



Automotive Suspension Swing Arm Multi-Process Generative Study

This study addresses the client's need to reduce unsprung mass for a high-performance vehicle platform while evaluating cost structures for two distinct production volumes. By utilizing Cognitive Design's generative workflow, we delivered a topology-optimized swing arm in Al-6061. The project achieved a **40% reduction in mass** while maintaining stiffness targets.

The analysis provided a **clear decision matrix**: CNC Machining for the low-volume Sports variant (eliminating tooling costs) versus High-Pressure Die Casting for mass production.

Engineering Challenge

In the modern Automotive and EV sector, reducing unsprung mass is critical for improving vehicle range and handling dynamics. The legacy component was an over-designed, heavy assembly that negatively impacted suspension response. The technical challenge lay in removing material without compromising structural integrity under complex multi-axial loads (braking, cornering, and pothole impact). Furthermore, the client required a dual-path manufacturing strategy to address both a limited-run sports edition and a standard high-volume economy model.





The Solution: Cognitive Design Workflow

1. DESIGN SPACE & LOAD CASES

We began by importing the legacy assembly. The mounting points (bushing housings) and the ball-joint interface were defined as "Non-Design Spaces" (regions that must remain untouched). We applied load cases representing 3G bump loads, 2G cornering forces, and 1.5G braking torque. The material baseline was set to Aluminum 6061 T6 for CNC and A380 Aluminum Alloy for Casting.

2. GENERATIVE EXPLORATION

Using **Topology Optimization**, we generated the optimal material layout. The optimizer removed material from regions that were not contributing significantly to load transfer, resulting in an optimized organic structure. This created functional regions connected with structural pathways, ensuring the load path was direct and efficient.

3. PERFORMANCE & MANUFACTURABILITY (MDD)

We applied **Manufacturing-Driven Design (MDD) constraints** to create two distinct variations based on the same topology:

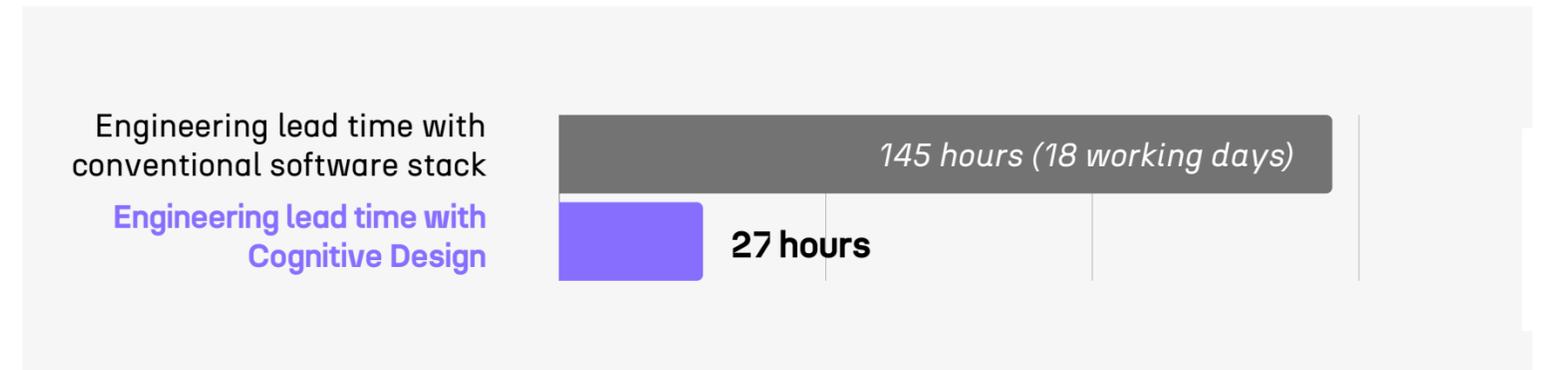
- Variation A: **Machining** (Sport Version)
 - Constraint: 3-Axis CNC Milling.
 - Geometry: Enforced flat planes and cylindrical surfaces to minimize machining time and tool changes.
 - Result: A sharp, organic aesthetic with accessible pockets for end-mills.
- Variation B: **Die Casting** (Volume Version)
 - Constraint: High-Pressure Die Casting (HPDC).
 - Geometry: Applied a central parting line, strict draft angles (minimum 2 degrees) to ensure ejection, and smooth transitions to improve flow and reduce porosity.

4. VALIDATION

Using **Simulation-Driven Design (SDD) with meshless FEA**, we validated both geometries against the original load cases. We verified that the maximum Von Mises stress remained below the yield strength of the respective aluminium alloy, ensuring a consistent Factor of Safety (FoS) of 1.5.

Key Metrics Comparison

	Die Casting	CNC-Machining	Improvement
Mass	2.13kg	1.92 kg	10% Reduction
Max Stress	120 MPa	170 MPa	Safe (<275 MPa yield)
Max Deflection	0.45 mm	0.48 mm	Parity maintained
Material	A380 Alloy	Al-6061-T6	-
Unit Cost (1 000 units)	\$213.00	\$145.00	-
Unit Cost (50 000 units)	\$28.00	\$122.00	-



Die Casting Optimized



CNC-Machining Optimized