



# Physics-Driven Engineering Design

*with ToffeeX*

*RICOH "Beyond Print" Event*

29 February 2024



**Antonio Di Caterino**

*Customer Success Lead*



# Agenda

- Introduction
- Topology Optimization and Generative Design
- ToffeeX: Physics-Driven Generative Design
- Applications Examples
- Q&A Session



# Company Overview



## About Us

- London-based CAE software start-up founded in 2020

## What we do

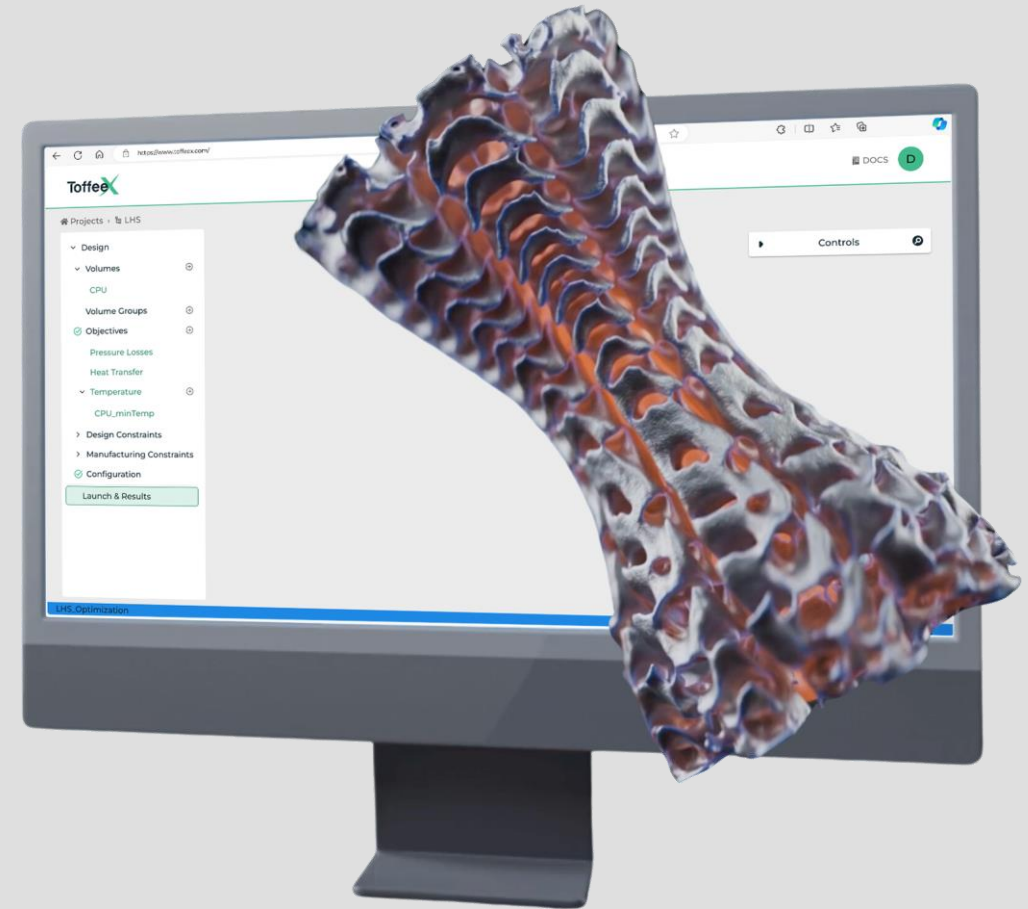
- Physics-Driven Generative Design Software
- Leveraging high-fidelity physics simulations to empower engineers, designers, and analysts

## How we do it

- Cloud-native software service

## Who we are

- A unique blend of mathematicians, engineers, and software developers driven by a passion for innovation



# Engineering Design Pain Points



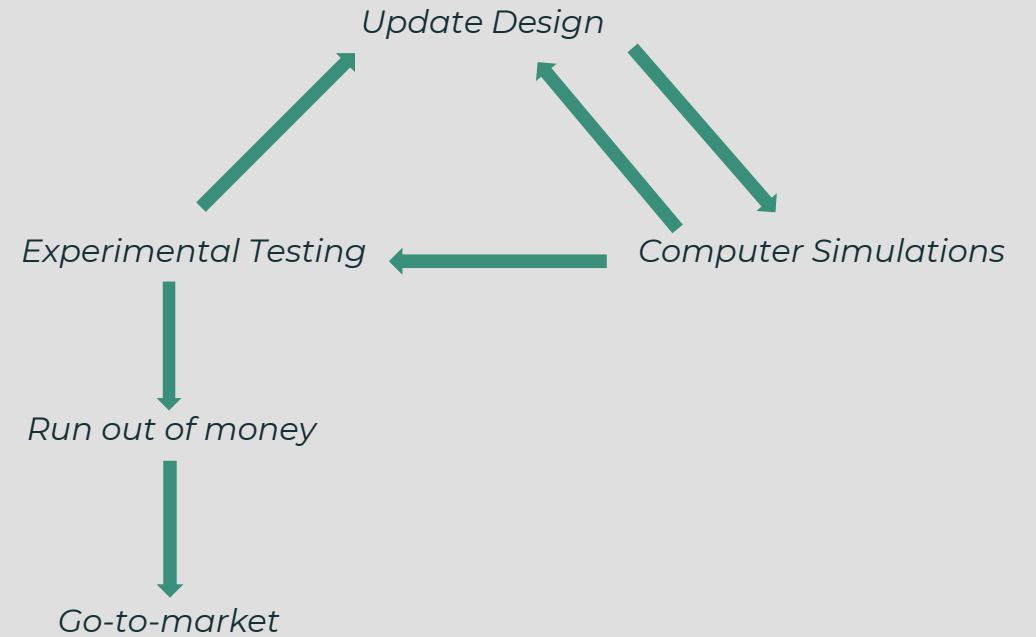
*Time-consuming design process*



*Limited design exploration*



*Performance limitations*



# Topology Optimization: Powerful but Limited

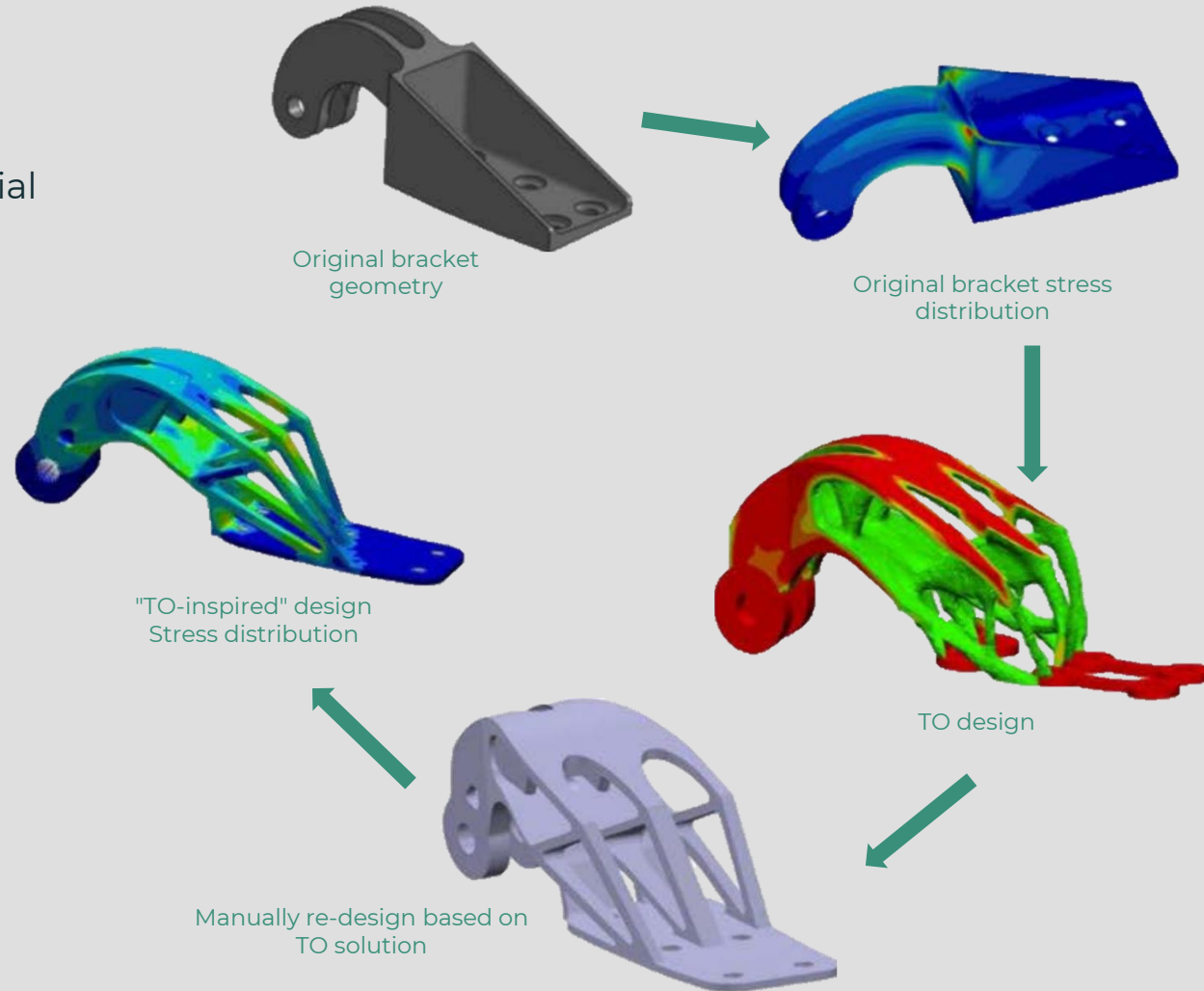


## What is Topology Optimization (TO)?

- Mathematical method to find the best distribution of material in a space
- The definition of "best" is (or should be) up to the user:
  - Lightweight Components
  - Material Reduction
  - Enhanced Performance

## Why isn't it widespread?

- **Complexity**
- **Limited Applications**
- **Real-World Requirements**
- **Interdisciplinary Expertise**



# Generative Design: a Step Further?

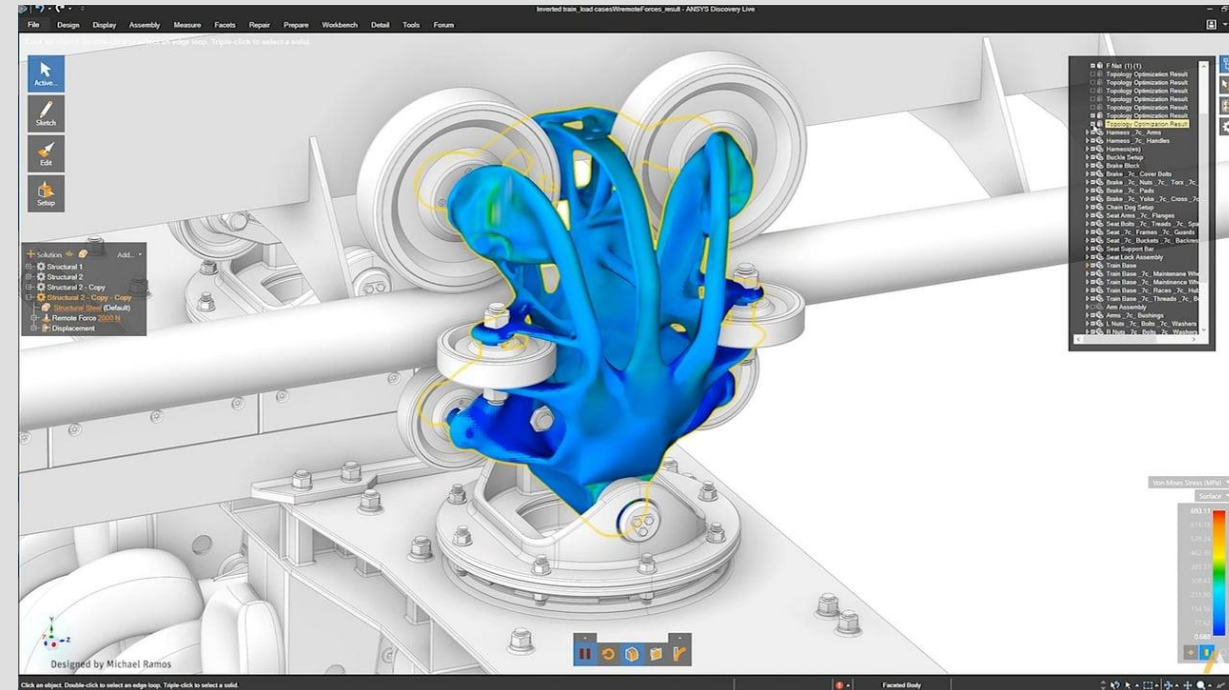


## What is Generative Design (GD)?

- Generative Design is a methodology to autonomously generate a multitude of design iterations based on predefined constraints and objectives.
- The outcome is several different designs that build a DoE based on the fitness of the solution.

## Why isn't it widespread?

- **Complexity**
- **Limited Applications**
- **Computation Demands**
- **Interdisciplinary Expertise**



Source: Ansys. Ansys Discovery

# Our Vision for The Future of Engineering Design

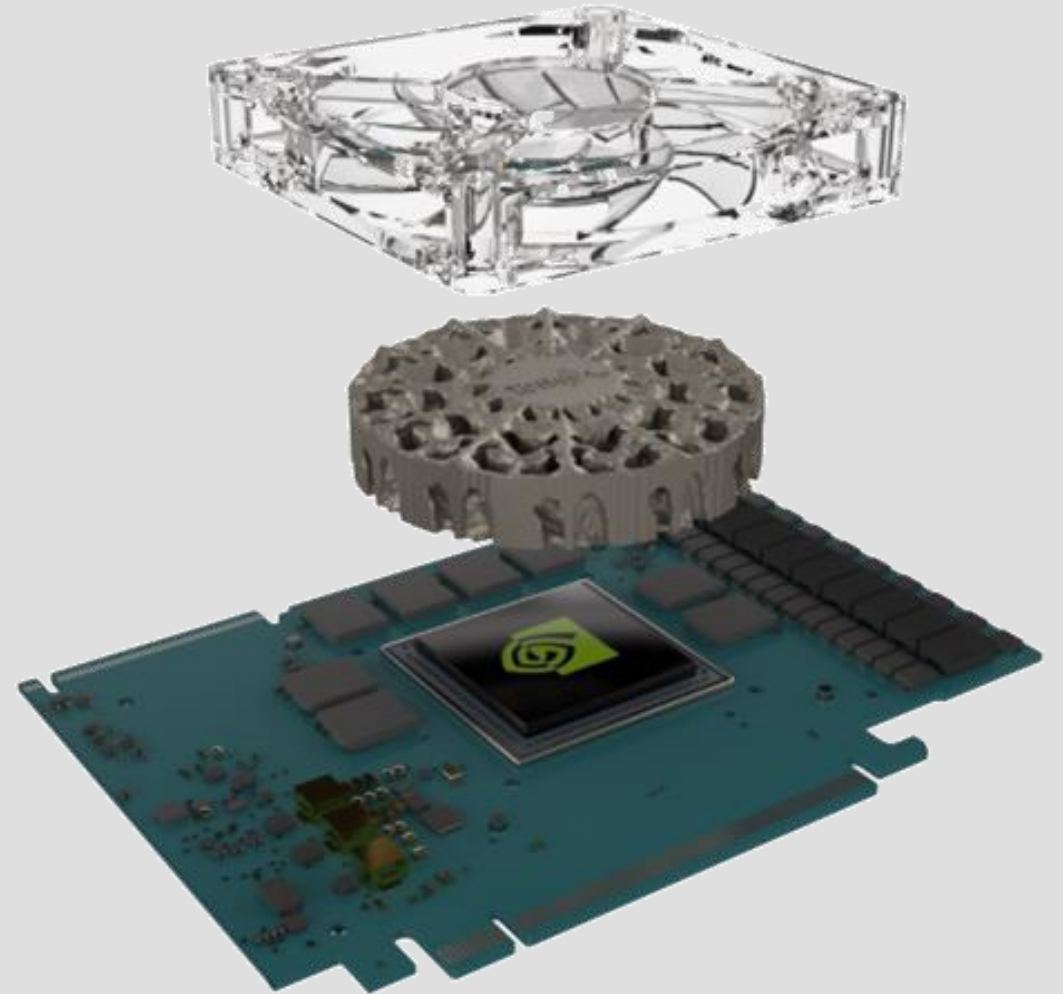


*Multi-Physics Models for Simulation and Optimization*

*Automation & Integration of Workflow*

*Integrated Cloud-Based Service*

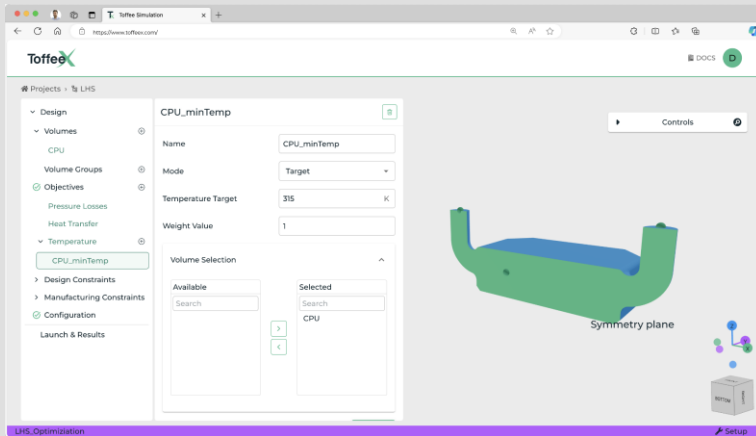
*Keep it Real*



# Streamline your Workflow with ToffeeX

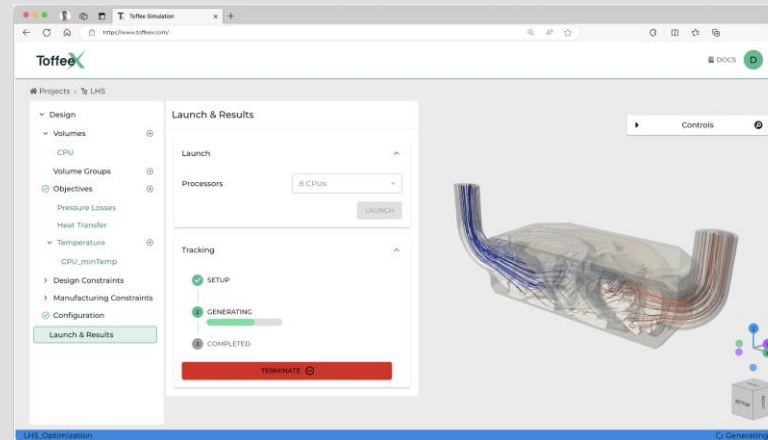


## Setup



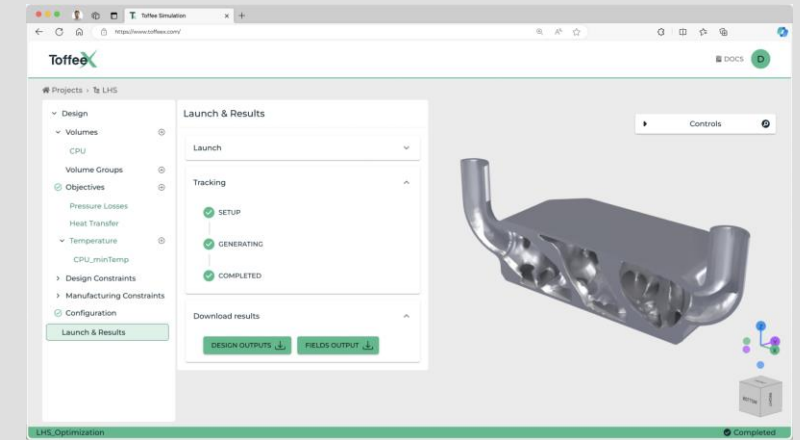
1. Define your domain and goals

## Design



2. Generate optimized designs in hours

## Export



3. Export your designs ready to test

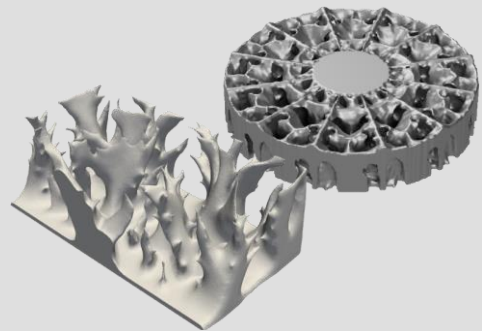


# One Software, Many Applications



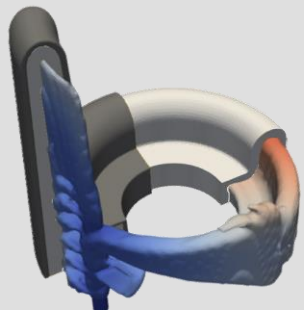
## Cold Plates

- Battery Cooling
- Liquid Cooling Solutions
- Energy Storage Systems



## Heat Sinks

- Electronic Components
- CPUs/GPUs
- LEDs

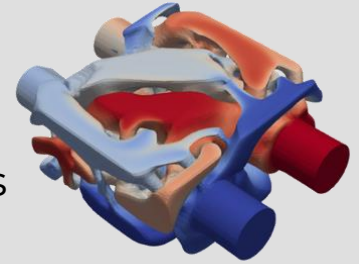


## Conformal Cooling

- Injection Molding Tooling
- Die Casting Tooling
- Sand Casting

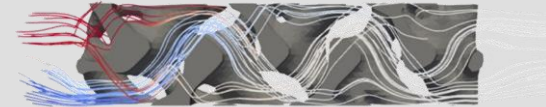
## Heat Exchangers

- Aerospace HEX
- Automotive Components
- HVAC Systems



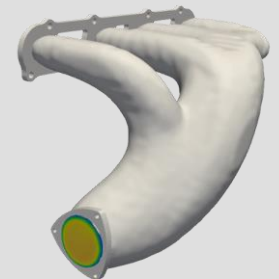
## Power Generation

- Carbon Capture
- Fuel Cells
- Power Generation



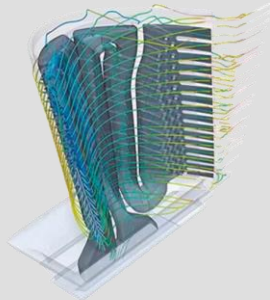
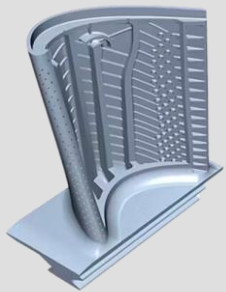
## Flow Optimization

- Exhaust manifolds
- Fluid collectors
- Laminar Mixers



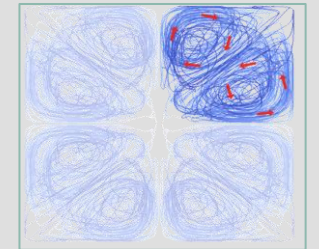
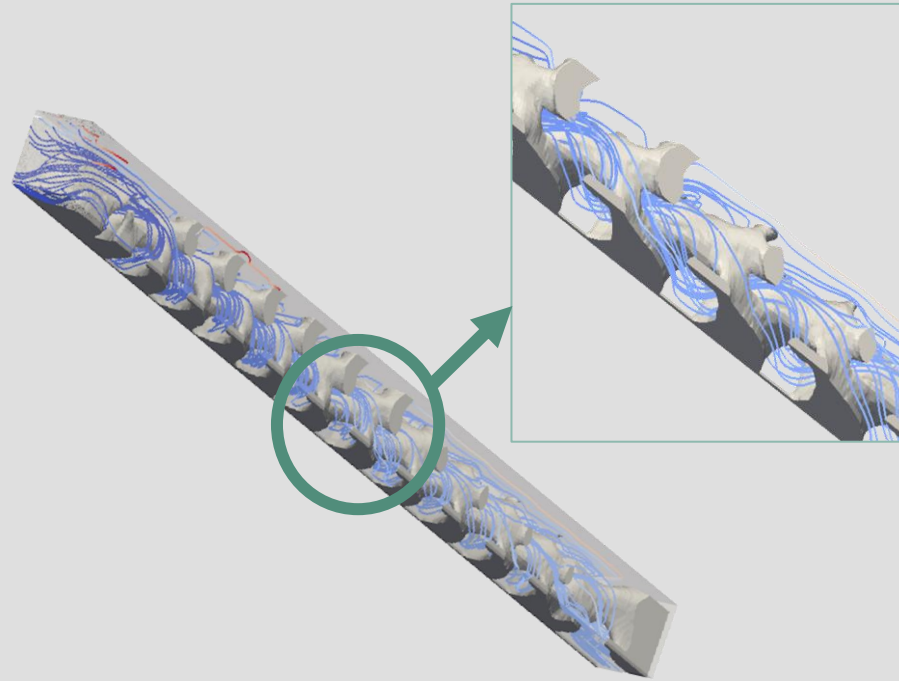
# 3X Improved Heat Transfer in Gas Turbine Blades

Original



- Turbine blades operating at very high temperatures
- Active Cooling to prevent them from melting

ToffeeX

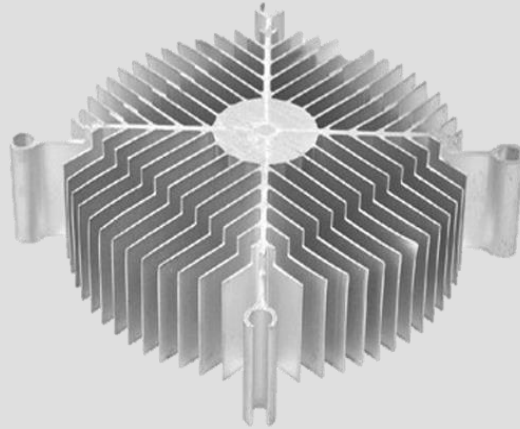


*Enhanced Heat Transfer with 8 counter rotating vortices*

- 3X improvement in heat transfer
- Same pressure losses as traditional design

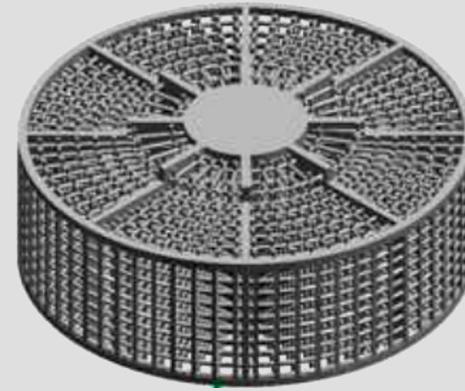
# 54% More efficient Heat Sinks for Electronics

Conventional Design



Aluminium Extrusion

Lattice Design (DfAM)

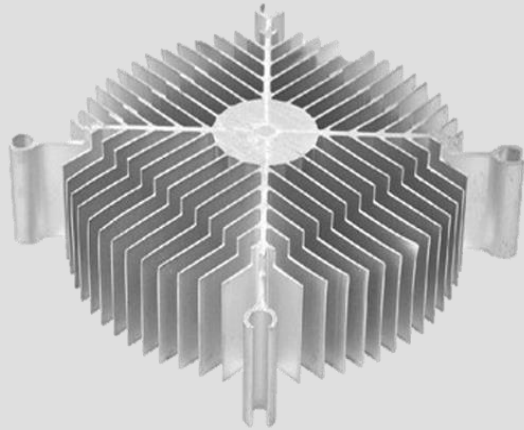


Aluminium Binder-Jetting Process



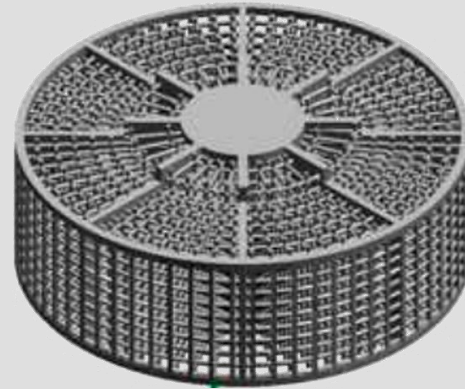
# 54% More efficient Heat Sinks for Electronics

Conventional Design



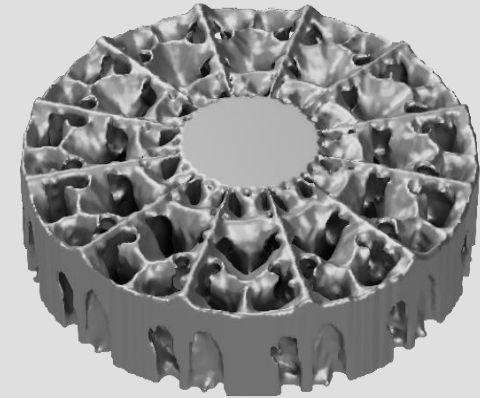
Aluminium Extrusion

Lattice Design (DfAM)



Aluminium Binder-Jetting Process

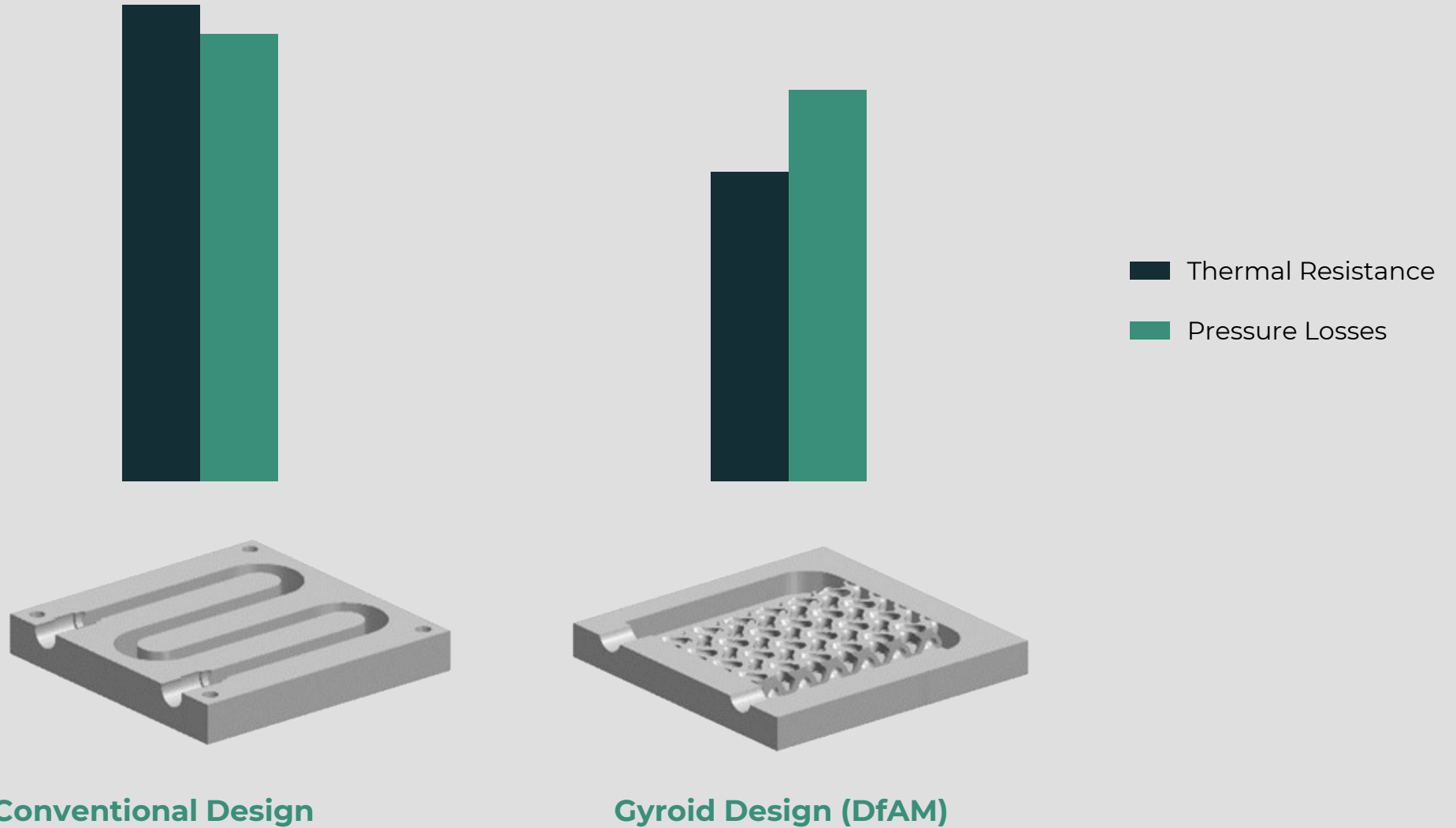
ToffeeX



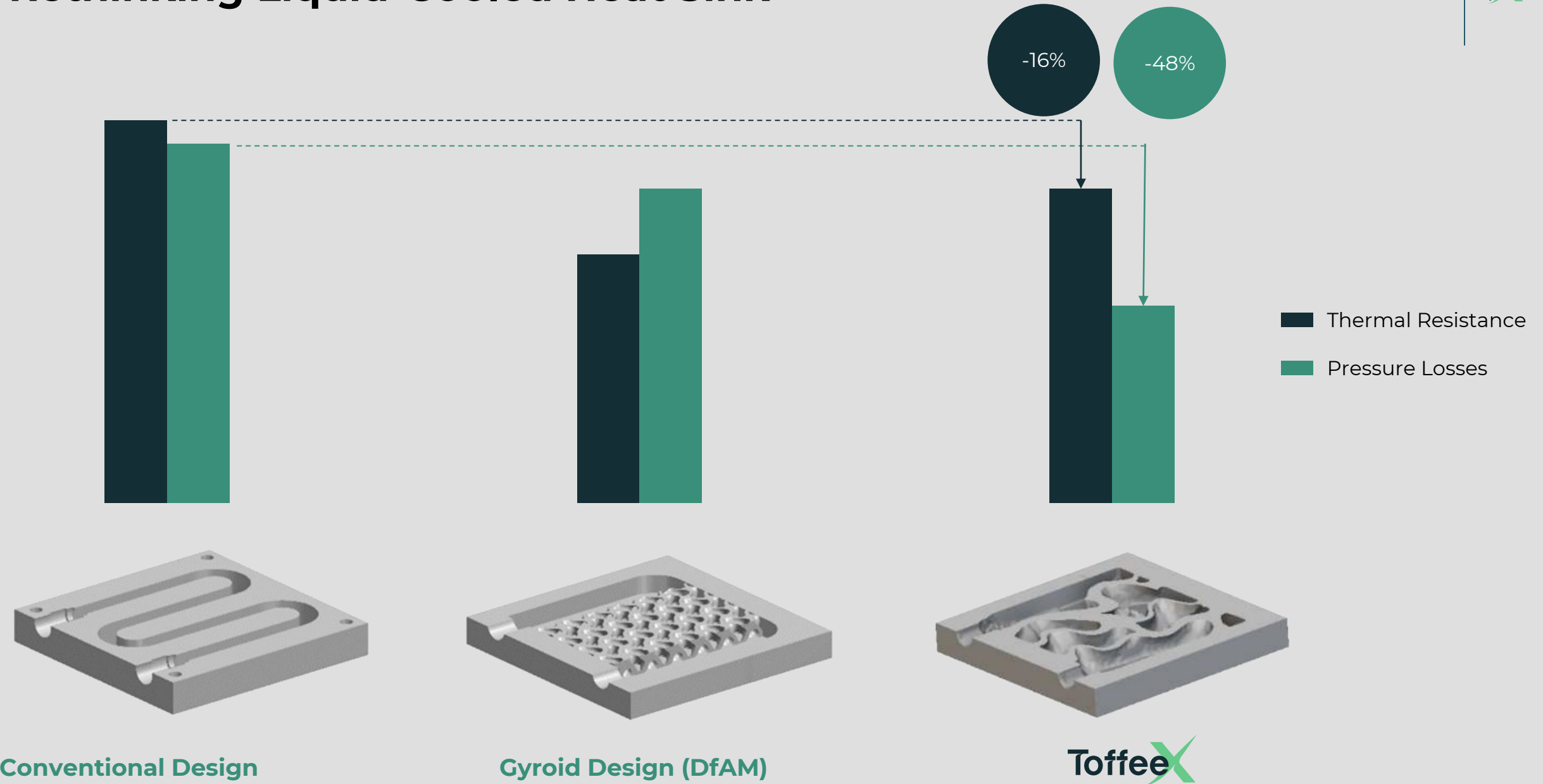
Aluminium Binder-Jetting Process



# Rethinking Liquid-Cooled Heat Sink



# Rethinking Liquid-Cooled Heat Sink

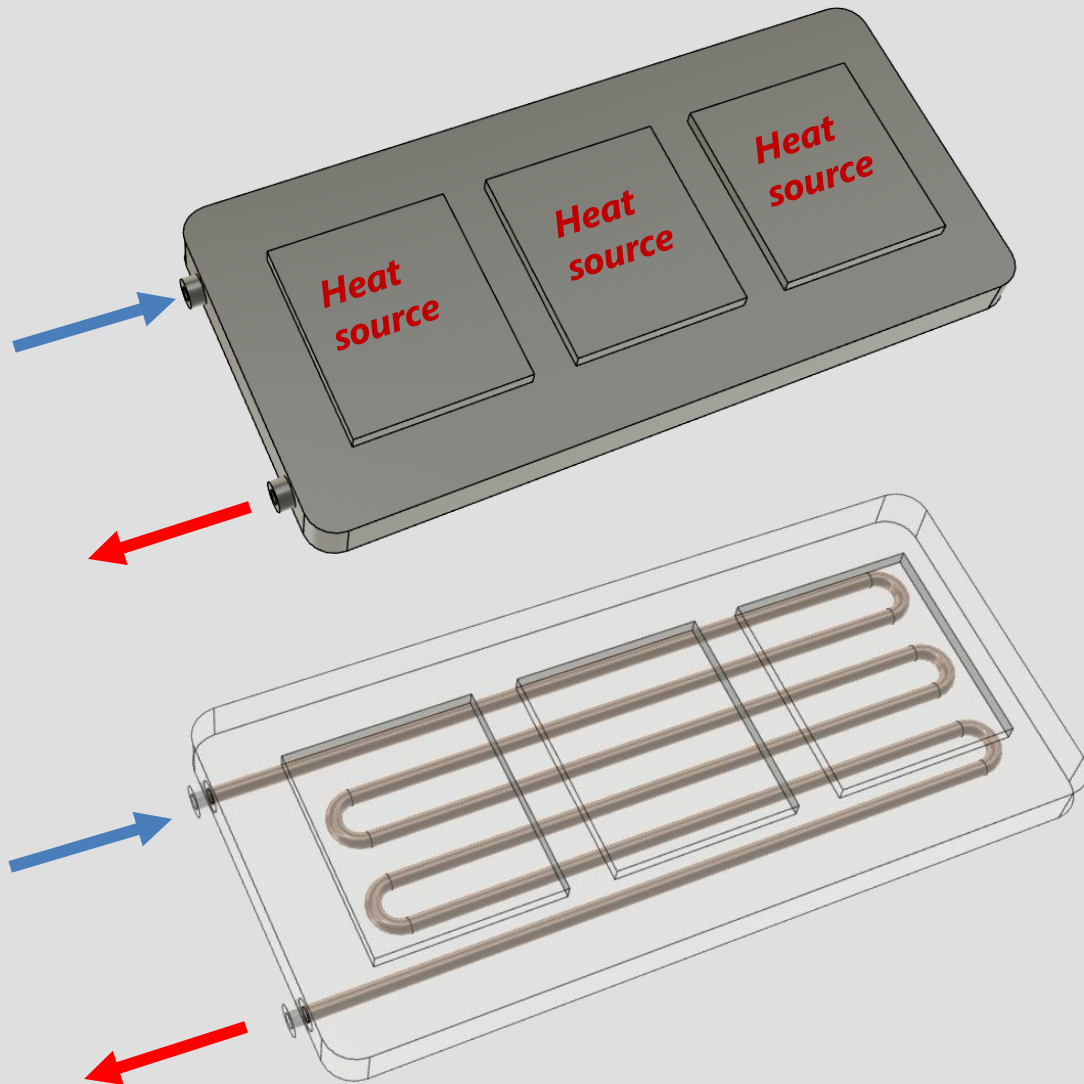


Conventional Design

Gyroid Design (DfAM)

ToffeeX

# Redesigning Cold Plates for Battery Cooling



## Requirements

- Manufacture using a milling process (high volume)
- Optimize for maximum cooling of the three heat sources for a minimal pumping power

## Operating Conditions

- Inlet volumetric flow rate: 1.5 L/min
- Inlet Temperature: 298.15 K
- Power Input : 400 W

	Copper	PG25 Coolant
Density [kg/m <sup>3</sup> ]	8960	1023
Thermal Conductivity [W/m K]	383	0.475
Specific Heat Capacity [J/kg K]	386	3930
Kinematic Viscosity [m <sup>2</sup> /s]	/	2e-6

# Redesigning Cold Plates for Battery Cooling



*65% Lower Pressure Drop*

*4 Degrees Colder Operating Temperature*

*38.5% Lighter Design*

*Manufacturable with Traditional Techniques*



# Double-Fluid Uniform Flow Optimization

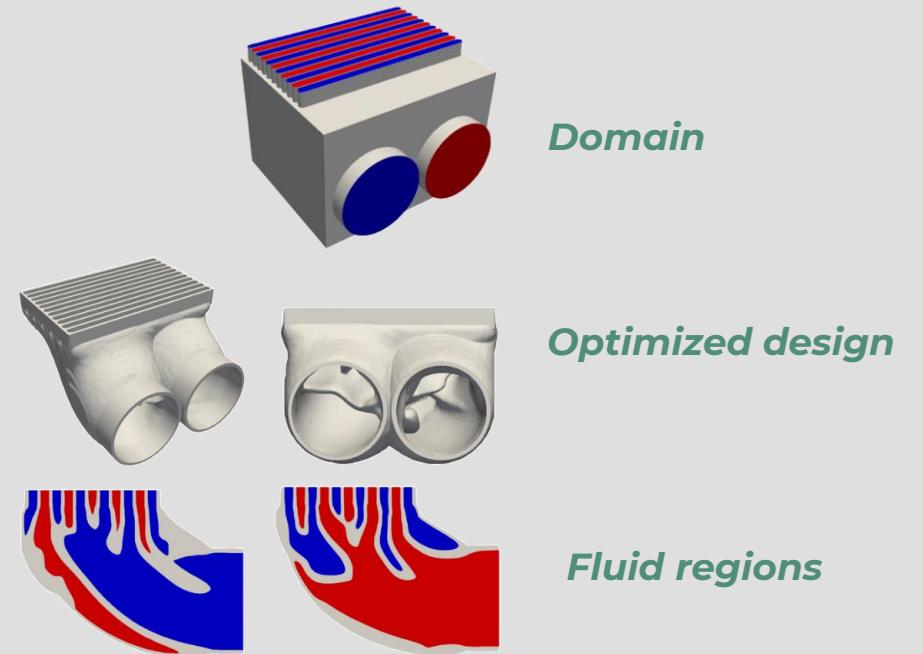
Overcoming traditional CAD issues leveraging ToffeeX

Original



- Uniformity of flow is not guaranteed

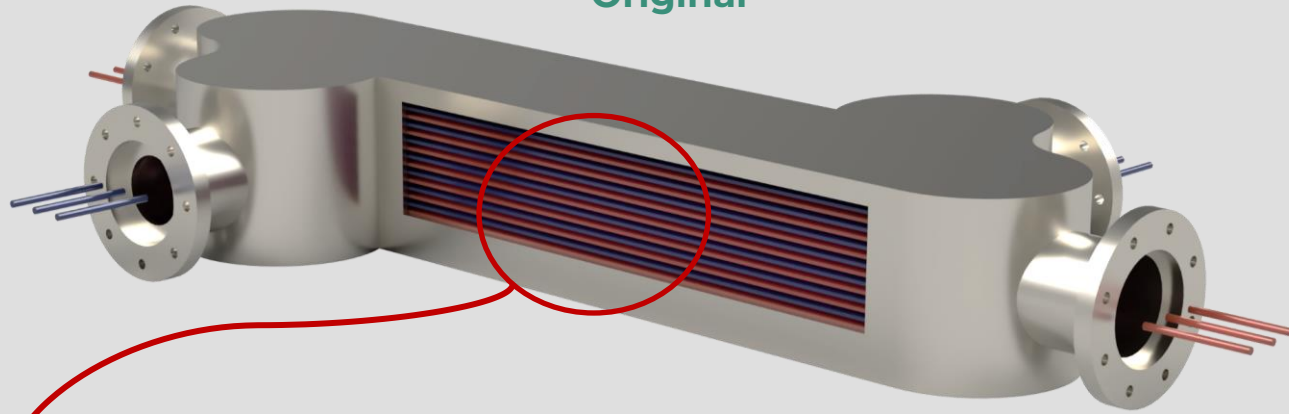
ToffeeX



- Uniform outlet flow rate for optimal performance

# Advanced Printed Circuit Heat Exchangers (PCHE)

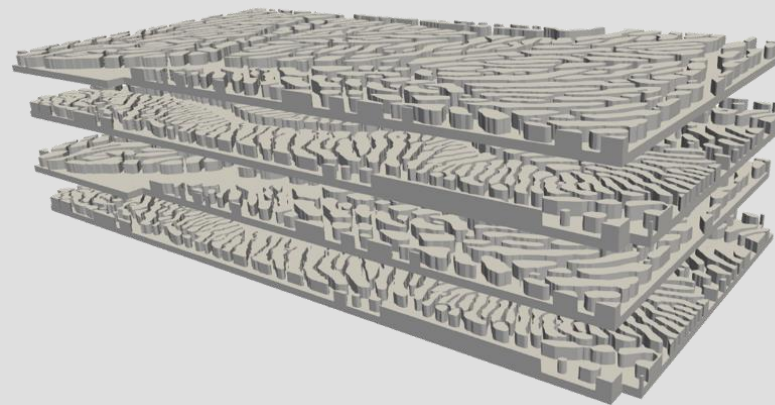
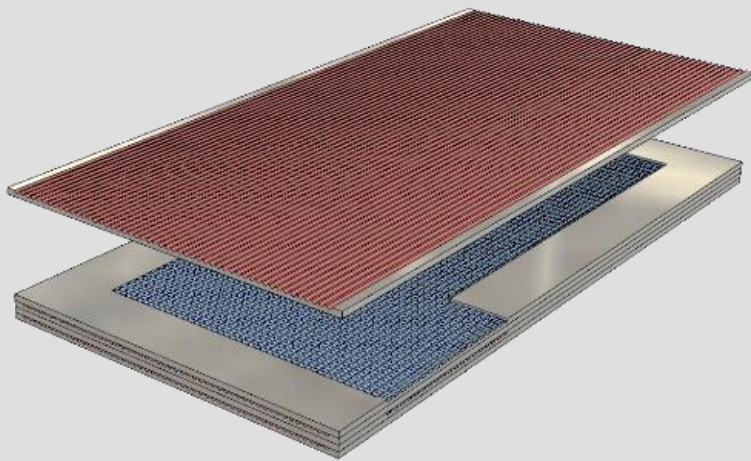
Original

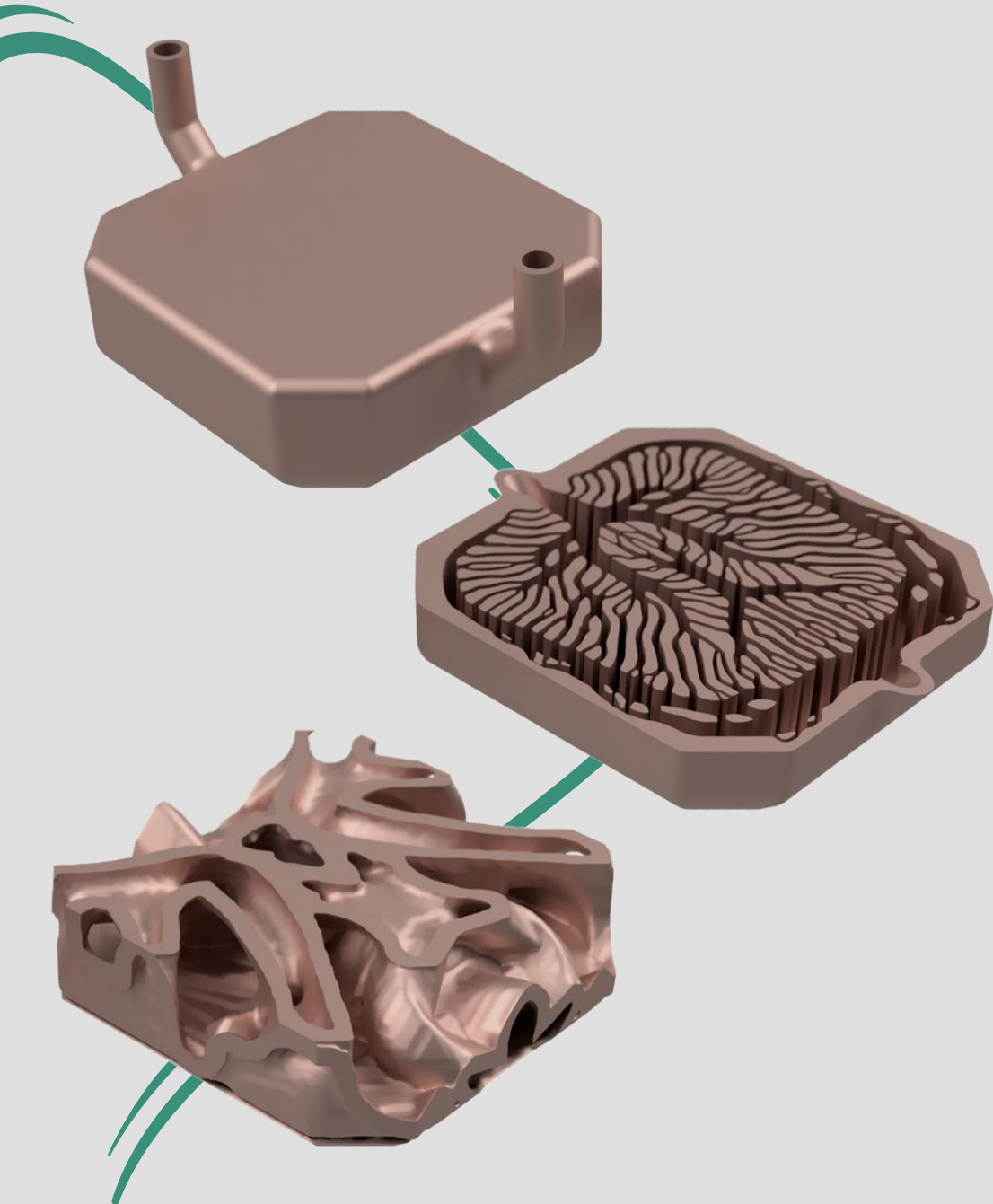


## Heat Exchanger for Nuclear Industry

- Multi-fluid configuration (Helium/Nitrogen)
- 8.5% Increase in Heat Transfer between the layers
- Designed for Chemical etching and Diffusion Bonding to avoid any leakage in the material

ToffeeX





## Optimize for your Manufacturing Process

With ToffeeX, users can select the complexity of the final design with their manufacturing process in mind.

Whether you are using traditional manufacturing techniques, or you have adopted Additive Manufacturing, ToffeeX can create the optimal design for any process.

# Design for Additive Manufacturing



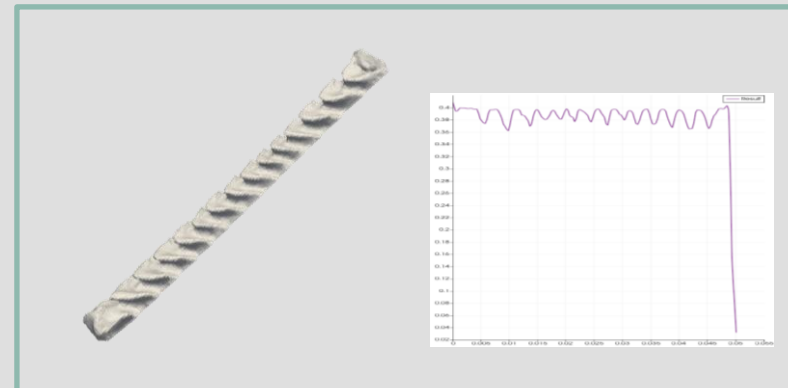
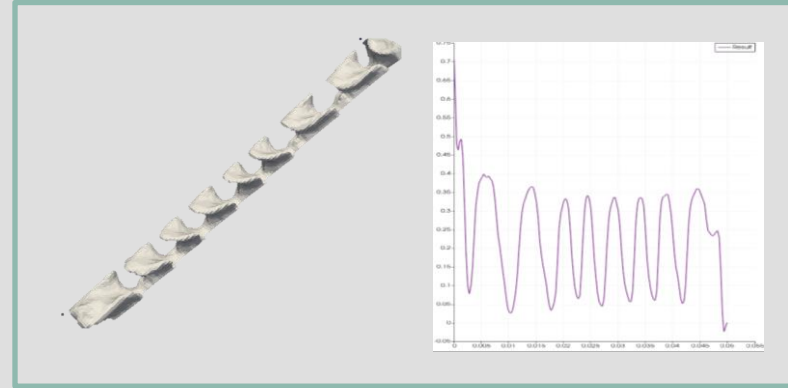
ToffeeX includes a list of constraint to maximize the success of your additive manufacturing process

- Unsupported Overhang minimization
- Shrinkage/Warping control

## Overhang Control



## Shrinkage/Warping Minimization



# Design For Conventional Manufacturing



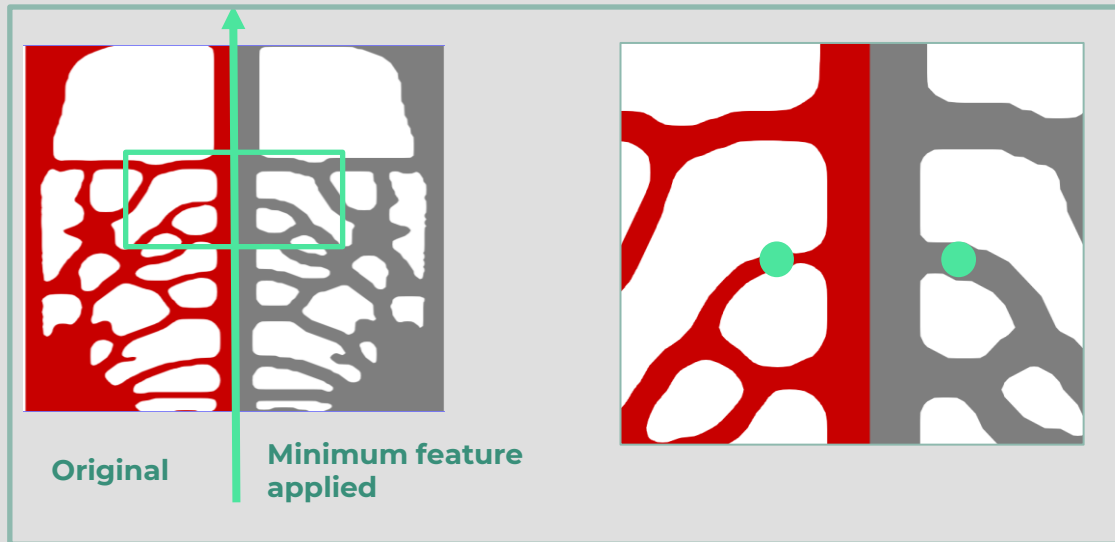
It's not all about Additive Manufacturing.  
ToffeeX integrates constraints for traditional manufacturing.

- Minimum channel width (tooling size)
- 2.5D Milling



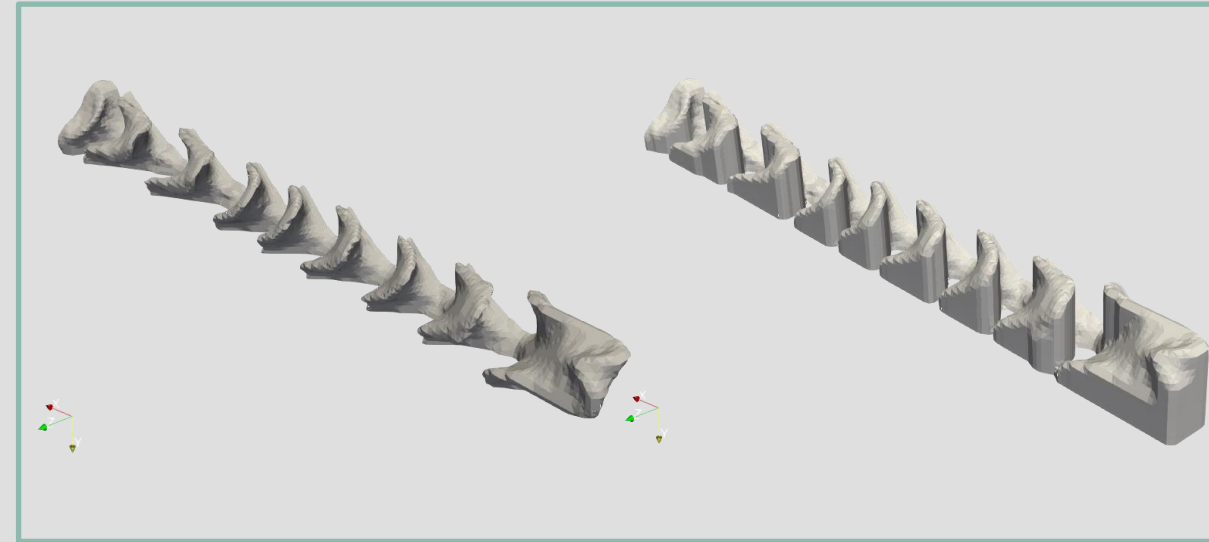
Baseline Design:

Constraint Imposed:



Baseline Design:

Constraint Imposed:



# Curious to Know More?



ToffeeX

RICOH

## Launching ToffeeX:

The latest in physics-driven generative design

*Tuesday 5th March, 11am GMT*



Featuring Live Demo and Q&A!



# ToffeeX

*The best design, every time.*

Trusted by



**AIRBUS**

**Panasonic**



**RICOH**



**IHI**

FABRIC8LABS