Heavy-Lift Drone Chassis: Process Migration from AM to Investment Casting

This internal study demonstrates the capabilities of Cognitive Design software in optimizing a heavy-lift industrial inspection drone structure. By leveraging Topology Optimization, Topology Weaving and Manufacturing-Driven Design (MDD) in Cognitive Design, the team achieved an **87% engineering lead time reduction** compared to conventional CAD method.

A critical economic analysis compared Additive Manufacturing (AM) against Investment Casting for a production run of 100 units, revealing a potential **cost reduction of approximately 85%** by migrating the organic design to a castable workflow.

Engineering Challenge

Industrial inspection drones operate in demanding environments requiring high agility and extended battery life. The primary technical hurdle was maximizing the payload-to-weight ratio for a drone frame measuring 400mm x 250mm. Legacy designs used bulky, machined block components which limited flight time.

The engineering team needed to:
1) Drastically reduce mass without compromising stiffness (handling 20kg payload).
2) Explore complex organic geometries enabled by AM.
3) Validate a cost-effective manufacturing strategy for a series of 100 parts, as direct Metal AM (Ti-6Al-4V) proved cost-prohibitive for the target volume.

The Solution: Cognitive Design Workflow

1. DESIGN SPACE & LOAD CASES

The base design space was defined as a central hub with four varying attachment points (400mm width, 250mm height).

- Material Candidates: Ti-6Al-4V (Titanium) for high specific strength, Al-6061 (Aluminum) for cost/weight balance.
- Boundary Conditions: Fixed constraints at the central payload interface.
- Loads: Applied 20kg payload forces, simulated rotor thrust vectors, and 3G vertical landing shock.

2. GENERATIVE EXPLORATION

Using the software's Design of Experiments (DoE) capabilities, multiple topology strategies were explored simultaneously:

- **Topology Optimization**: Starts from a full material envelope and progressively removes non-structural material to converge toward the most efficient load path.
- **Topology Weaving**: A new CDS' generative design method connecting functional regions through organic shapes and tube-like pathways, ruled out for final casting suitability.

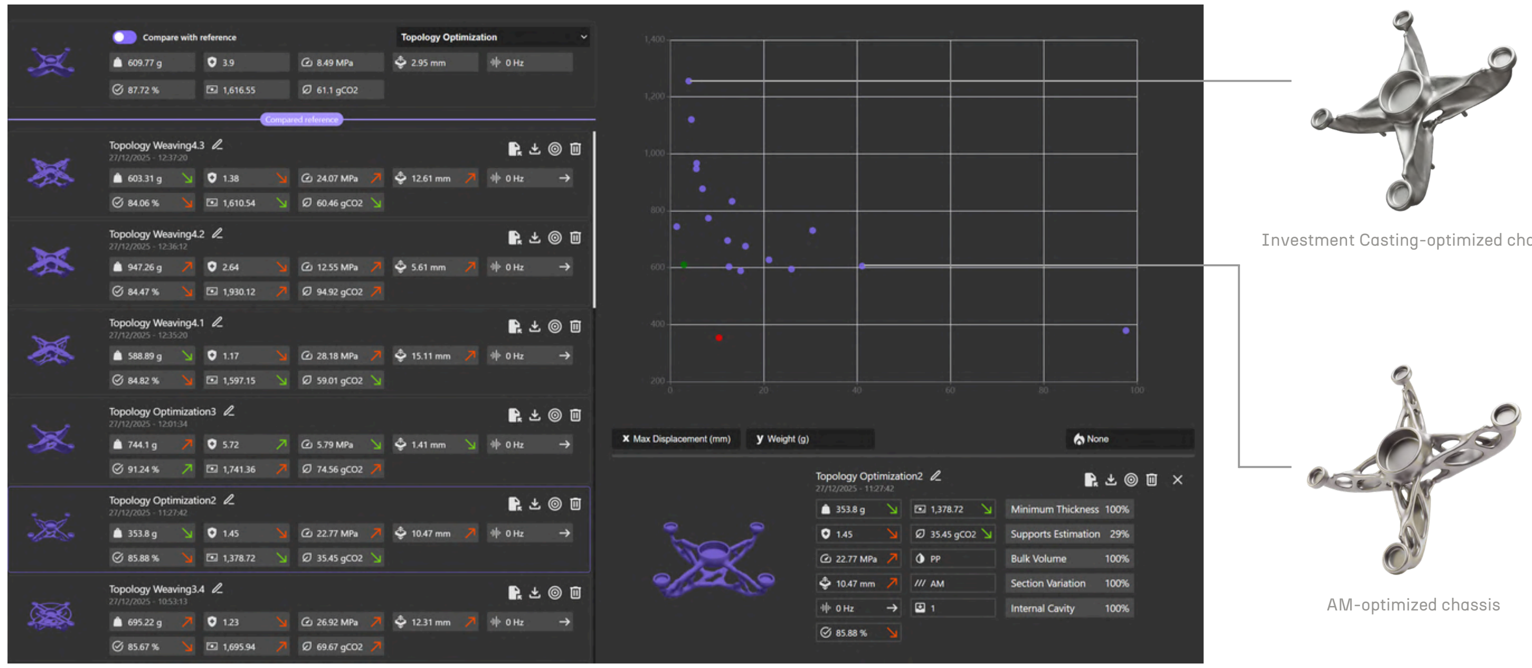
3. PERFORMANCE & MANUFACTURABILITY (SDD & MDD)

The core success factor was the application of **Manufacturing-Driven Design (MDD)**.

- Initial Shape: Generated using "Organic/No Overhangs" constraints to ensure printability for the prototype.
- Process Migration: The organic shape was refined for Investment Casting. This involved running a draft-angle analysis and smoothing undercuts to ensure a ceramic shell could be formed and removed around a printed wax pattern (sacrificial pattern casting).
- **Simulation-Driven Design (SDD)**: Meshless FEA provided instant feedback on stress concentrations at the strut junctions, allowing for rapid thickening of weak areas without re-meshing.

4. VALIDATION

Final Finite Element Analysis (FEA) confirmed the organic Ti-6Al-4V structure could withstand the 20kg payload with a safety factor of 1.5. The optimized geometry directs forces through skeletal limbs, eliminating all non-structural material.



Metric	AM Design (Ti-6Al-4V)	Casting Design (Al-6061)	Improvement
Mass	0.50 kg	0.74 kg	-
Max Displacement	0.38 mm	0.40 mm	Within structural limit
Safety Factor	1,50	1,50	Maintained
Unit Cost (batch of 100)	3,450 EUR	515 EUR	~85% cost reduction