CDS
COGNITIVE DESIGN SYSTEMS

AI-GENERATIVE DESIGN FOR ADVANCED MANUFACTURING

COGNITIVE DESIGN

INTRODUCTION

Alejandro Carcel Lopez
Director of Application Engineering & Services
Cognitive Design Systems

Aerospace Engineer with 8+ years of experience in structural, thermal, and fluid systems for advanced manufacturing. Technical lead known for innovative, collaborative solutions to complex engineering challenges.

CDS: WHO WE ARE

2021

year of creation

60+

customers worldwide

SAFRAN NISSAN TOYOTA

MITSUBISHI ELECTRIC NAVAL GROUP

20

team members

We accelerate innovation in Aerospace, Defense, and Automotive with transparent, modular generative design software— driving operational excellence, sustainable manufacturing, and tech leadership.

AGENDA

1. **Introduction: Global Challenges and Product Development Pain Points**

2. **Cognitive Design Key Enablers for Enhanced Product Development**

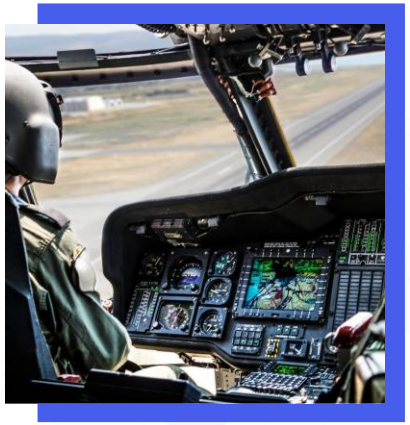
3. **Generative Design and AI methods**
   i. Automated Design modifications for Manufacturability
   ii. Level Set Topology Optimization – Design Exploration
   iii. Topological Enclosures
   iv. Multi-Objective Topology Weaving using Genetic Algorithms
   v. AI for CAD Geometry Reconstruction

4. **Use Cases**

GLOBAL ARISING CHALLENGES

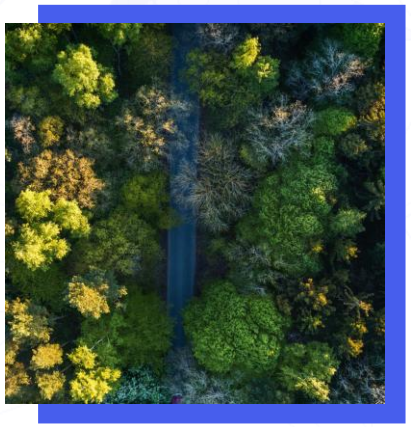
Increasing Global Competition

Faster product cycles and cost pressure are driving the need for high-performance designs delivered in less time. Staying competitive requires continuous innovation and efficient engineering processes.



Defense and Security Demands

Defense and aerospace sectors demand **rapid innovation under strict regulations**. Ensuring compliance, traceability, and supply chain resilience is critical.



Decarbonization

OEMs must now integrate **sustainability early in design,** reducing carbon impact, optimizing materials, and aligning with evolving regulations and customer expectations.

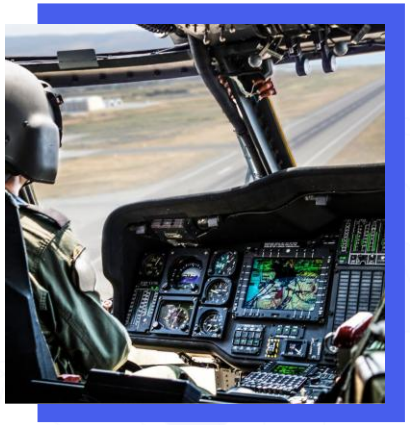
Technological Complexity & AI Integration

Modern design involves **complex data, simulation, and manufacturing constraints**. Engineering teams must ensure tight integration across tools and disciplines to stay efficient.

OPPORTUNITIES

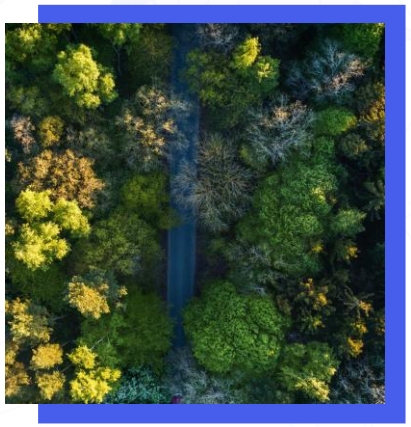
Increasing Global Competition

Leveraging AI and generative design tools enables faster, more efficient product development, helping companies **stay competitive** amid increasing **global pressure** and **shrinking innovation cycles.**



Defense and Security Demands

Defense primes need transformative, innovative tools—such as digital twins, secure AI-driven design platforms, and traceable manufacturing systems—to **accelerate innovation** while ensuring compliance, transparency, and supply chain resilience.



Decarbonization

Need for **eco-design** and **lightweighting** to meet **environmental targets** and improve **energy efficiency** across the product lifecycle

Technological Complexity & AI Integration

Implement **digital twin** and MBSE to manage system-level design and performance while keeping **manufacturability and feasibility checks in early design phases**

COLLABORATIVE PLATFORM

Product Life Cycle Management

Product Life Cycle Management

CAE Engineering

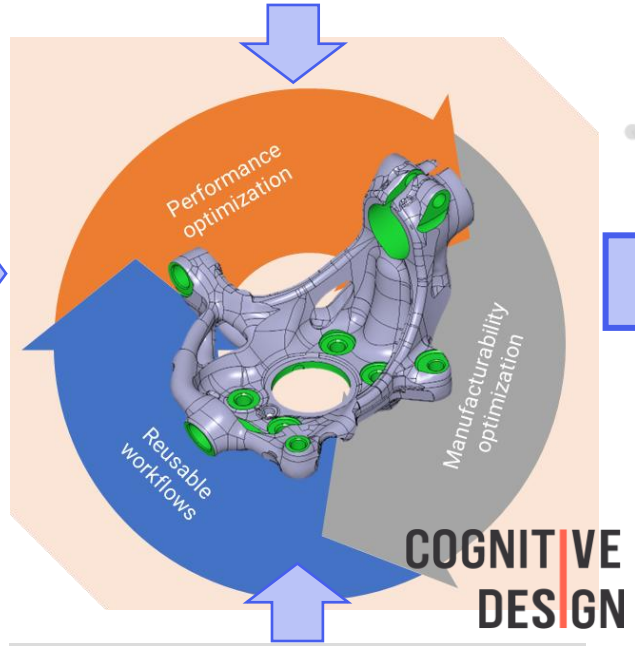
FEA | **Engineering Data**

Project Management

CAD

Costing

Sustainability



Test Data | **Material**

Manufacturing **Engineering**

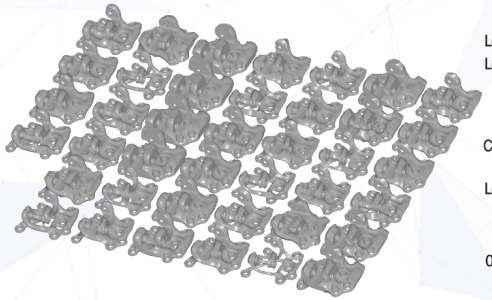
- **Optimized CAD**
- **Reusable Engineering workflow**
- **Engineering Reports**
- **CAE Data**
- **Manufacturing data**

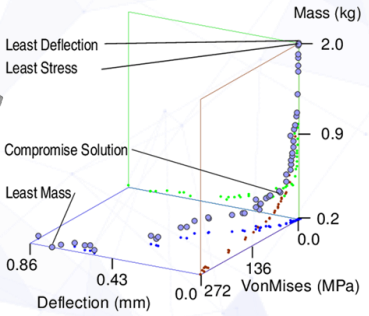
COGNITIVE DESIGN KEY ENABLERS

Design Exploration

Parametric and scalable Generative Design

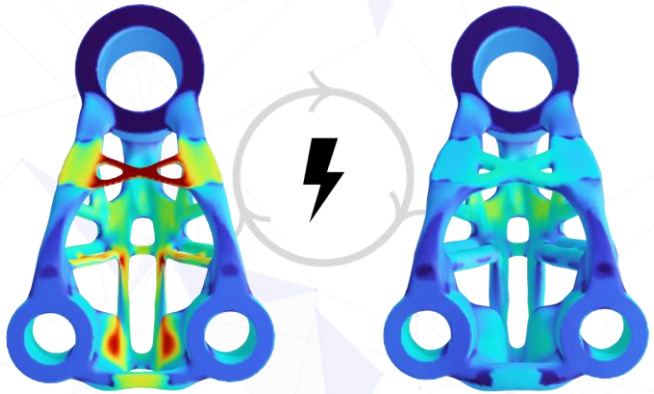
Multi-disciplinary Optimization





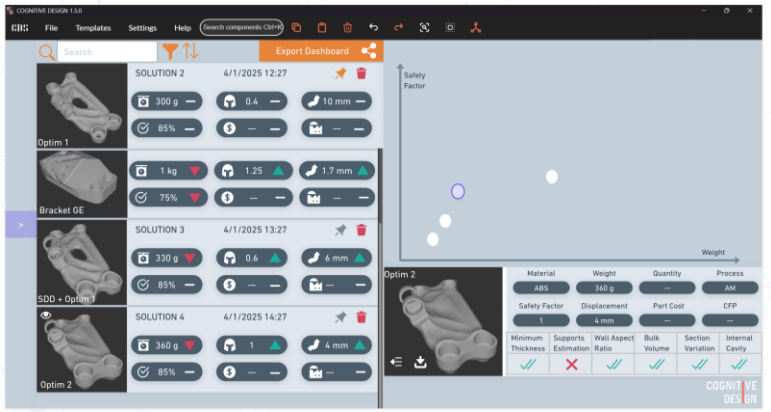
Design for Manufacturability

Automated Detail Design

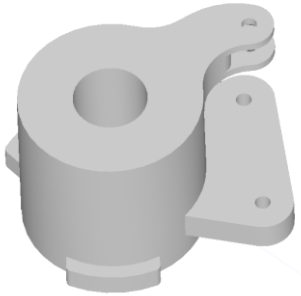


Simulation-Driven Design
Manufacturing-Driven Design

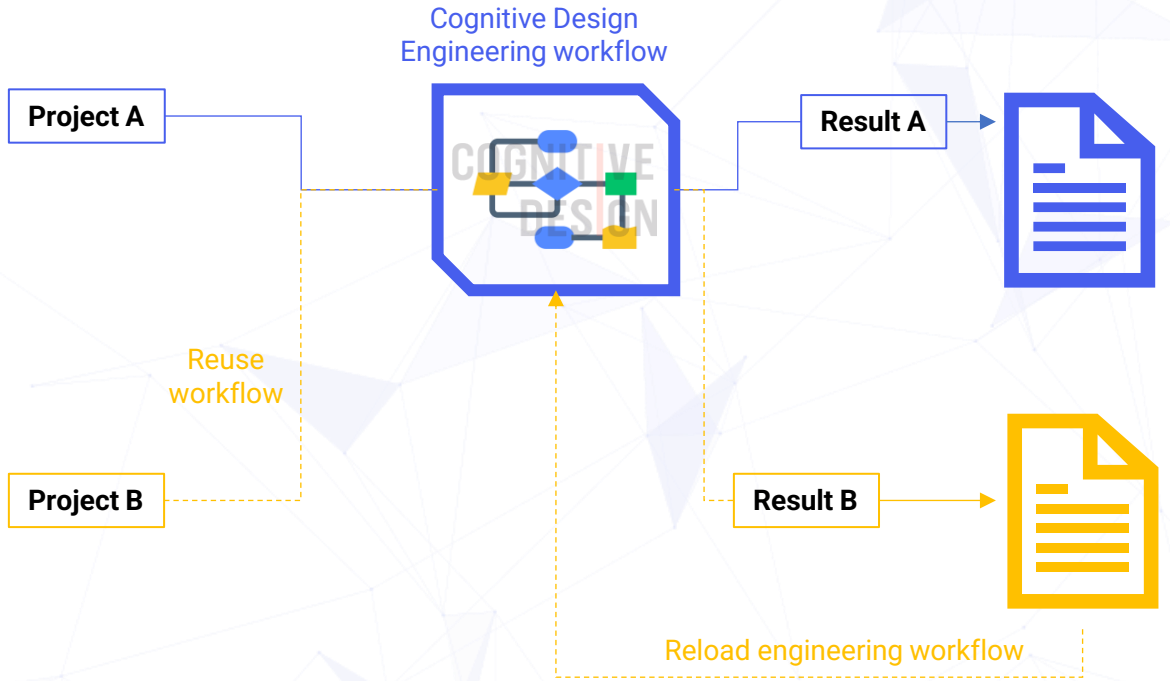
Reporting



COGNITIVE DESIGN KEY ENABLERS



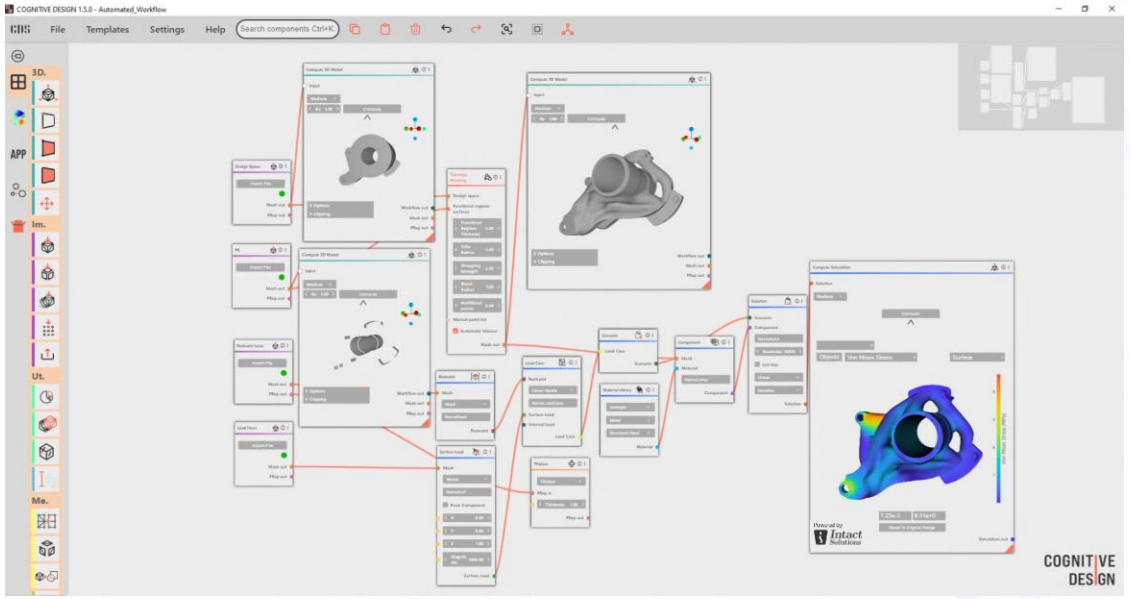
Re-usable Engineering Workflows

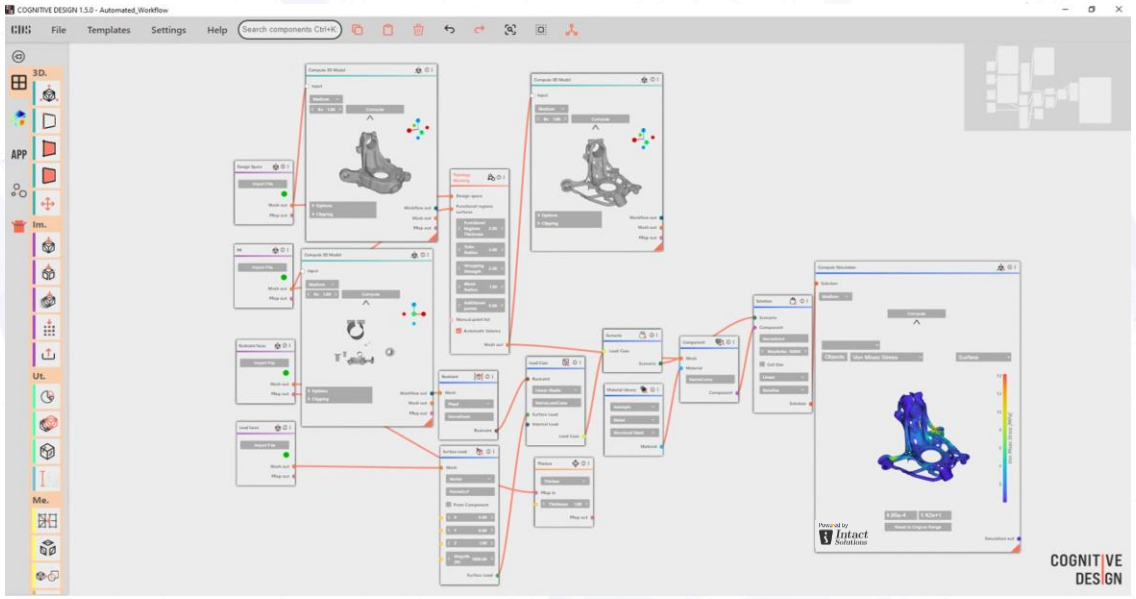


- Create and **standardize engineering workflow** for reuse.
- An engineering workflow is **saved as engineering know-how**
- **Engineering and design intent** can be accessed and **reused.**

COGNITIVE DESIGN KEY ENABLERS

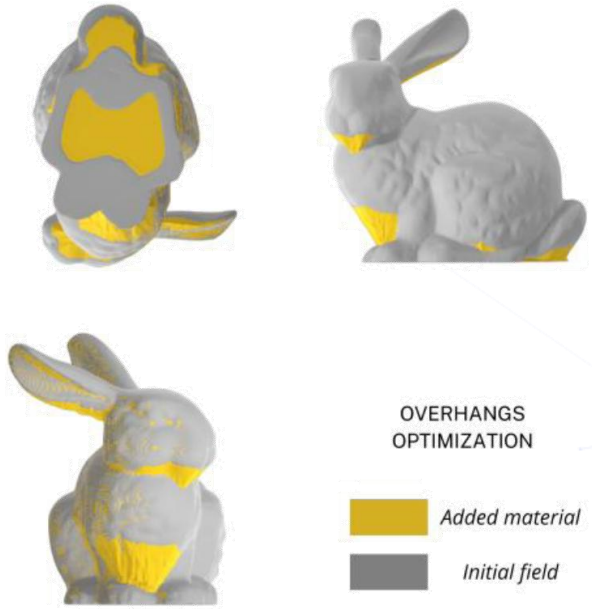
Re-usable Engineering Workflows

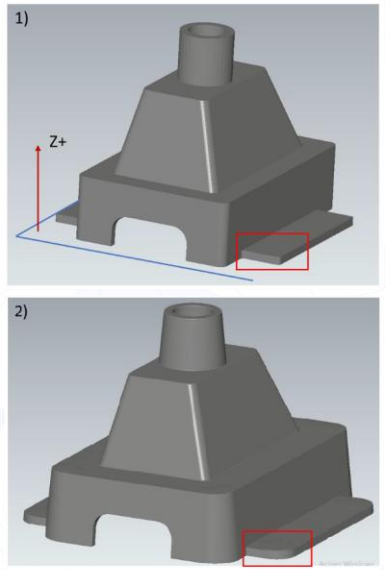




GENERATIVE DESIGN AND AI METHODS

Automated Design modifications for manufacturability





Additive Manufacturing

- Overhang morpher without going through TopOpt
- Feature distortion automatic correction
- Thermal distortion correction
- Powder removal

Molding – Injection Molding, Die Casting

- Complex parting line
- Uniform thickness
- Automated Draft angle

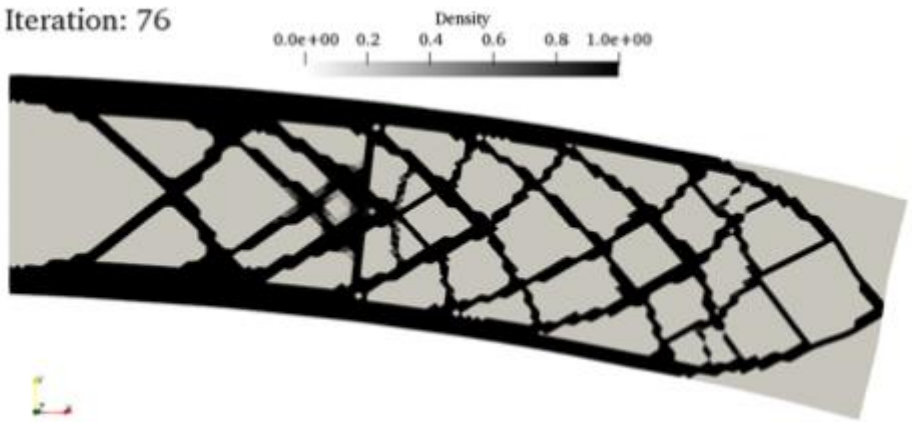
CNC Machining

- Multi-direction pockets
- Automated fillets
- Tool access

GENERATIVE DESIGN AND AI METHODS

Level Set Topology Optimization

SIMP



Density variation create new holes at each iteration. End result is complex and the output mesh is rough

Level Set

The thinning process uses implicit functions, and when they are too thin, they create holes. Output mesh is smooth

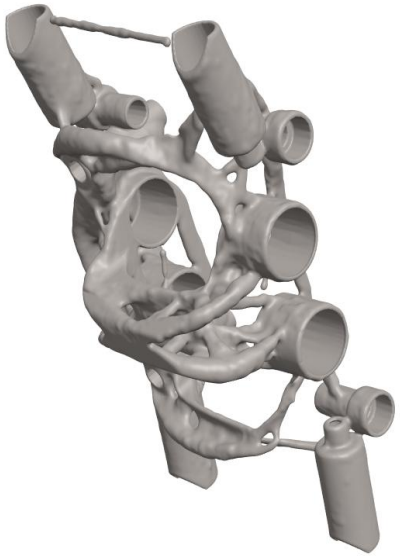
GENERATIVE DESIGN AND AI METHODS

Level Set Topology Optimization - Design Exploration

Result 1

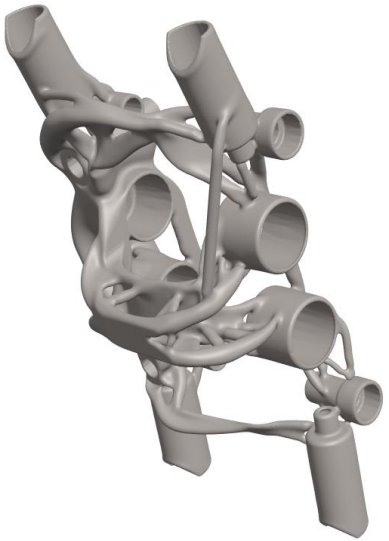
LevelSet Cell: 0.5
Initialization: NONE
Volume Fraction: 0.3

Result 2



LevelSet Cell: 0.5
Initialization: Perforated XYZ
Volume Fraction: 0.15

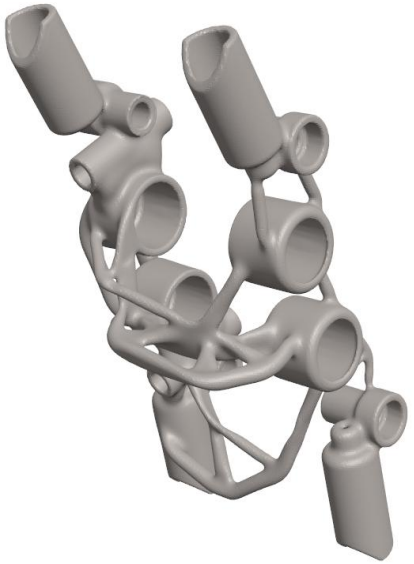
Result 3



LevelSet Cell: 0.5
Initialization: Perforated Y
Volume Fraction: 0.15

• • •

Result ‘n’



LevelSet Cell: 1
Initialization: Perforated Y
Volume Fraction: 0.15

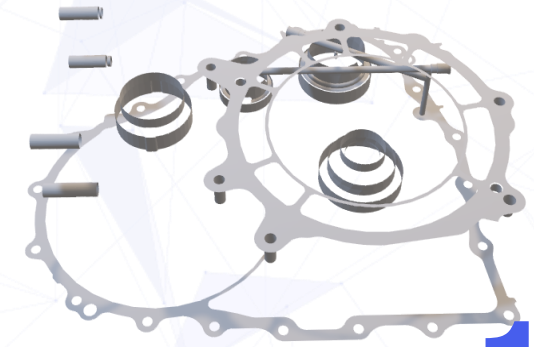
GENERATIVE DESIGN AND AI METHODS

Detail Process

AUTOMATION

1. **Interface Identification**
   Detect interfaces and non-design regions in CAD.
2. **Generative Enclosure Design**
   Auto-joins functional regions, avoiding non-design areas.
3. **Manufacturing-Driven Design**
   Automates DfM with mid-surface, undercut removal, draft angle
4. **Simulation-Driven Design**
   Ensures durability under load cases.
5. **Manufacturing Analysis**
   Checks draft, thickness, and undercuts.
6. **Back-to-CAD**
   Final manual modifications before sending to Manufacturing Engineering

Topological Enclosures

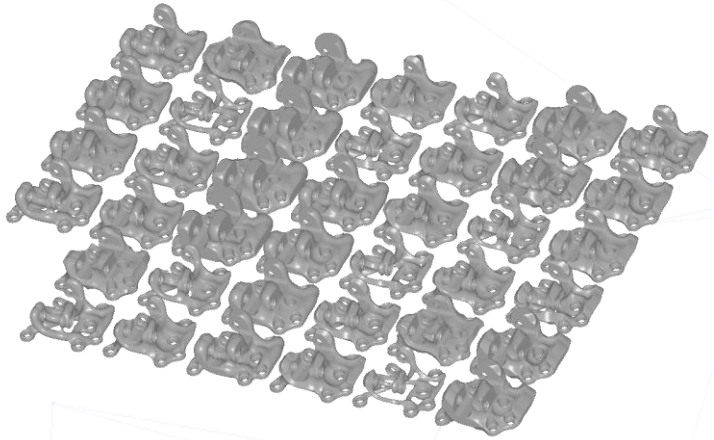


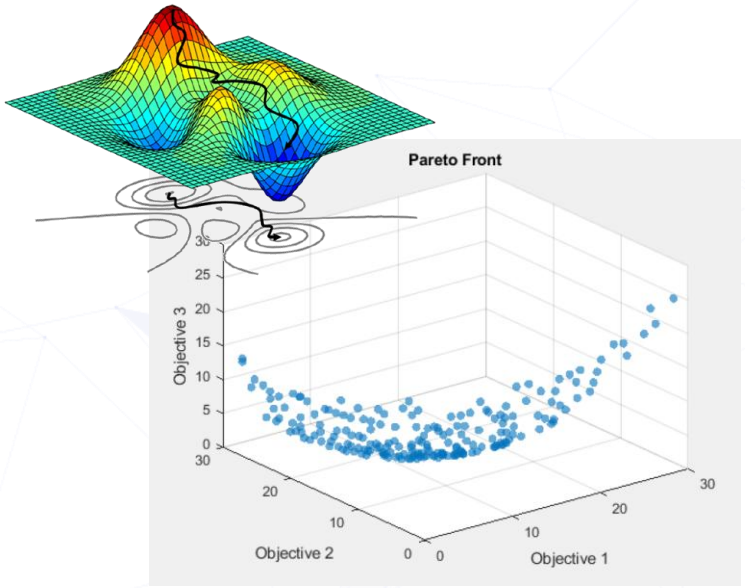
10X FASTER DESIGN GENERATION

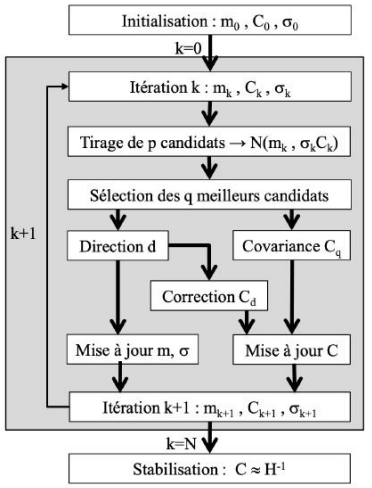
- ✓ Manufacturable
- ✓ Durable
- ✓ Lightweight
- ✓ PLM/CAD Friendly

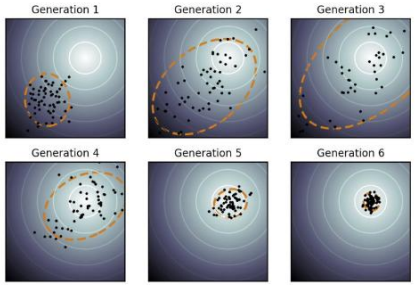
GENERATIVE DESIGN AND AI METHODS

Multi-Objective Topology Weaving using Genetic Algorithms









Design Parameters

- Tube radius
- Valency (number of connections)
- Wrapping strength

Objective Functions

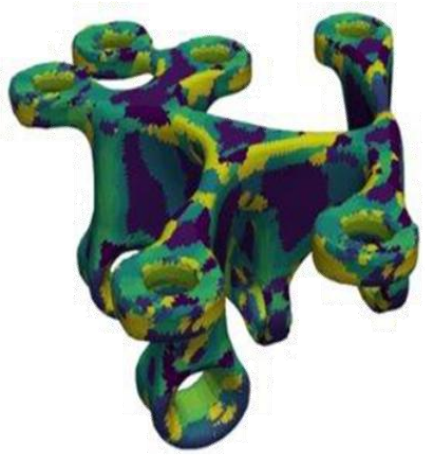
- Cost
- Manufacturability
- Stiffness/Strength
- Weight
- Carbon footprint
- A combination of the above…

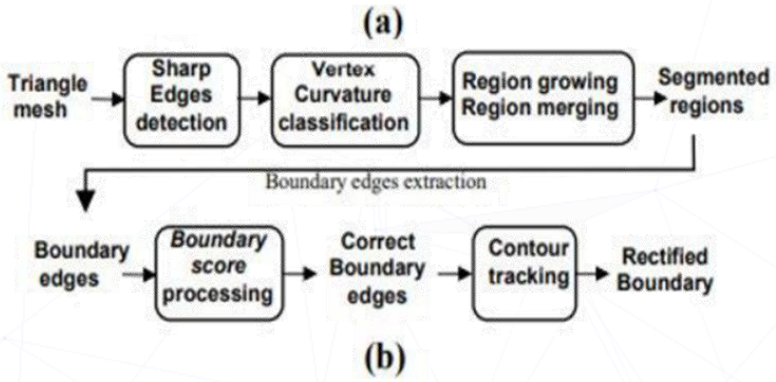
Solver methods

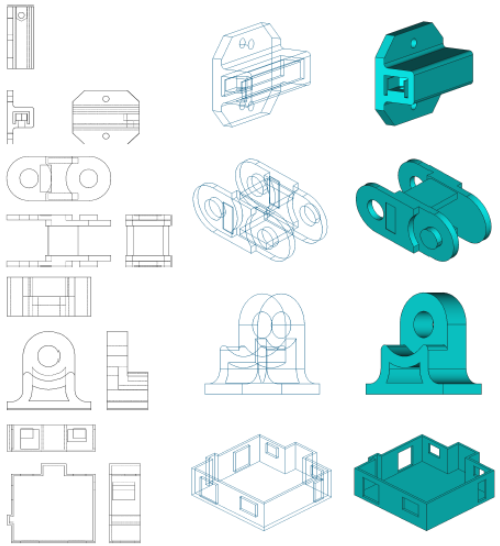
- Multi-objective optimization
- AI Genetic Algorithms

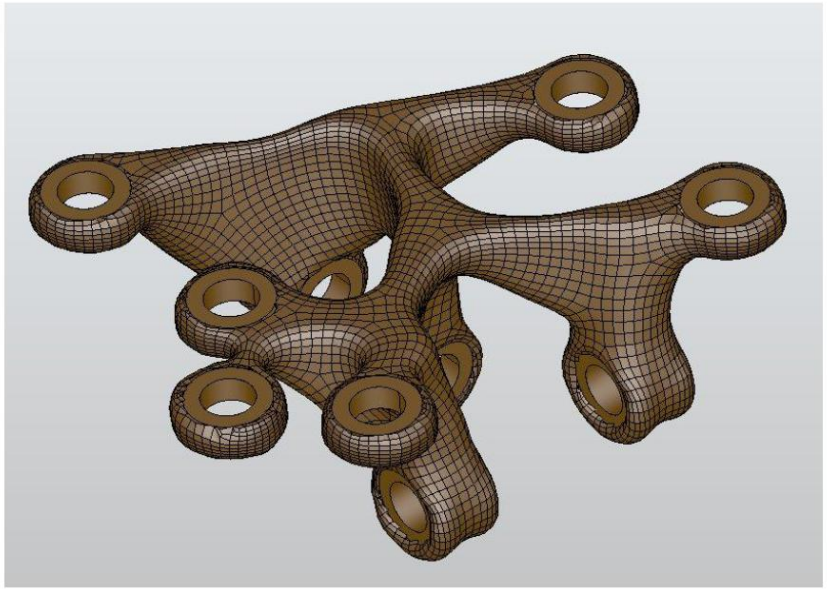
GENERATIVE DESIGN AND AI METHODS

AI for CAD Geometry Reconstruction









- From generative (Implicit) Model to **Clean CAD** through **proprietary AI feature recognition algorithms**
- From **2D** drawing **to 3D** part
- Clean interfaces
- **CAD/PLM-ready**

FALCON 6X DOOR BRACKET

Industry: Aerospace

Application: Design Exploration of Optimized Designs for different manufacturing methods

Manufacturing process and material: Laser Powder-Bed Fusion (LPBF) vs CNC machining, TA6V

Optimizations:

- Generative Design vs Cost & Structural requirements
- Simulation-Driven Design
- Manufacturing-Driven Design – Automated DFM for AM and Casting

-91% **-30%**

VS traditional CAD

Aircraft bracket optimized for 5-axis Machining

Aircraft bracket optimized for Additive Manufacturing

COGNITIVE DESIGN SYSTEMS

POTEZ AÉRONAUTIQUE

RENAULT STEERING KNUCKLE

Industry: Automotive

Application: Design optimization and manufacturability

Material and manufacturing process: Die Casting, Aluminium

Optimizations:

- Generative Design vs Cost requirement
- Simulation-Driven Design
- Manufacturing-Driven Design – Automated DFM for Casting

-89%

-35%

VS traditional CAD

COGNITIVE DESIGN SYSTEMS

CETIM

CONCLUSIONS

Generative Design and AI…

- **Accelerate Design Exploration**
  Rapidly evaluate multiple design options to balance performance, cost, manufacturability, and sustainability.
- **Beyond Niche Use Cases**
  Bring AI and generative design into daily mechanical engineering workflows—not just for complex, exotic parts.
- **Boost Engineer Productivity**
  Automate repetitive tasks while maintaining full integration with existing PLM systems.
- **Reduce Lead Times**
  Leverage AI-driven tools to speed up iterations and decision-making under real-world constraints.

THANK YOU !
QUESTIONS?