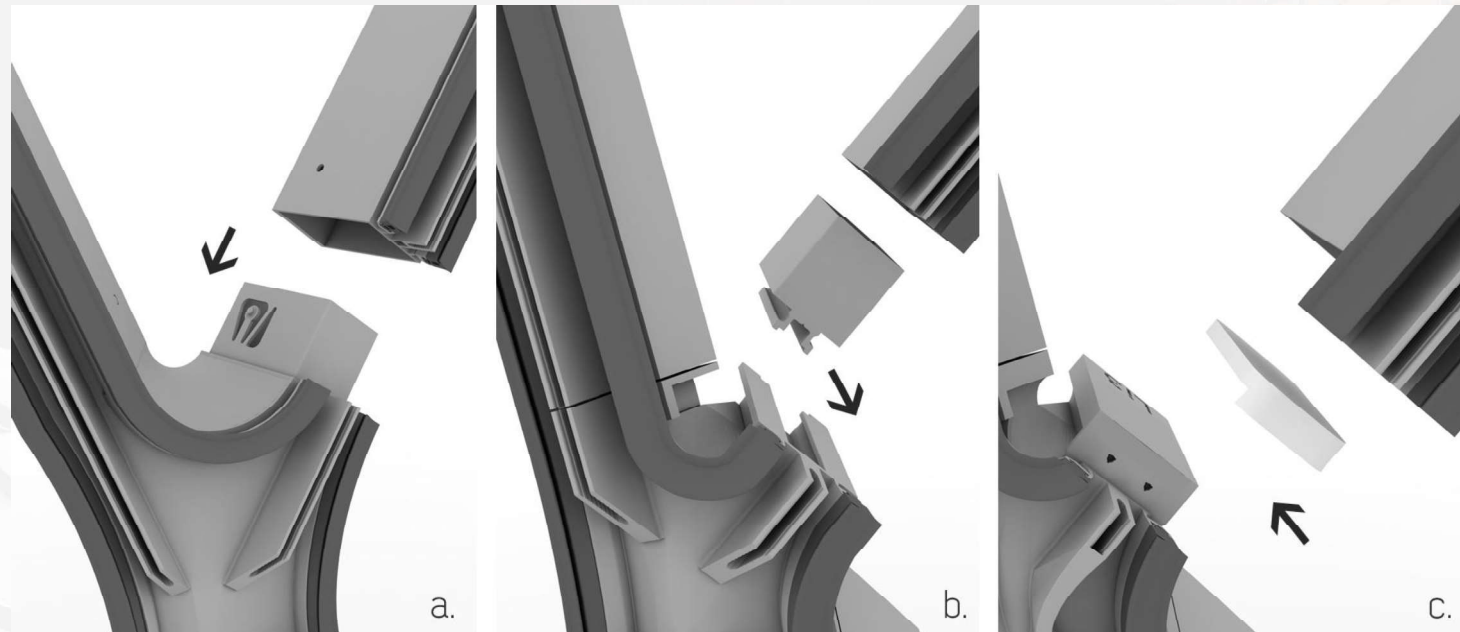


Load cases analysis and support definition of the façade element. 26

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Connection Design

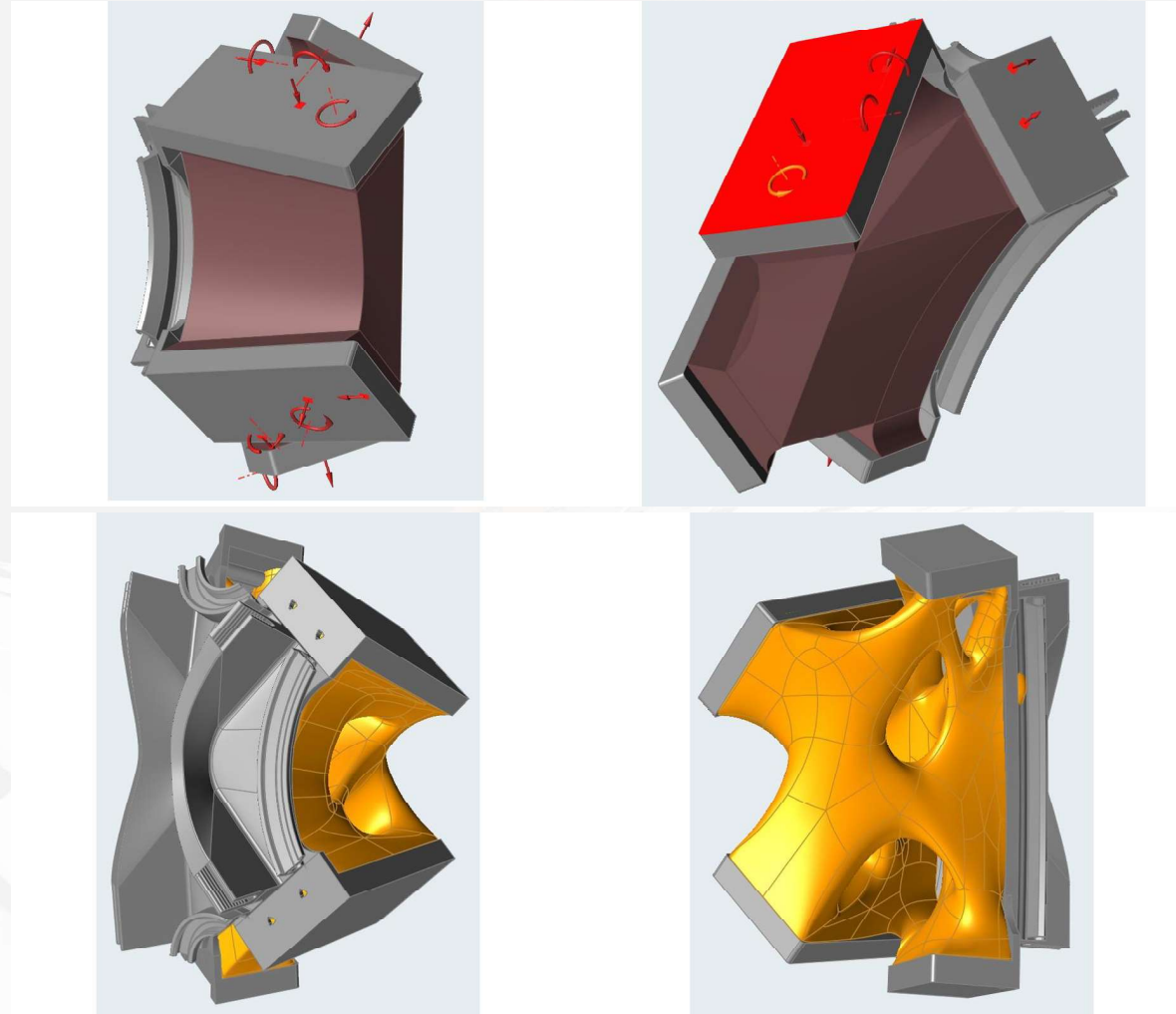


Investigating possible ways of connecting.

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

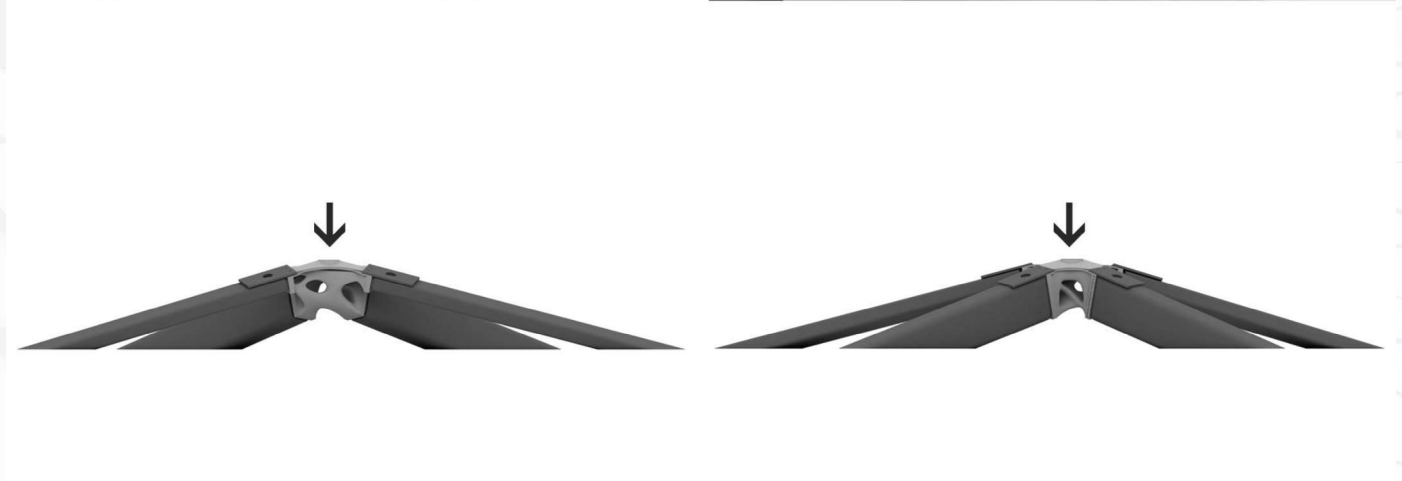
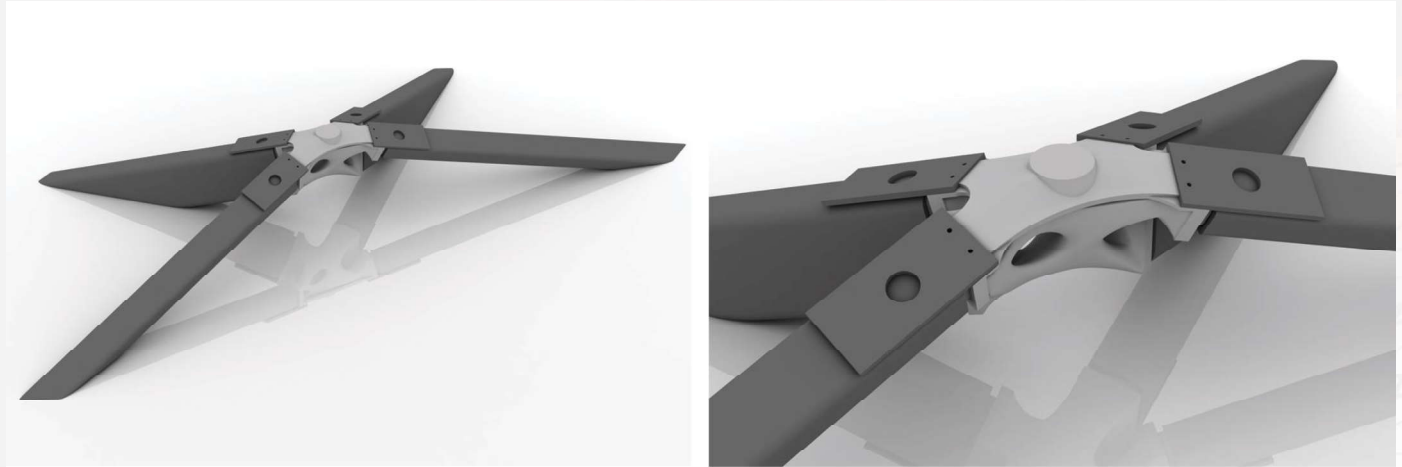
Topology Optimization



Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Building Component Test

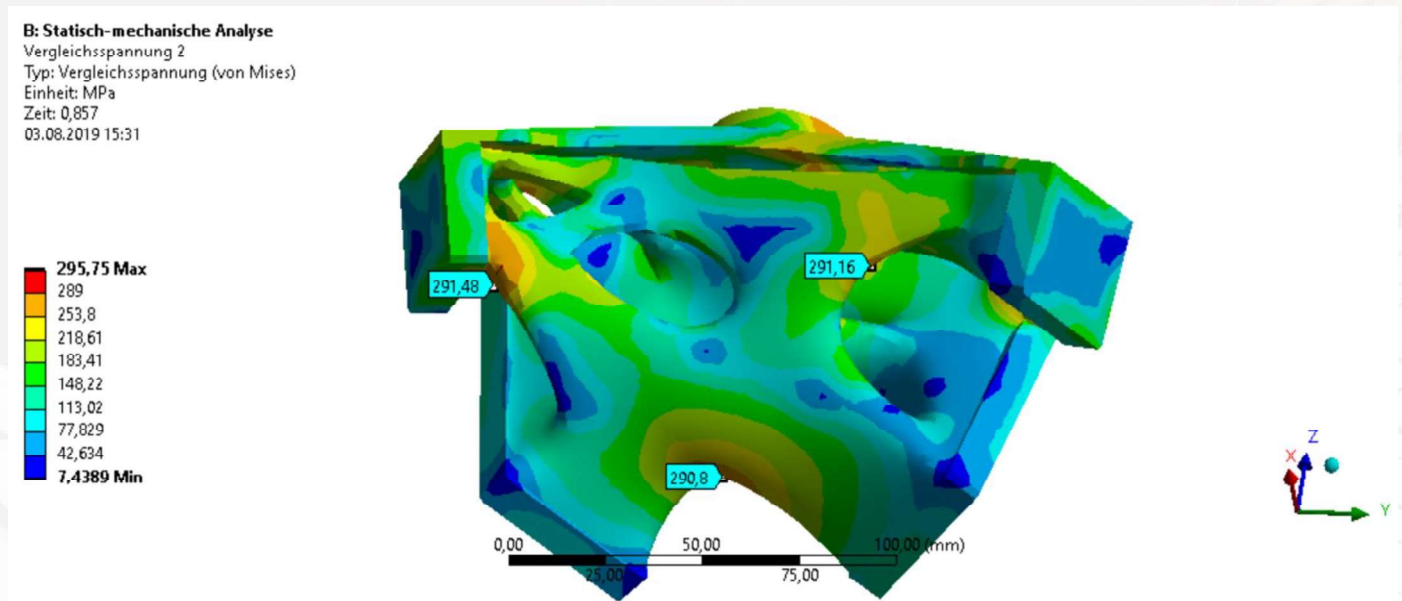


Conception of Building Component Test

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Building Component Test

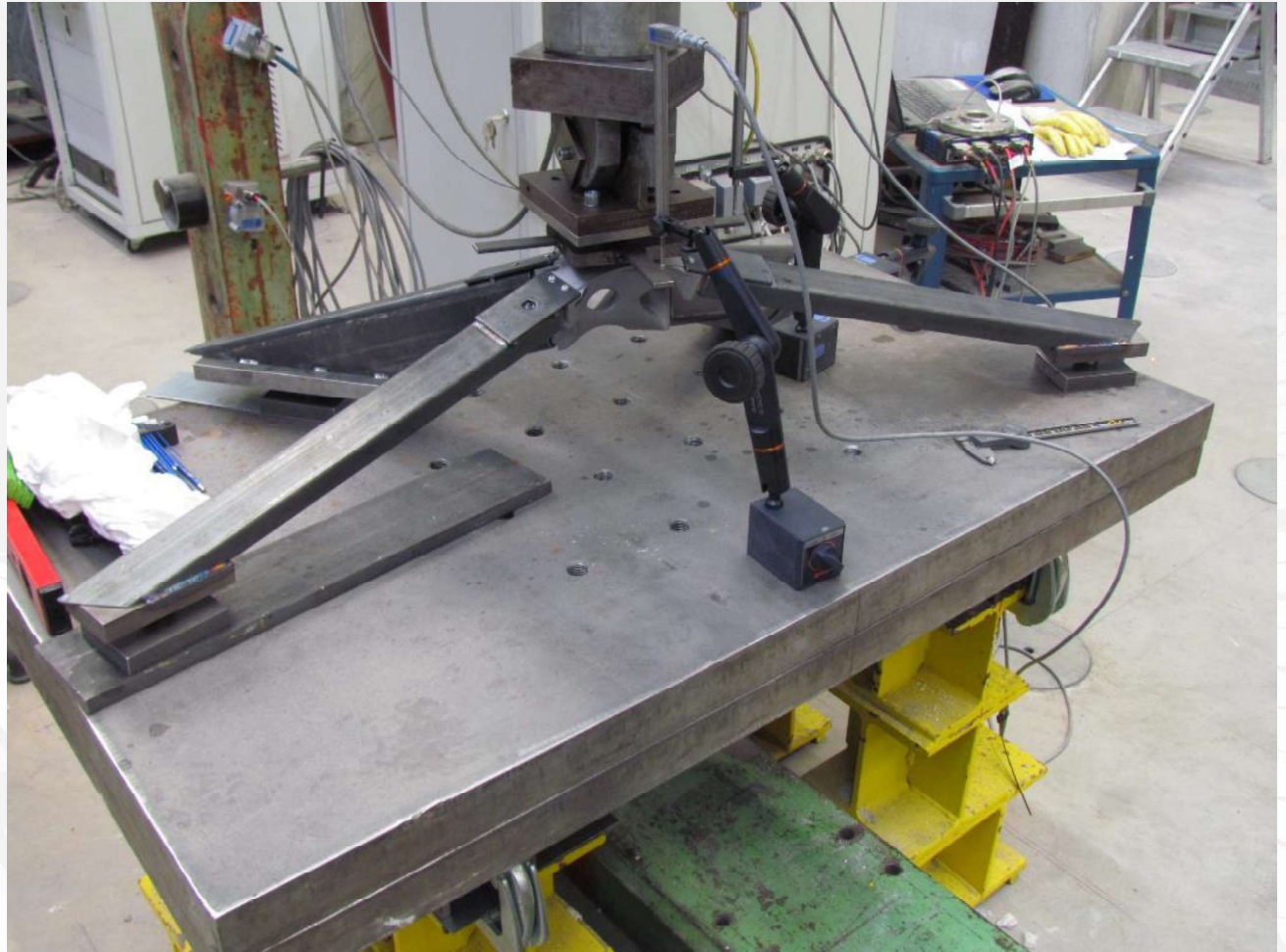


Simulative evaluation for the node structural behavior

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Building Component Test



Building component test physical construction

Li3-Method

- Global Geometric/Structural Phase.
- Local Geometric/Structural Phase.
- Validation of Manufacturing Phase.
- Façade erection Phase.

Building Component Test



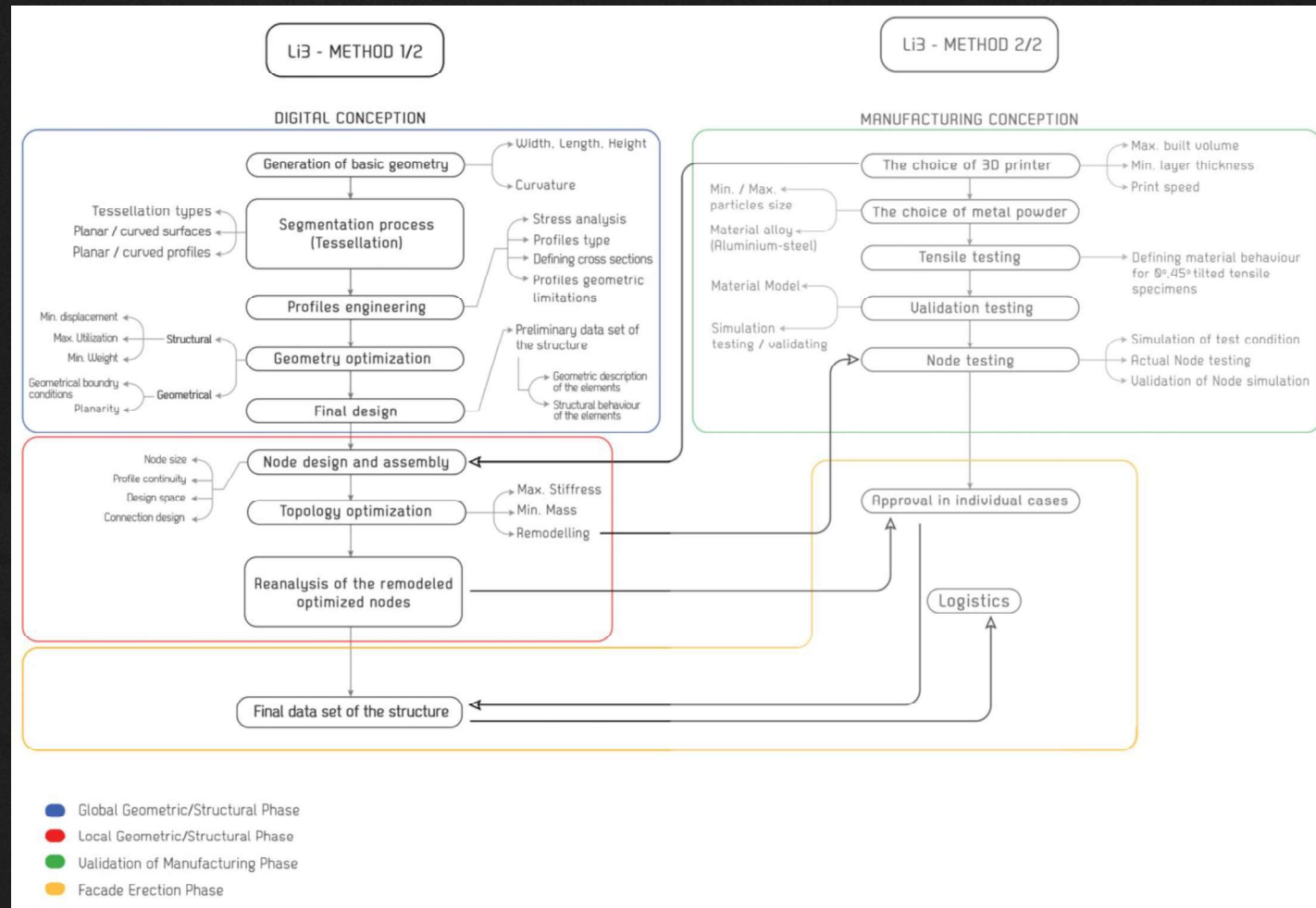
Building component test physical construction

Proof of Concept

- Li3_Method:

- > Digital Planning concept.
- > Manufacturing Planning concept.
- > N-AM_Li3.

Li3_Method



HivE

- First Free-Form façade in the world to be constructed out of standard façade systems and 3D Printed Façade node N-AM_Li3.
- N-AM_Li3 will be the first worldwide 3D printed façade node that is certified to be used in Building industry for the German market.
- Project completion is June 2021.

© Lithium Architects GmbH

HivE



Day time visualization of HivE

HivE

- First Free-Form façade in the world to be constructed out of standard façade systems and 3D Printed Façade node N-AM_Li3.
- N-AM_Li3 will be the first worldwide 3D printed façade node that is certified to be used in Building industry for the German market.
- Project completion is June 2021.

© Lithium Architects GmbH

HivE



Night time visualization of HivE

Cooperation

- About H+B Hightech GmbH.
- Technical Engineering.
- Additive Manufacturing.
- Quality Assurance.

H+B Hightech GmbH



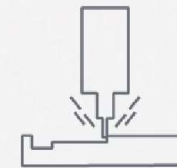
Cooperation

- High quality automotive supplier.
- Established in 2014.
- 100 Employees.
- 6.000 m² Production floor space.
- 2019 annual revenue of 38 Mio. €.

About H+B Hightech GmbH



**TECHNICAL
ENGINEERING**



**MACHINING
PRODUCTION**



**ADDITIVE
MANUFACTURING**



**AUTOMATION
ENGINEERING**



**QUALITY
ASSURANCE**



**MATERIALS
KNOW-HOW**

Cooperation

- Engineering support and consultation for manufacturability evaluation and production-ready design.
- Research, technical development, design and manufacturing.

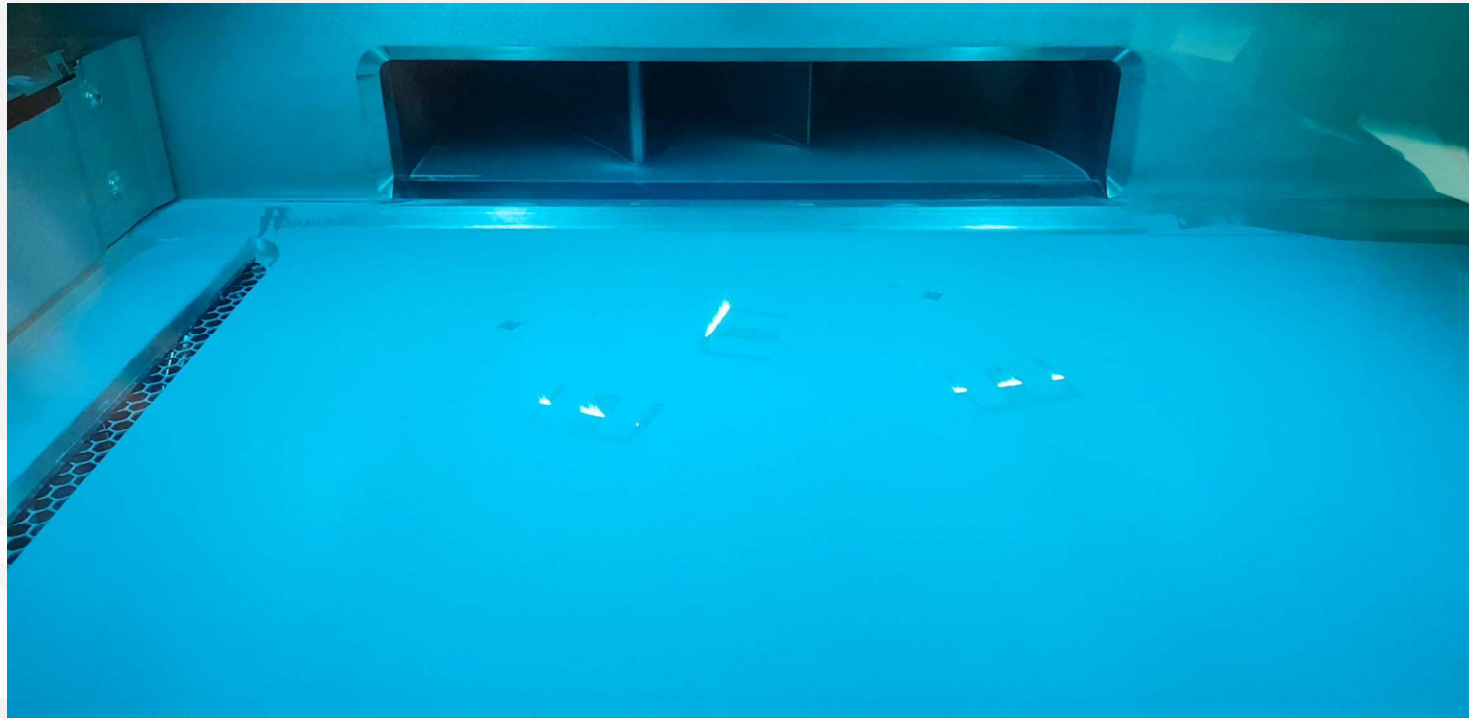
Technical Engineering



Cooperation

- In-house production of N-AM_Li3 with highly productive, partially automated Truprint 5000 3D printing system by Trumpf.

Technical Engineering

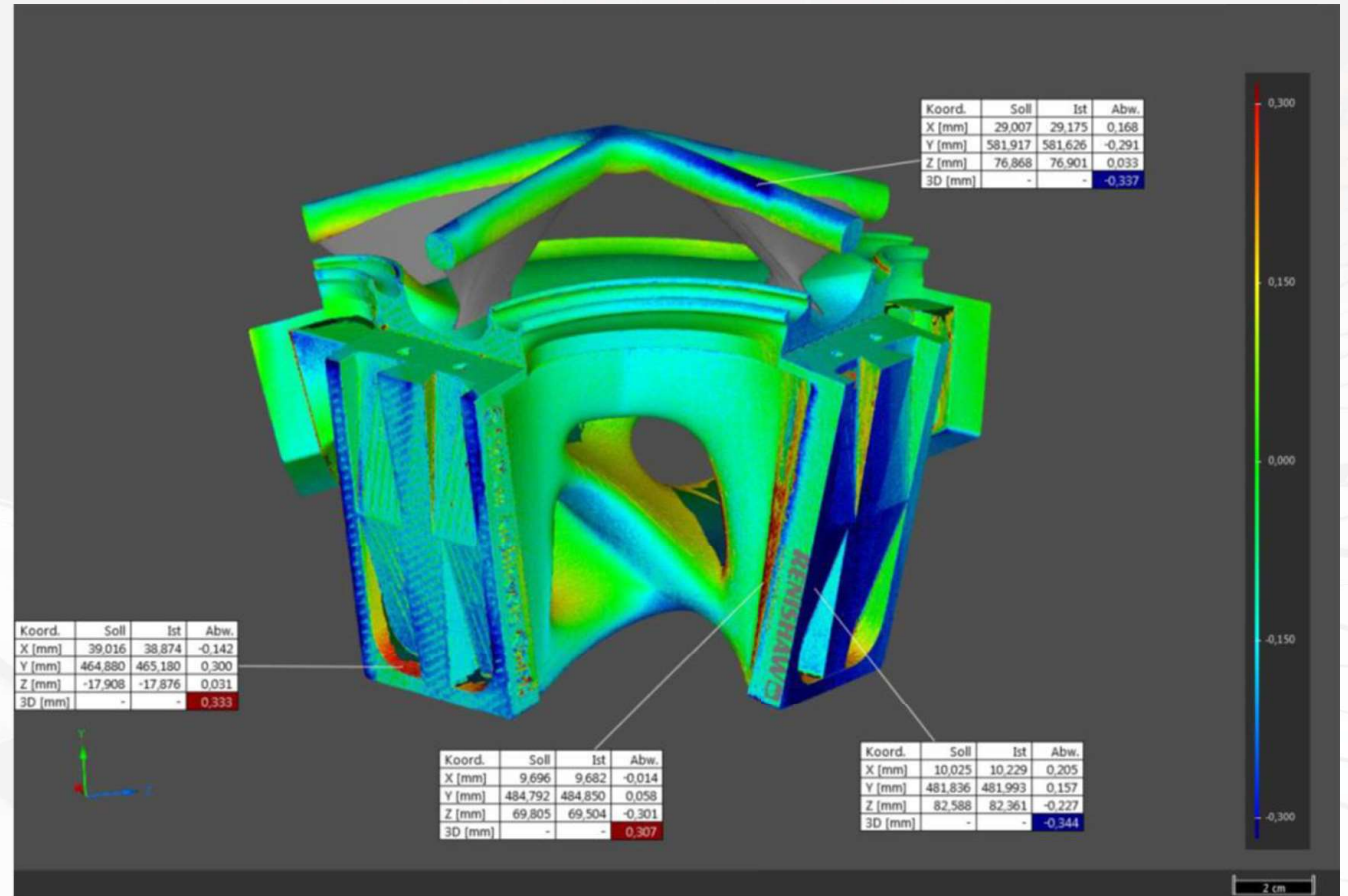


Cooperation

- Operation and process data transfer and management.
- In-House lab with the latest measuring and testing technologies.
- Certificates:

DIN EN ISO 9001:2015
IATF 16949:2016
DIN ISO 14001:2015
DIN EN ISO 50001:2011

Technical Engineering



Follow Us!

- www.li3architects.com
- <https://www.hb-hightech.de/>
- LinkedIn: @Lithium Architects GmbH
- FB: @Lithium Architects GmbH
- Instagram: @li3architects
- Youtube: @Lithium Architects GmbH

Stay Tuned!
Thanks for being here.

Live & Online.

Aktuelles Bauwissen aus erster Hand.