



Landing Gear Bracket: 60% Weight Reduction Through Assembly-Aware Topology Optimization

This case study documents the lightweighting of a landing gear actuation bracket. The value Cognitive Design delivered here was not a single clever optimization; it was the ability to generate and compare distinct design concepts quickly and converge on the best balance of weight, structural performance, and manufacturability. By running multiple optimization routes in parallel and using simulation to guide targeted reinforcement, the team reached a 60% weight reduction while holding peak stress to within 9% of the baseline.

Engineering Challenge

Landing gear brackets operate under cyclic loading across three distinct actuation phases: retraction, extension, and ground contact at touchdown. The hard part of lightweighting a component like this is rarely a single optimization run; it is exploring enough of the design space, fast enough, to find a concept that is light and strong and practical to manufacture.

The challenges the team set out to address:

- 1. Breadth of exploration under time pressure:** Conventional workflows produce one or two concepts sequentially, by hand, before deadlines force a choice. Promising design directions are often never evaluated simply because there is no time to model them.
- 2. Competing objectives:** Aggressive mass reduction drives peak stress up and tends to produce geometry that is harder or more expensive to manufacture. The goal is the best trade-off, not minimum weight in isolation.
- 3. Keeping feasibility and cost in the loop early:** Performance, manufacturability, and cost need to be evaluated together from the start, rather than discovering downstream that the lightest concept cannot be produced economically.





The Solution: Cognitive Design Workflow

1. Design Space & Load Cases

The customer's engineering team imported the bracket together with its two fasteners, each placed in its correct spatial position from the legacy CAD environment. The team defined preservation zones around the fastener interfaces and structural mounting regions, then configured three load cases corresponding to the mechanism's actuation sequence: retraction, extension, and landing impact. Loads were applied through the fastener bodies so the optimization captured realistic lever-arm effects rather than loads smeared onto a single face. Modeling the parts in their assembled context also made the load setup easy to read and review.

2. Rapid Concept Exploration

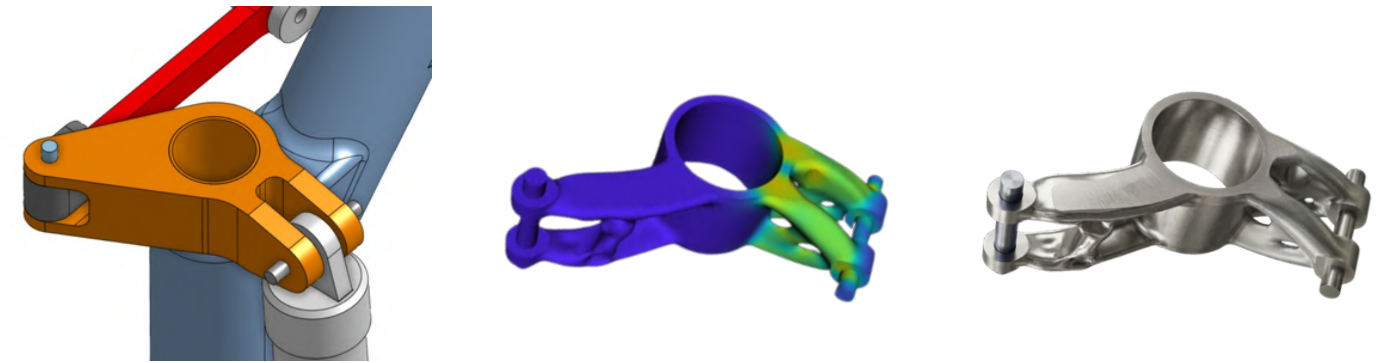
The core of the workflow was **generating multiple distinct concepts and evaluating them side by side**. The customer's engineering team ran two optimization routes in parallel: a standard topology optimization and a Start Design for LevelSet pass, which seeds the input mesh with holes to guide the level-set solver toward more organic, interconnected material distributions. The two routes produced **different geometric families** (one favoring tubular members, the other a more distributed aperture pattern), giving the team real shape diversity to compare instead of a single answer to accept or reject. Smoothing was applied in post-processing to maximize the quality of the organic connections.

3. Finding the Best Trade-off

The initial optimization **cut mass from 1.4 kg to 0.56 kg, a 60% reduction**, but peak Von Mises stress rose from 270 MPa to 426 MPa. Rather than discard the lightest concept, the customer's engineering team used Simulation-Driven Design to add material back only where the simulation showed it was needed: variable ribbing targeted at the landing load case, where stress concentration was highest. This localized reinforcement brought **peak stress down to 294 MPa** while preserving a 60% mass reduction (59.9%). Adding material precisely where it earns its weight (rather than uniformly thickening the part) is what makes the final trade-off favorable.

4. Manufacturability & Feasibility

Every concept was assessed on more than weight and stress. **Manufacturing-Driven Design** adapts the optimized geometry to the intended production process, and cost and CO2 metrics let concepts be compared on feasibility and footprint, not performance alone. The result is that the concept chosen for the bracket was selected as the **best overall trade-off across the criteria that matter in production**, not just the lightest geometry on paper.



Key Metrics Comparison

Metric	Legacy (Al-7075-T6)	Optimized CNC (Al-7075-T6)	Improvement
Mass (kg)	1.40	0.56	60% reduction
Peak Von Mises Stress (MPa)	270	294	9%
Design concepts generated & compared	1 (single manual concept)	2 routes (standard + Start Design for LevelSet)	
Feasibility & cost in the loop	Late, manual	Continuous, alongside performance	Earlier trade-off decisions
Engineering lead time (first part)	8-10 weeks (Est.)	1-2 weeks (Est.)	~85% faster

