Gusset — comparison with the SimJEB bracket dataset

12 October 2026 · Gusset 0.15.5 · Windows 11

Summary

11 of the dataset's 381 jet engine brackets were run in Gusset at the **Standard (3 passes)** setting, each under its four load cases, and compared with the dataset's own finite element results at the same points. Over the 44 bracket and load case pairs the largest displacement differs from the reference by a median of **+5.2%** (from −1.5% to +16.4%), and the high stress (the level only 0.1% of points exceed) by a median of **+17.6%** (from +3.1% to +64.5%). A bracket took a median of 179 s for all four cases.

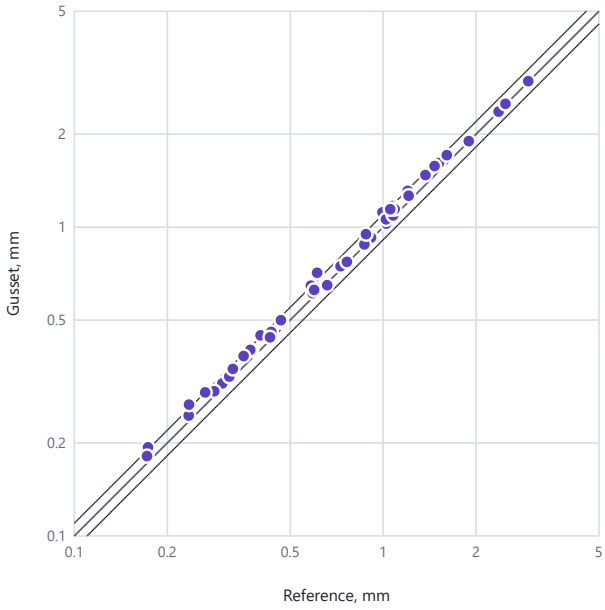
3 of these 11 brackets stopped before their last pass: finer cells at holes and fillets would not fit in the memory free (378, 113, 133). Their results are those of the pass before, which the program marks as not confirmed by a finer pass; the Passes column of the table below says how many each ran.

The reference is another finite element result, not an exact answer: first-order tetrahedra about 1.3 mm across, which are known to be a little stiff, with stresses averaged at the nodes. Agreement says the two programs solve the same problem alike; a difference does not say which is nearer the truth.

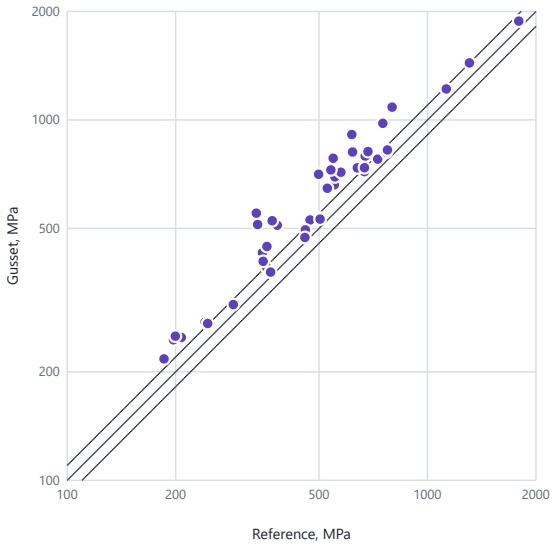
Against a second reference of quadratic tetrahedra, made for 4 of the brackets (40, 148, 488, 570), Gusset's largest displacement differs by a median of **−1.4%** and its mean stress on the surface by **+1.3%**; the dataset's differ by −7.1% and −11.8%. Most of the difference between Gusset and the dataset is the dataset reading stiff, and low at the surface. See *Against a second reference* below.

Gusset marked 4 of the brackets as having thin material its cells did not resolve (378, 82, 133, 488): struts and webs a few millimetres across, under two cells wide at this setting or in the memory there was. Their results are given, with the program's warning that deflections there are likely too small and stresses unreliable.

Largest displacement: Gusset against the reference, one dot per bracket and load case. Solid line: agreement. Dashed: 10% either side.



High stress (99.9th percentile of von Mises): Gusset against the reference, one dot per bracket and load case. Solid line: agreement. Dashed: 10% either side.



What was compared

Dataset	SimJEB, the Simulated Jet Engine Bracket Dataset (Whalen, Beyene and Mueller, 2021): 381 bracket designs from the GE jet engine bracket challenge, each with cleaned CAD, a tetrahedral mesh and linear static results from Altair OptiStruct for four load cases.
Brackets run	The dataset's sample bracket (148), and two from each of its five main kinds (arch, beam, block, butterfly, flat): those a third and two thirds of the way up each kind's range of volume. Chosen before any was run.
Geometry	The dataset's STEP file, opened as any model is.
Material	Ti-6Al-4V as in the dataset's solver deck: E = 113.8 GPa, ν = 0.342.
Held	The walls of the four bolt holes, fixed. In the reference each hole's nodes hang on a rigid spider whose centre is held.
Loaded	The walls of the two clevis pin holes, with a remote load at the point the reference loads: vertical, 35.6 kN up; horizontal, 37.8 kN sideways; diagonal, 42.3 kN at 42° from vertical; torsion, 565 N m about the vertical. In the reference the load is spread over the same walls by a distributing spider (RBE3).
Faces	Found from the reference deck: the CAD faces lying on the spiders' nodes. Every spider node of every bracket run lies on a face so chosen.
Solving	Through the program's normal pipeline. The first load case is solved with the adaptive passes; the other three reuse its cells, as the program does when only the loads change. Where the passes stopped early the program keeps nothing for reuse, and each load case is solved from the start.
Points	60,000 of the reference mesh's nodes per bracket, drawn at random, the same for every case. Displacement is compared at all of them. Stress is compared at those more than 4 mm from a held or loaded node: at the edges of the held and loaded faces the stress is singular in both models and its value there depends on the cells.

Displacement

The largest displacement anywhere in the bracket, Gusset against the reference, per load case; and the difference between the two displacement fields over all the points compared (root mean square of the difference over that of the reference), the median of the four cases.

BRACKET	KIND	PASSES	UNKNOWNS	TIME	VERTICAL	HORIZONTAL	DIAGONAL	TORSION	FIELD
378	arch	2 of 3	184,551	246 s	+0.2%	−1.5%	+3.4%	+3.4%	3.1%
597	arch	3 of 3	684,165	179 s	+9.1%	+8.9%	+12.2%	+11.3%	9.3%
8	beam	3 of 3	356,466	179 s	+6.5%	+6.3%	+5.9%	+10.9%	6.4%
82	beam	3 of 3	224,571	146 s	+0.6%	+0.0%	+1.2%	+3.3%	1.6%
113	block	2 of 3	173,106	100 s	+4.7%	+4.8%	+4.6%	+11.9%	4.8%
133	block	2 of 3	185,613	175 s	+3.7%	+2.7%	+5.4%	+13.2%	4.4%
40	butterfly	3 of 3	397,629	183 s	+7.5%	+7.5%	+6.5%	+16.4%	7.4%
148	butterfly	3 of 3	389,583	268 s	+0.6%	+0.2%	+1.2%	+3.6%	1.1%
337	butterfly	3 of 3	207,717	170 s	+1.3%	+1.1%	+2.3%	+7.1%	1.9%
488	flat	3 of 3	534,582	208 s	+5.0%	+4.4%	+7.9%	+9.8%	4.8%
570	flat	3 of 3	457,095	124 s	+8.3%	+7.8%	+8.3%	+5.4%	8.6%

Stress

The von Mises stress that only 0.1% of the compared points exceed, Gusset against the reference, per load case, at points more than 4 mm from the held and loaded holes; the single highest value at those points, for the vertical case; and the difference between the two stress fields (as for displacement), the median of the four cases.

BRACKET	VERTICAL	HORIZONTAL	DIAGONAL	TORSION	PEAK, VERTICAL	REFERENCE	FIELD
378	+7.5%	+19.9%	+6.2%	+9.9%	1,546 MPa	1,185 MPa	20%
597	+18.2%	+25.6%	+31.6%	+23.0%	945 MPa	767 MPa	16%
8	+24.6%	+30.2%	+24.4%	+22.5%	882 MPa	732 MPa	13%
82	+4.9%	+10.1%	+7.0%	+10.2%	2,953 MPa	2,514 MPa	19%
113	+15.8%	+13.8%	+17.0%	+24.4%	513 MPa	448 MPa	16%
133	+15.3%	+11.8%	+33.3%	+20.1%	1,061 MPa	843 MPa	20%
40	+19.5%	+5.9%	+8.2%	+47.8%	1,125 MPa	952 MPa	14%
148	+8.1%	+6.6%	+10.3%	+11.0%	1,478 MPa	1,337 MPa	10%
337	+5.4%	+6.3%	+3.1%	+3.3%	661 MPa	630 MPa	13%
488	+41.8%	+43.1%	+51.8%	+64.5%	1,629 MPa	1,589 MPa	34%
570	+36.1%	+34.8%	+41.7%	+25.8%	1,809 MPa	1,244 MPa	22%

Against a second reference

The dataset's results are from first-order tetrahedra: each holds one stress, and the value at a node on the surface is the average of the elements round it - a reading from a fraction of a millimetre inside, where a bending stress is lower. To tell that apart from an error of Gusset's, 4 of the brackets were solved again, independently: the same STEP file meshed with gmsh into quadratic (10-node) tetrahedra and solved with scikit-fem and Pardiso, held on the same bolt-hole walls and loaded on the same clevis walls with the deck's force and moment (`validation/simjeb_p2.py`). The table gives Gusset and the dataset against that solution: the largest displacement, and the stress at the dataset's surface nodes more than 4 mm from the held and loaded holes - its mean, the level 0.1% of the nodes exceed, and the difference between the two fields (root mean square) - each the median of the four load cases.

BRACKET	QUADRATIC TETS	UNKNOWNS	LARGEST DISPLACEMENT		SURFACE STRESS, MEAN		SURFACE STRESS, HIGH		STRESS FIELD	
			GUSSET	DATASET	GUSSET	DATASET	GUSSET	DATASET	GUSSET	DAT
40	36,485 (3 mm)	193,113	+0.2%	−7.2%	+1.4%	−10.5%	+1.9%	−10.1%	9%	
148	131,923 (5 mm)	672,612	−2.9%	−3.6%	+0.7%	−6.8%	+0.0%	−10.5%	9%	
488 *	51,531 (3 mm)	299,799	−4.0%	−9.3%	+5.2%	−13.0%	+24.9%	−19.8%	30%	
570	109,990 (5 mm)	507,363	+0.1%	−7.0%	+1.1%	−15.2%	+0.7%	−26.3%	14%	

* Marked by Gusset as having thin material its cells did not resolve. The second reference has about one element across the same struts, so the stresses in them are not settled by either; the displacement is the firmer comparison there.

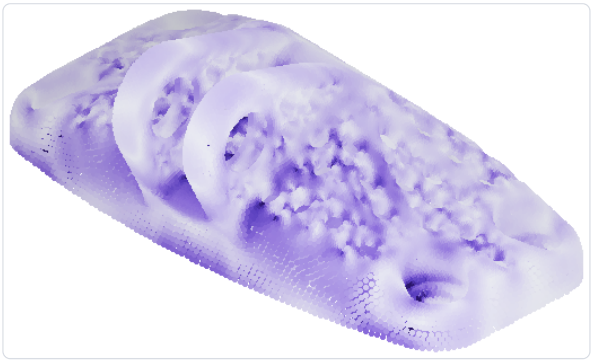
The second reference is itself a finite element result. Its elements are straight-sided on curved faces, the load is a traction on the clevis walls where the program applies a remote load, and a few of the dataset's nodes on curved faces lie just outside its mesh and are read by extrapolation. On the sample bracket (148) a mesh

of 2.3 times the unknowns moved its largest displacement by 0.4% and its high stress by 1.5%.

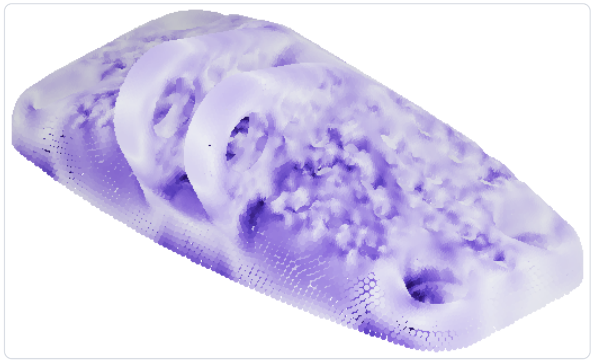
The brackets

Von Mises stress on the surface under the vertical load, the reference beside Gusset at the same points and on the same scale.

Bracket 378 — arch



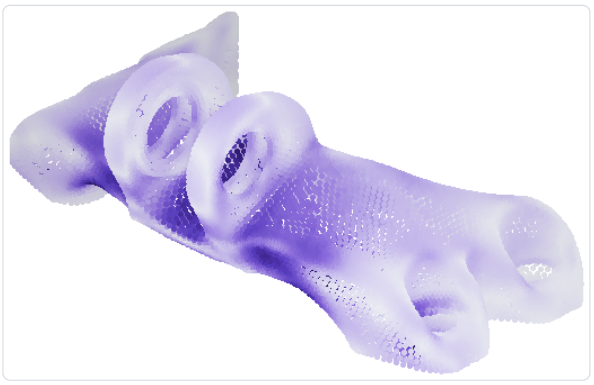
Reference: largest displacement 1.024 mm



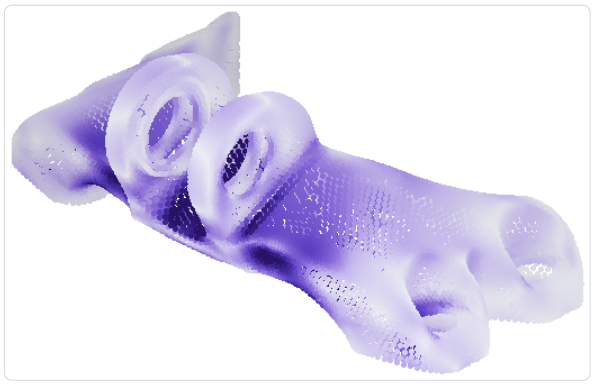
Gusset: largest displacement 1.027 mm (+0.2%)

0 649 MPa and over

Bracket 597 — arch



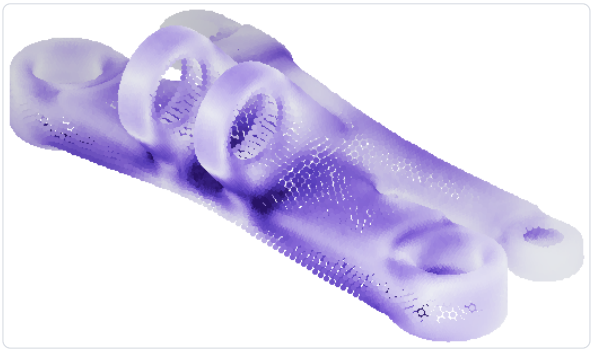
Reference: largest displacement 1.201 mm



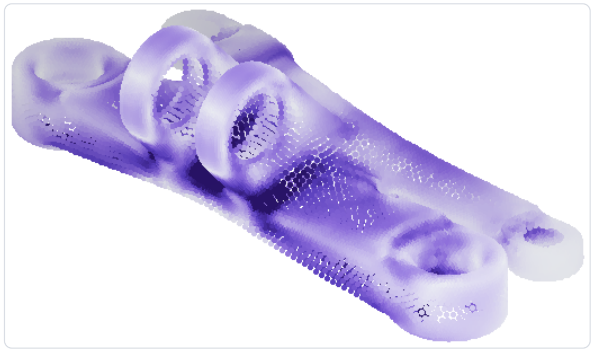
Gusset: largest displacement 1.311 mm (+9.1%)

0 607 MPa and over

Bracket 8 — beam



Reference: largest displacement 1.516 mm



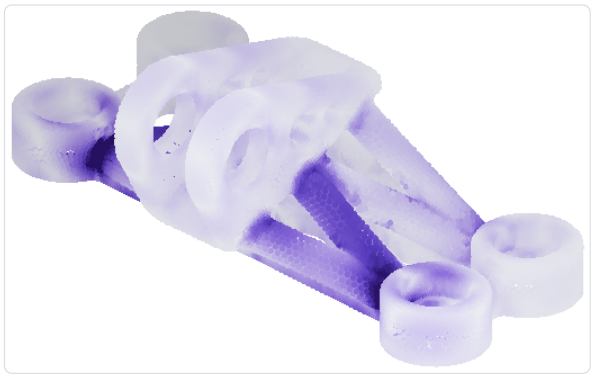
Gusset: largest displacement 1.614 mm (+6.5%)

0 547 MPa and over

Bracket 82 — beam



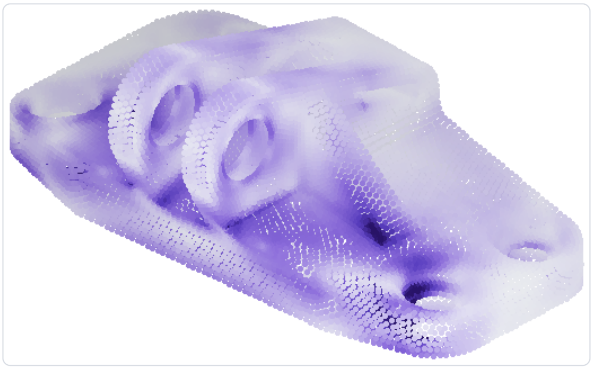
Reference: largest displacement 2.950 mm



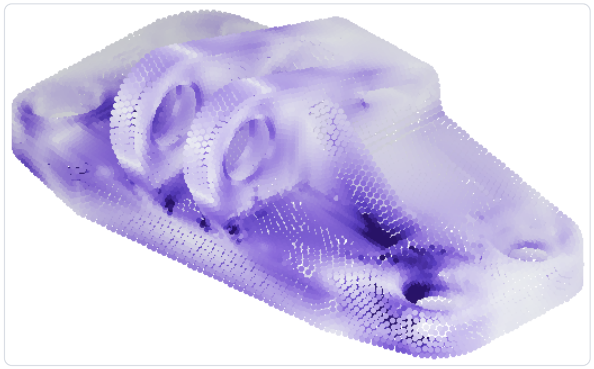
Gusset: largest displacement 2.967 mm (+0.6%)

0 1,331 MPa and over

Bracket 113 — block



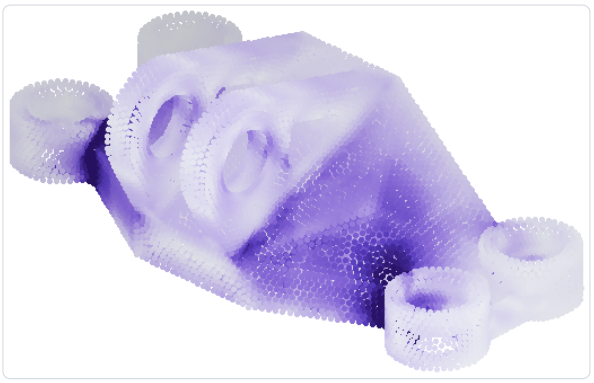
Reference: largest displacement 0.598 mm



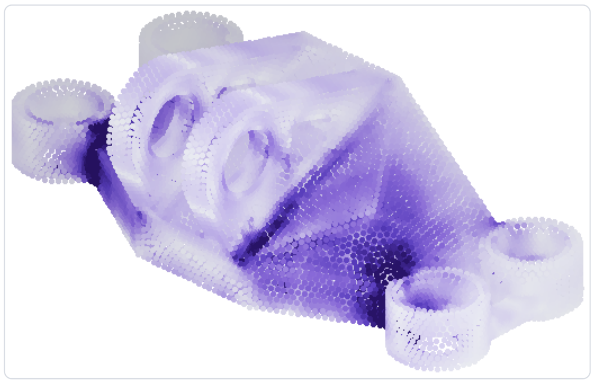
Gusset: largest displacement 0.626 mm (+4.7%)

0 340 MPa and over

Bracket 133 — block



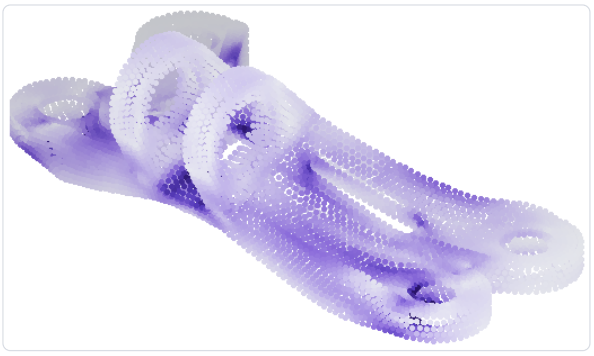
Reference: largest displacement 1.021 mm



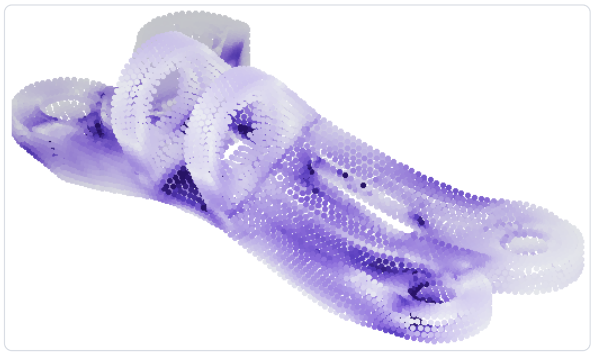
Gusset: largest displacement 1.059 mm (+3.7%)

0 554 MPa and over

Bracket 40 — butterfly



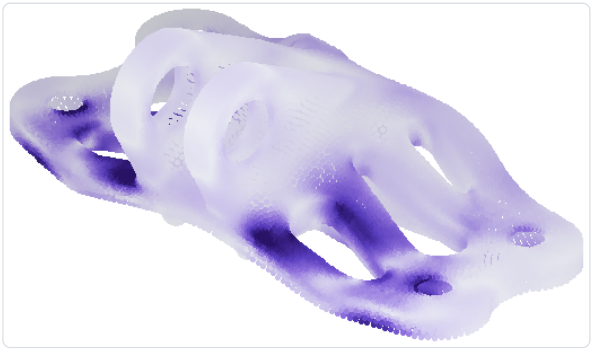
Reference: largest displacement 1.371 mm



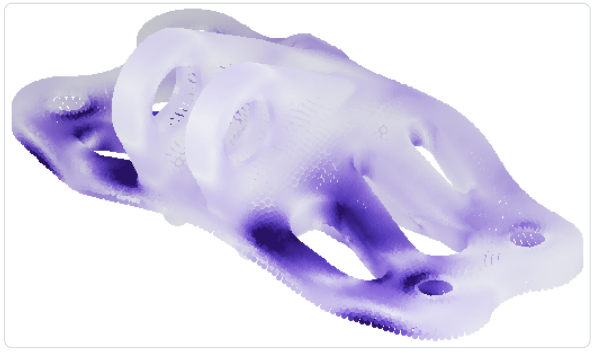
Gusset: largest displacement 1.474 mm (+7.5%)

0 679 MPa and over

Bracket 148 — butterfly



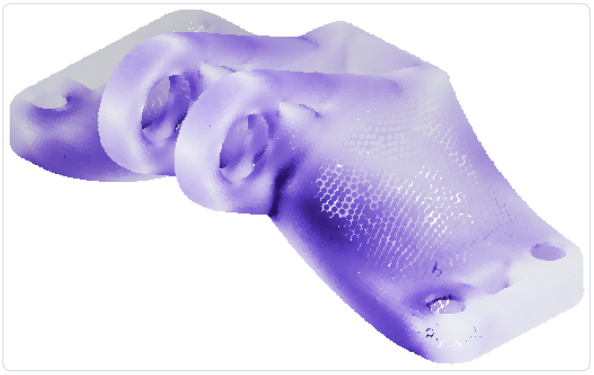
Reference: largest displacement 2.491 mm



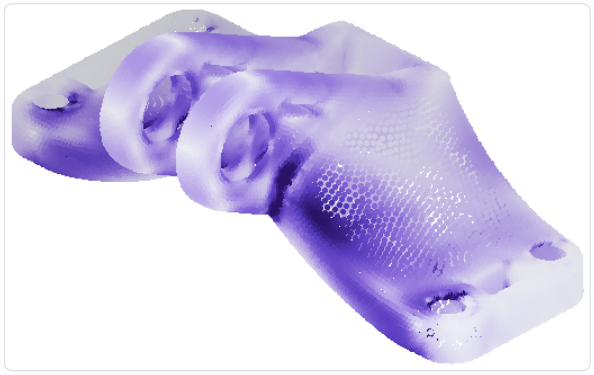
Gusset: largest displacement 2.506 mm (+0.6%)

0 1,095 MPa and over

Bracket 337 — butterfly



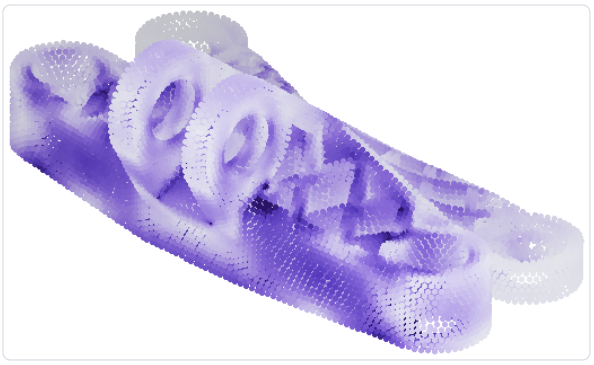
Reference: largest displacement 1.077 mm



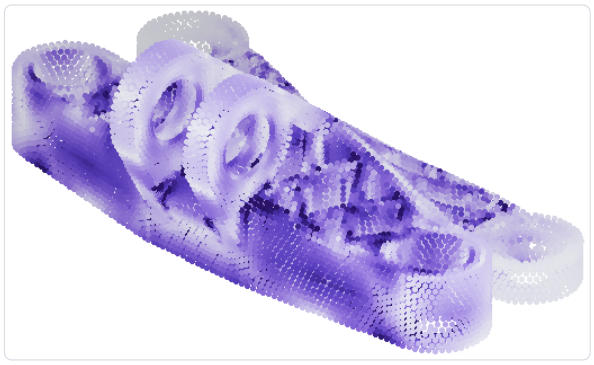
Gusset: largest displacement 1.091 mm (+1.3%)

0 492 MPa and over

Bracket 488 — flat



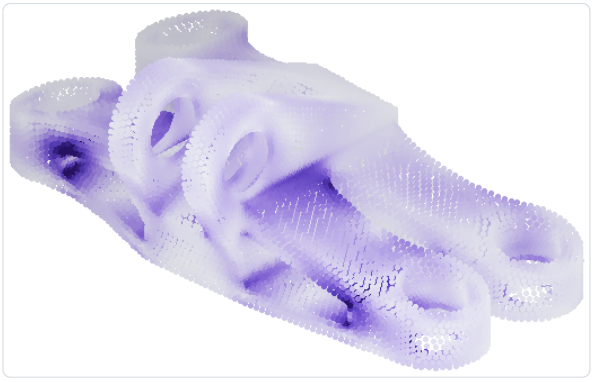
Reference: largest displacement 1.090 mm



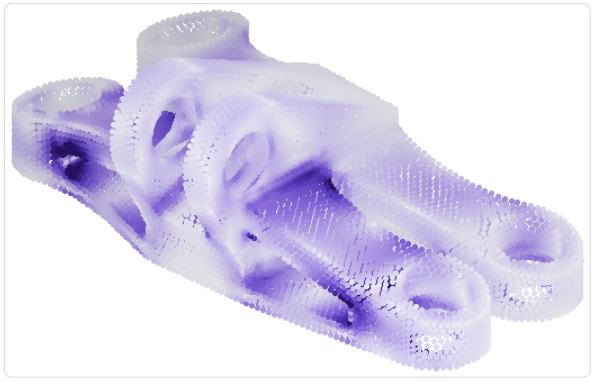
Gusset: largest displacement 1.144 mm (+5.0%)

0 424 MPa and over

Bracket 570 — flat



Reference: largest displacement 1.054 mm



Gusset: largest displacement 1.142 mm (+8.3%)

0 659 MPa and over

Gusset SimJEB comparison · SimJEB: E. Whalen, A. Beyene and C. Mueller, arXiv:2105.03534, Harvard Dataverse doi:10.7910/DVN/XFUWJG (Open Data Commons Attribution License; the bracket CAD is from the GrabCAD GE jet engine bracket challenge, licensed for non-commercial use).