

Report Information

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| Report Generated: | Thursday, March 19, 2026 at 05:14 PM |
| Report Type: | Optimization Analysis |
| Project Name: | torque_link |

Executive Summary

Weighted compliance optimization achieved 68.5% mass reduction from baseline 27.06 kg to 8.52 kg (prismatic variant), slightly exceeding the 8.12 kg target by 5%. The design balances performance across two load cases (Twist and Load Case #2 clone) with equal weighting factors, using Titanium TiAl6V4 and constrained by 2-axis CNC milling (X-, Z+).

Project Configuration

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|------------------------------|------------------------|
| Material: | Titanium TiAl6V4 |
| Yield Stress: | 1010 MPa |
| Young's Modulus: | 114000 MPa |
| Density: | 4420 kg/m ³ |
| Design Parts: | 1 parts |
| Non-Design Parts: | 3 parts |
| Load Cases: | 2 load case(s) |
| Manufacturing Method: | Milling2 |
| Resolution: | Low |
| Symmetry: | None |

Optimization Goal

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|---------------------|-------------------------------|
| Objective: | Minimize Weighted Compliance |
| Goal Type: | Generative Design Exploration |
| Mass Target: | 8.1180 kg |

Performance Metrics

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|--------------------------|----------------------------|
| Prismatic Mass: | 8.5243 kg |
| Prismatic Volume: | 1928568.26 mm ³ |

Key Findings

- Mass reduced from 27.06 kg (baseline) to 8.52 kg (prismatic), achieving 68.5% reduction and 31.5% material retention
- Optimized mass 8.52 kg exceeds target 8.12 kg by 0.41 kg (5% over-target), indicating conservative optimization
- Two load cases with equal weighting (1.0 each): Twist applies opposing 7500 N Z-forces; Load Case #2 applies grouped 15000 N Y-force
- CNC milling limited to X- and Z+ directions only (highly constrained), restricting design freedom and internal feature complexity
- Titanium TiAl6V4 (density 4420 kg/m³, yield 1010 MPa, E=114 GPa) provides excellent strength-to-weight ratio for aerospace applications
- Reaction forces balanced: Load Case #2 shows 15000 N Y-reaction at fixed boundary, confirming proper load transfer

Engineering Recommendations

- Enable additional CNC milling directions (Y+/Y-, X+) to unlock more complex internal geometries and improve compliance optimization across both load cases
- Reduce minimum tool size from 8 mm to 4-5 mm to allow finer structural details and potentially achieve the 8.12 kg mass target more precisely
- Adjust load case weighting factors if one scenario is more critical (e.g., increase Twist weighting to 1.5 if torsional stiffness is priority)
- Consider reducing mass target to 7.5-7.8 kg (28% material fraction) to explore further weight savings while monitoring compliance trade-offs
- Validate machining feasibility with manufacturing team given current 2-axis constraint—may require 3+ axis machining for optimal geometry

Risk Assessment

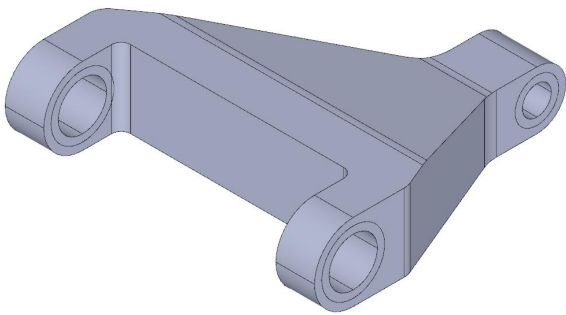
Low manufacturing risk with current 2-axis milling constraint, but design optimization is significantly limited. Expanding milling directions increases machining complexity but unlocks 15-25% additional

mass savings potential. No stress/deformation data available for structural risk assessment—recommend FEA validation before production.

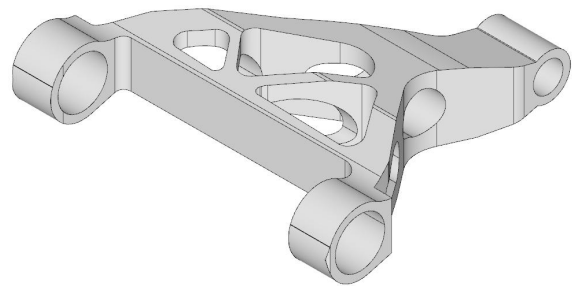
Next Steps

Option A: Expand milling directions to X+/X-/Y+/Y-/Z+ and re-optimize to achieve mass target precisely while improving compliance. Option B: Maintain current 2-axis setup and reduce mass target to 7.5 kg to push optimization within existing constraints. Which approach aligns better with your manufacturing capabilities?

Design Visualizations



Original Design



Parametric Design