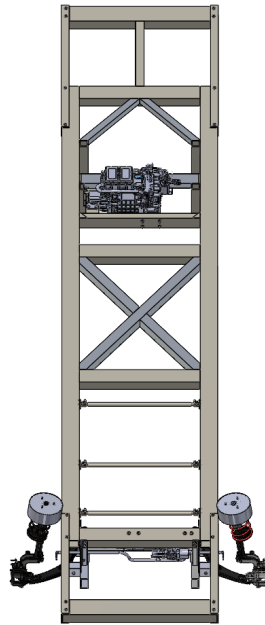


Modular Aluminium Ladder Frame for Electric Van and Light-Truck Bodies

Chassis architecture, suspension packaging, FEA and fabricator-ready documentation for a US manufacturer's modular EV platform



The brief

The client needed one frame family that could carry several van and light-truck bodies, at more than one wheelbase, on donor suspensions they could source locally. It had to be buildable by a general fabrication shop without CNC work, hit defined stiffness targets, and arrive as a complete pack the shop could cut, weld and bolt from without further engineering input.

What I designed

A flat, bend-free ladder frame in which every metal part is off-the-shelf 6061-T6 stock: 5 x 3 x 1/4 in rectangular-tube main rails, channel and angle crossmembers, and three 1.25 in round torsion tubes on bolted lugs. Members are welded where the load path demands it and bolted where the client wanted modularity, so the front module, rear module and pack bay can be repositioned along the rails for a different wheelbase or body. The front suspension was laser-scanned from a 2005 light commercial van, rebuilt in CAD, and packaged with its steering rack and anti-roll bar between the rails on bolted mounts. A rear-mounted Cascadia IDM190 drive unit sits on stock angle and plate brackets, with a central bay reserved for the battery pack.

Validation

Stiffness targets were 4 kNm/deg in torsion and 3 kN/mm in bending. The frame got there in three SolidWorks FEA iterations, with weld connections defined member by member. An A-braced front came in below half the torsional target; an X-brace at the front improved it but not enough; a further revision of the front section reached 4200 Nm/deg (105% of target) with bending stiffness of 10 kN/mm (330% of target). A bent-tube front was also trialled and gave no meaningful gain over straight members, so the production frame

keeps straight stock. Peak von Mises stress under the combined bending-plus-torsion case gives a safety factor of 4.5 against the 275 MPa yield of 6061-T6. Results were cross-checked against published ladder-chassis research.

Key figures

Wheelbase	3900 mm	Torsional stiffness	4200 Nm/deg (target 4000)
Front track	1827 mm	Bending stiffness	10 kN/mm (target 3)
Frame mass, bare	126 kg	Safety factor	4.5
Frame mass, complete	150 kg	Material	6061-T6, 100% stock sections
Main rails	5 x 3 x 1/4 in rectangular tube	Forming / CNC	None

Deliverables

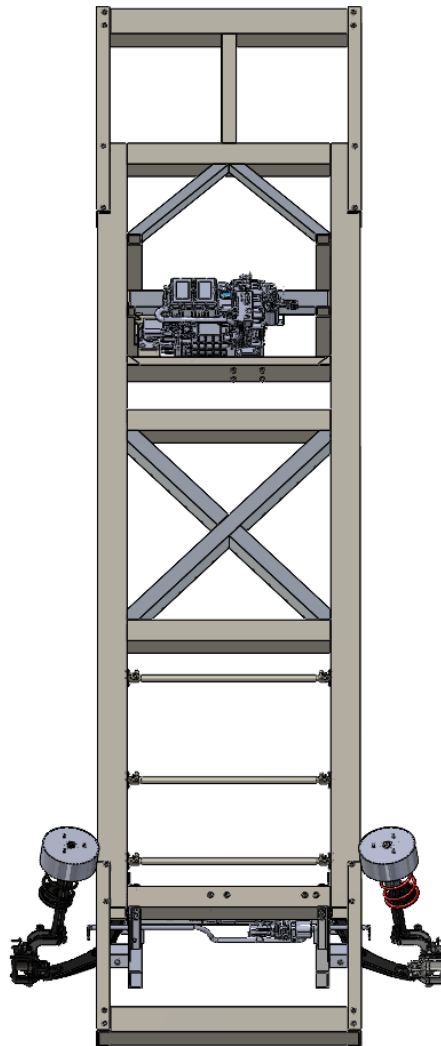
Full CAD model and STEP release; cut list and cut drawings for every section; a 30-page assembly instruction pack with weld sheets (fillet sizes called out at each joint), fastener stacks and tightening torques; and a bill of materials keyed to McMaster-Carr and MetalsDepot part numbers so the shop could order directly. Build is in progress with the client's fabricator.

Why it matters for your project

This is the working method I bring to any chassis or subsystem: vehicle dynamics and stiffness targets set first, geometry and packaging built around real donor parts, FEA used to iterate rather than to decorate, and design-for-manufacture treated as a constraint from day one so the result can be built by the shop you already have. I do the CAD, analysis and documentation myself, remotely, and I can own a full vehicle program or a single defined piece of one.

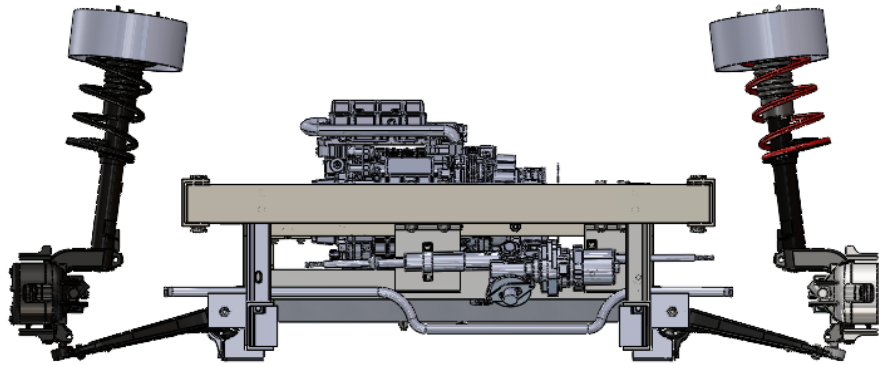
Ali Ellithy, B.Sc. Mechanical Engineering (Automotive minor), founder of Aeternum Engineering. Vehicle dynamics, suspension, chassis and packaging engineer, with FEA and design for manufacture. Top Rated Plus on Upwork (top 3%). Previous programs include a steer-to-tilt quad taken to production, an F1-style EV chassis and battery thermal system, and IVA validation of a Chrysler 300C through DVSA/UTAC.

Figure 1. Frame overview



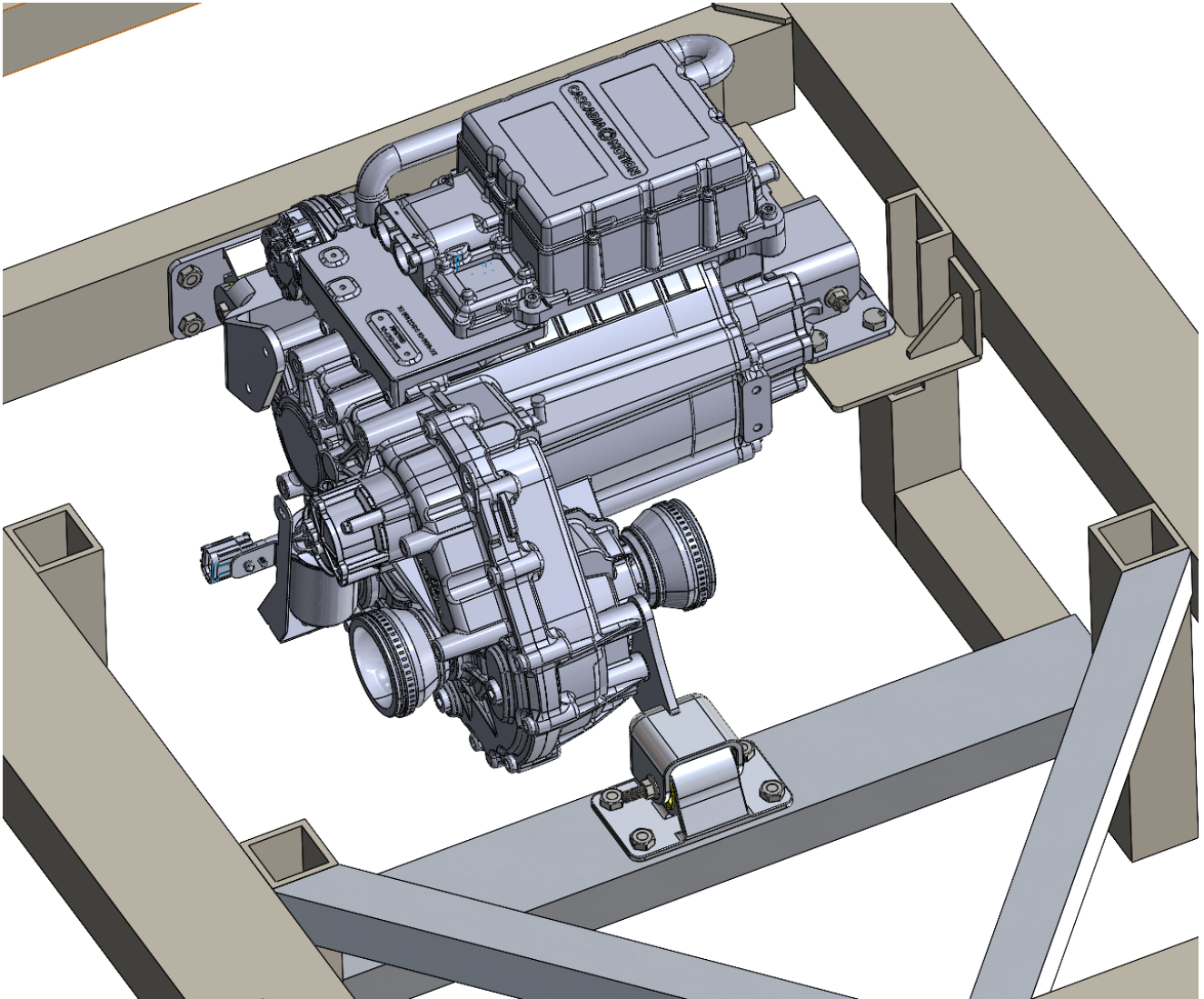
Full frame: rectangular-tube rails, X-braced and channel crossmembers, three round torsion tubes, rear drive unit, central pack bay and the scanned front suspension.

Figure 2. Front module



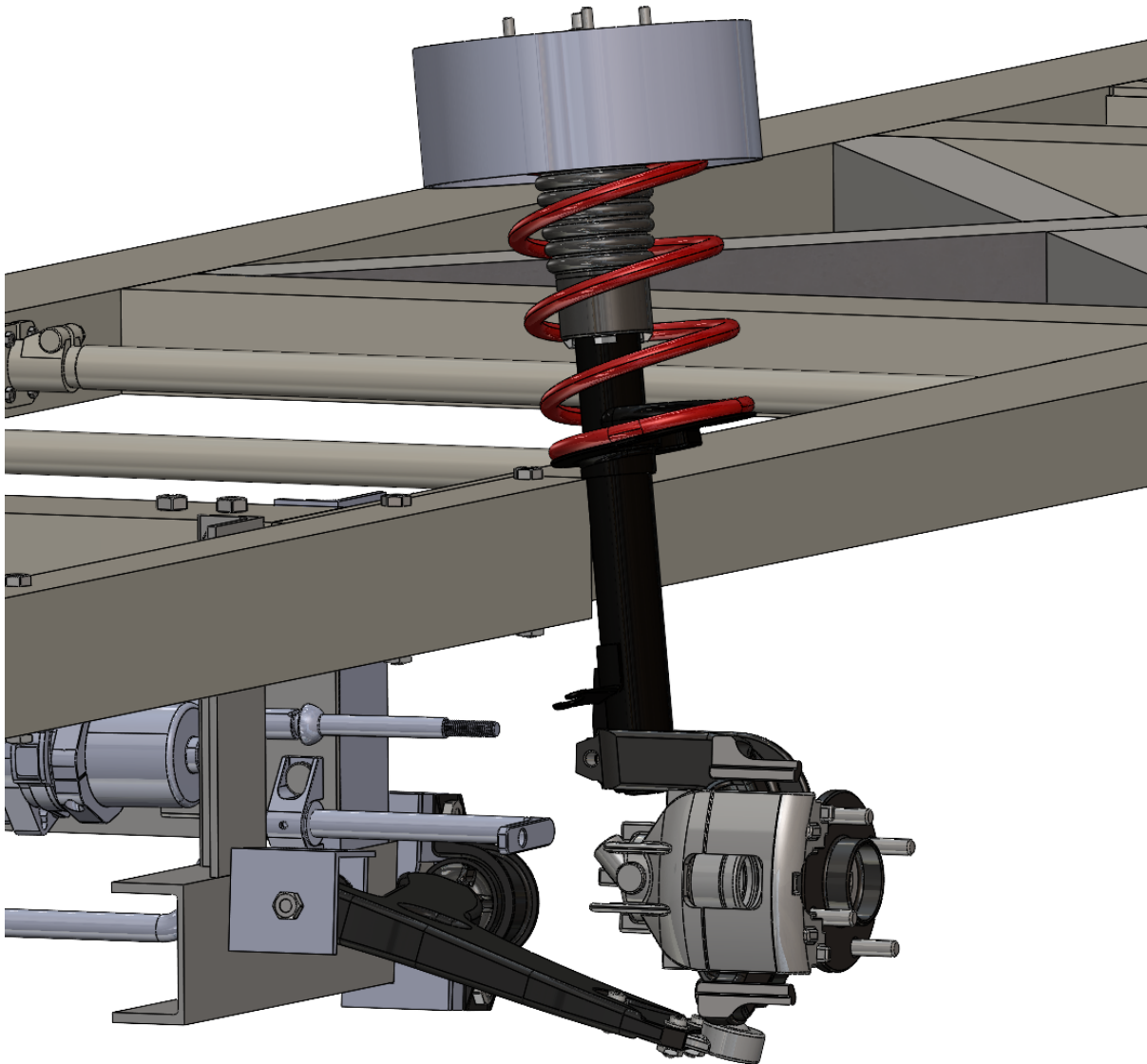
Laser-scanned donor struts and lower arms on bolted mounts, with the steering rack and anti-roll bar packaged between the rails.

Figure 3. Rear drive unit



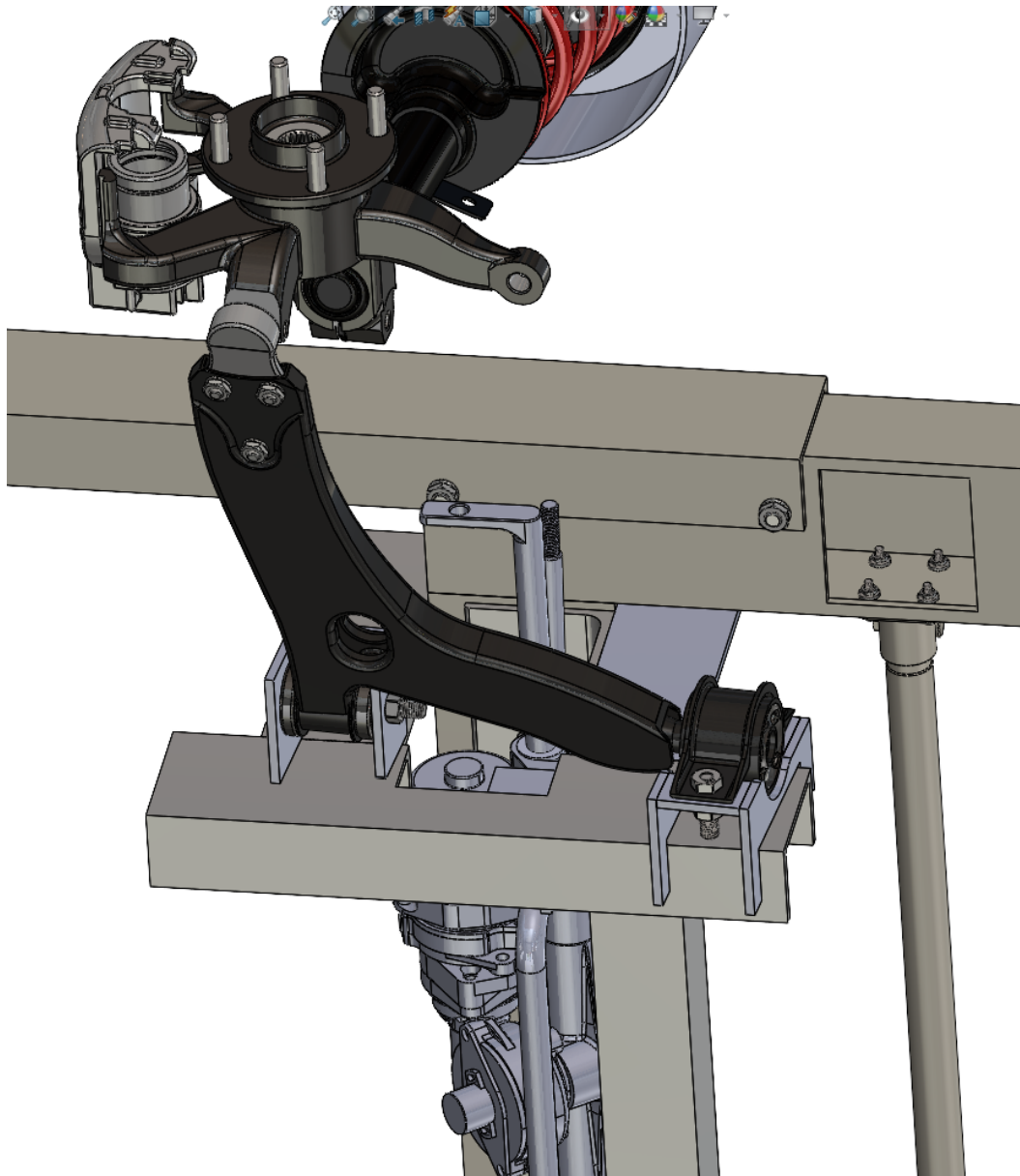
Drive unit carried on bolted brackets between the crossmembers, all cut from stock angle and plate.

Figure 4. Strut tower and knuckle



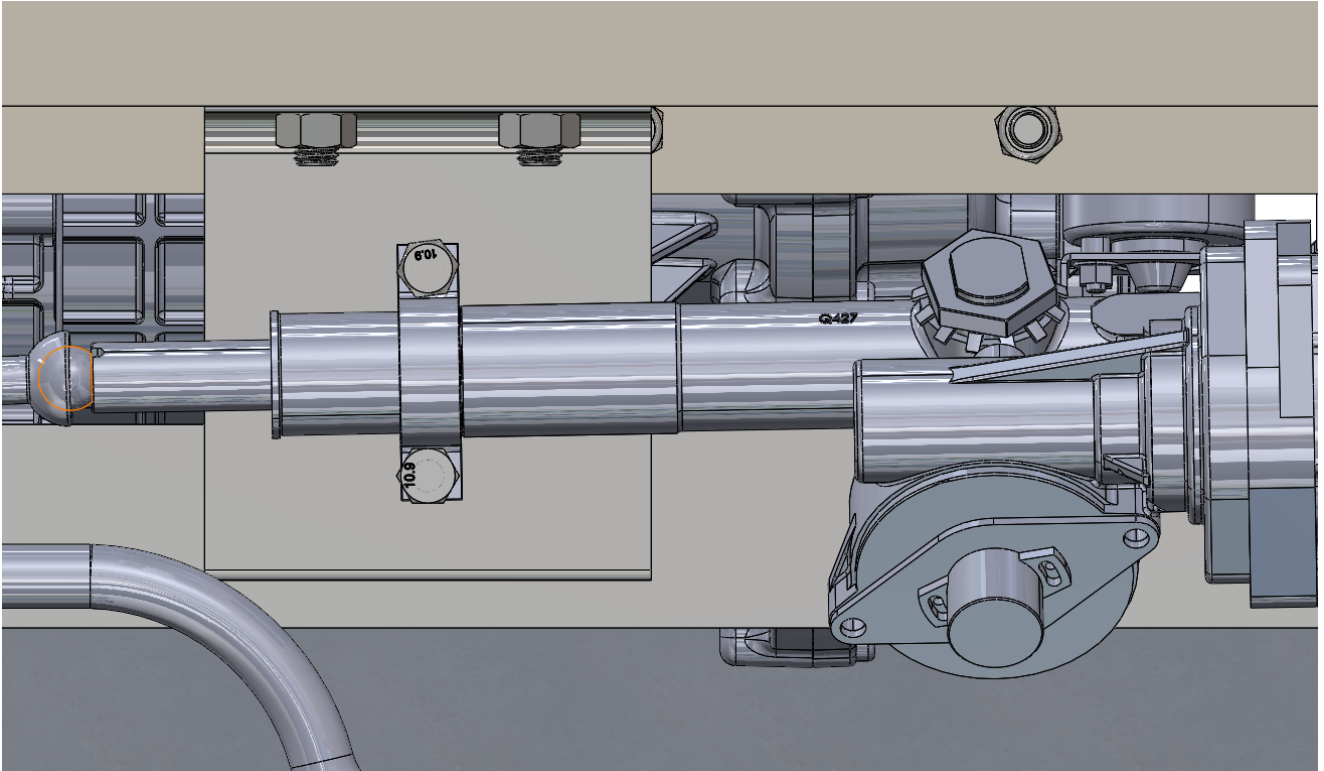
Strut tower and lower-arm pick-up reconstructed from the laser scan and mounted to stock sections.

Figure 5. Lower control arm mounts



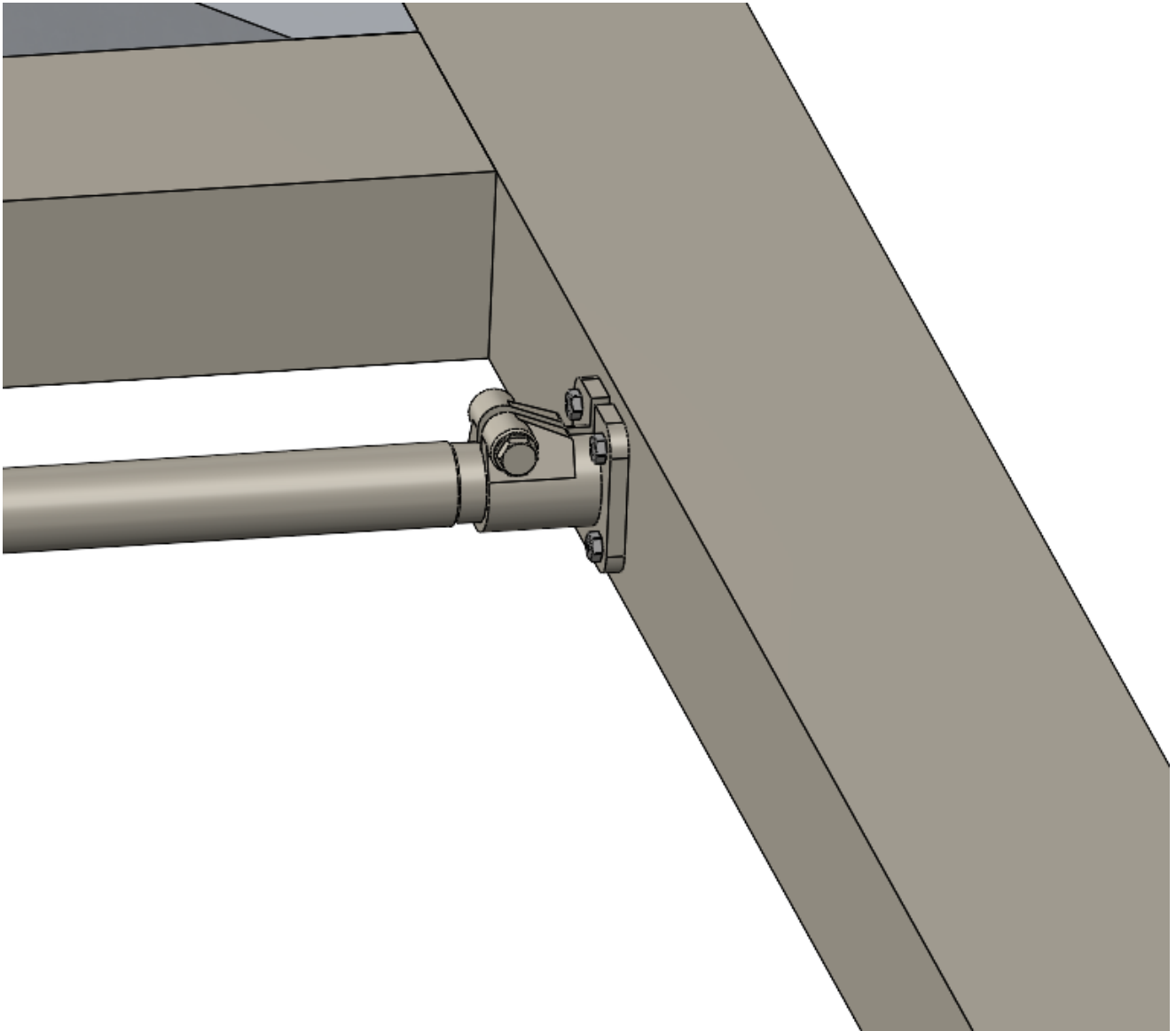
Lower arm bracketry bolted to the rail; no welds on the suspension load path.

Figure 6. Steering routing



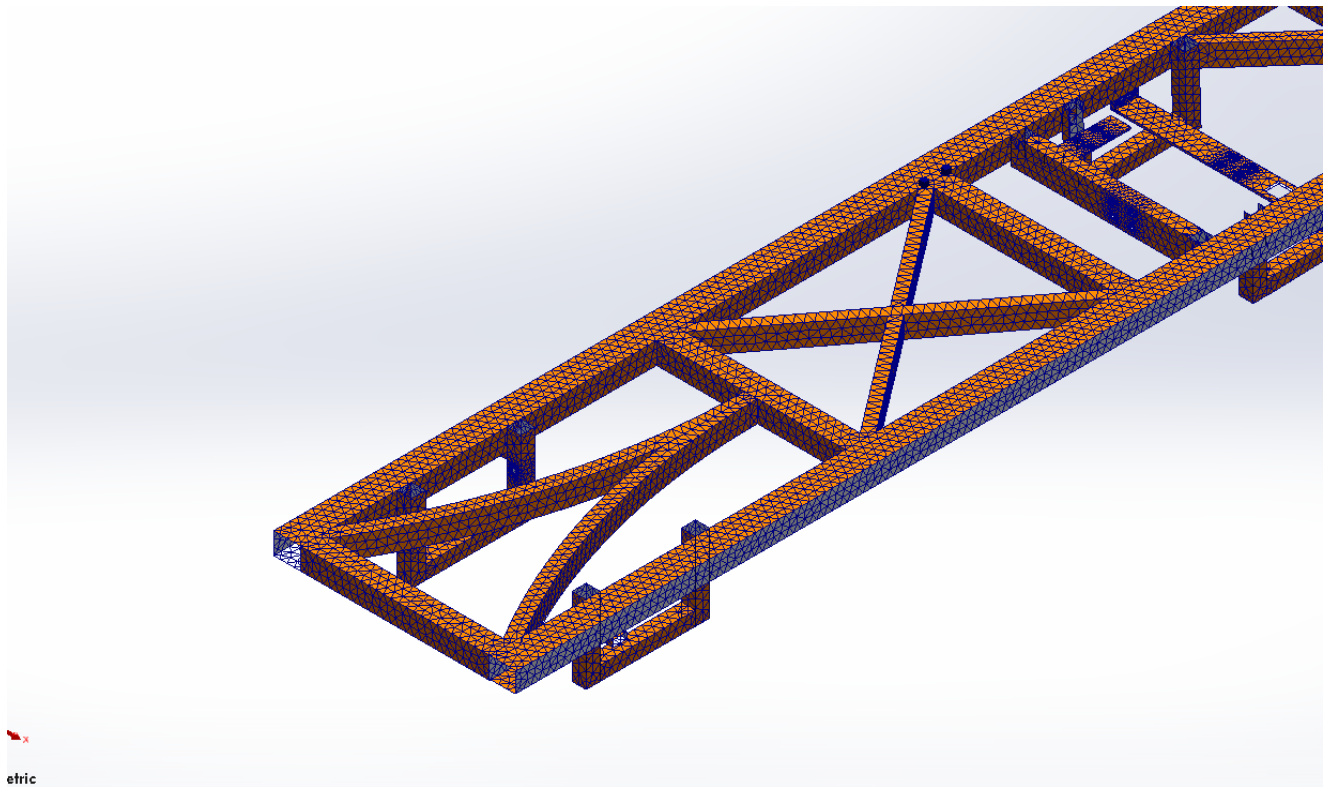
Steering column and intermediate shaft routed through the rail on a stock support bearing.

Figure 7. Torsion tube fitting



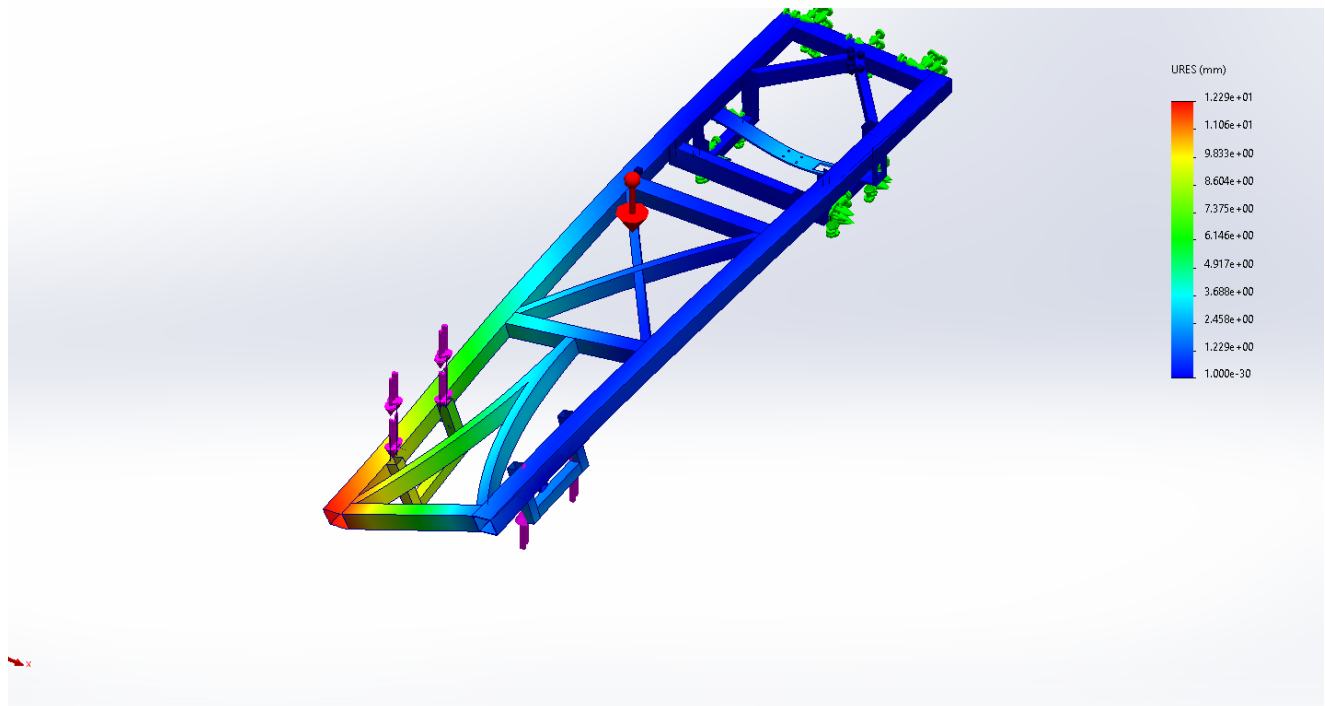
End fitting of one of the three round torsion tubes on its bolted lug.

Figure 8. FEA, iteration 1 mesh



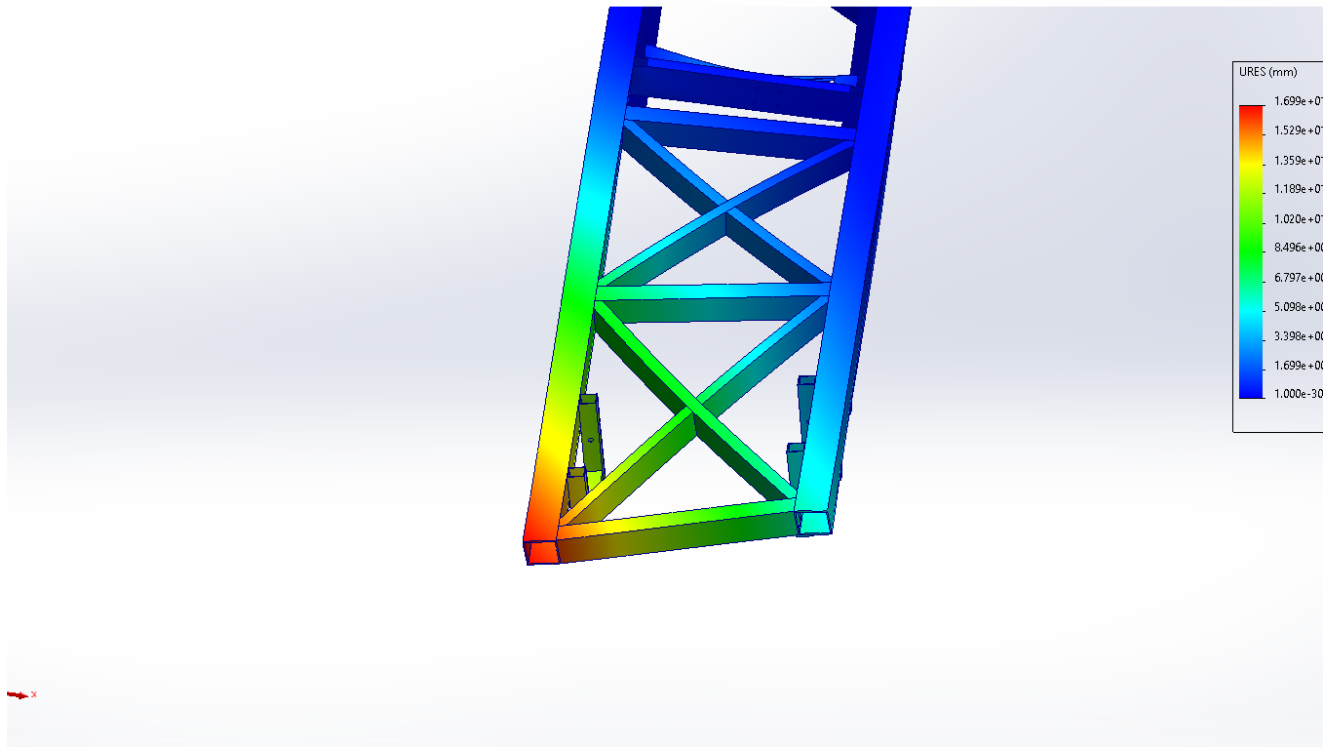
A-shaped front brace, three crossmembers, two rear diagonals. Weld connections defined manually between every member.

Figure 9. FEA, iteration 1 torsion



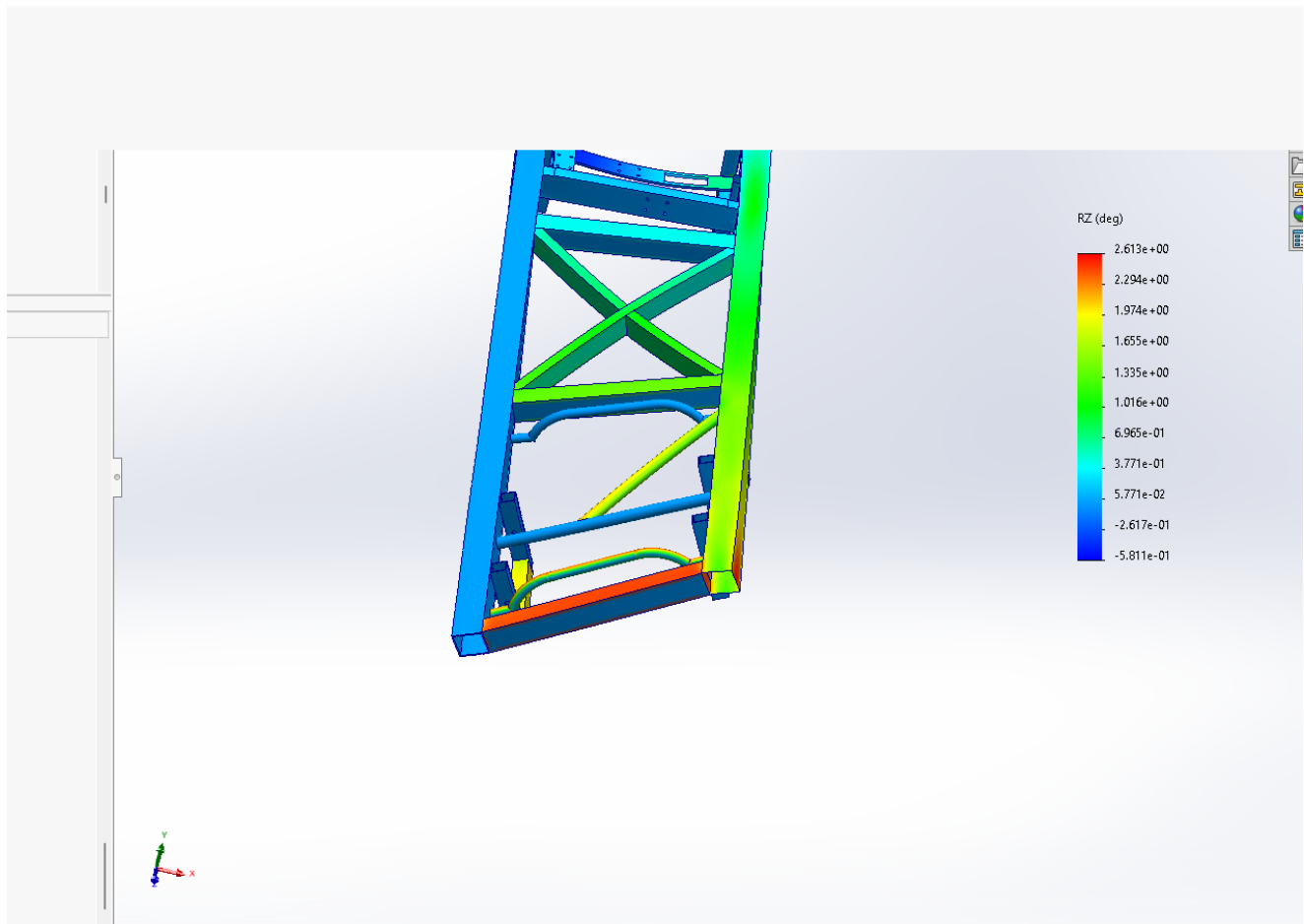
Torsion case, 2500 N couple: stiffness below half of the 4 kNm/deg target.

Figure 10. FEA, iteration 2 torsion



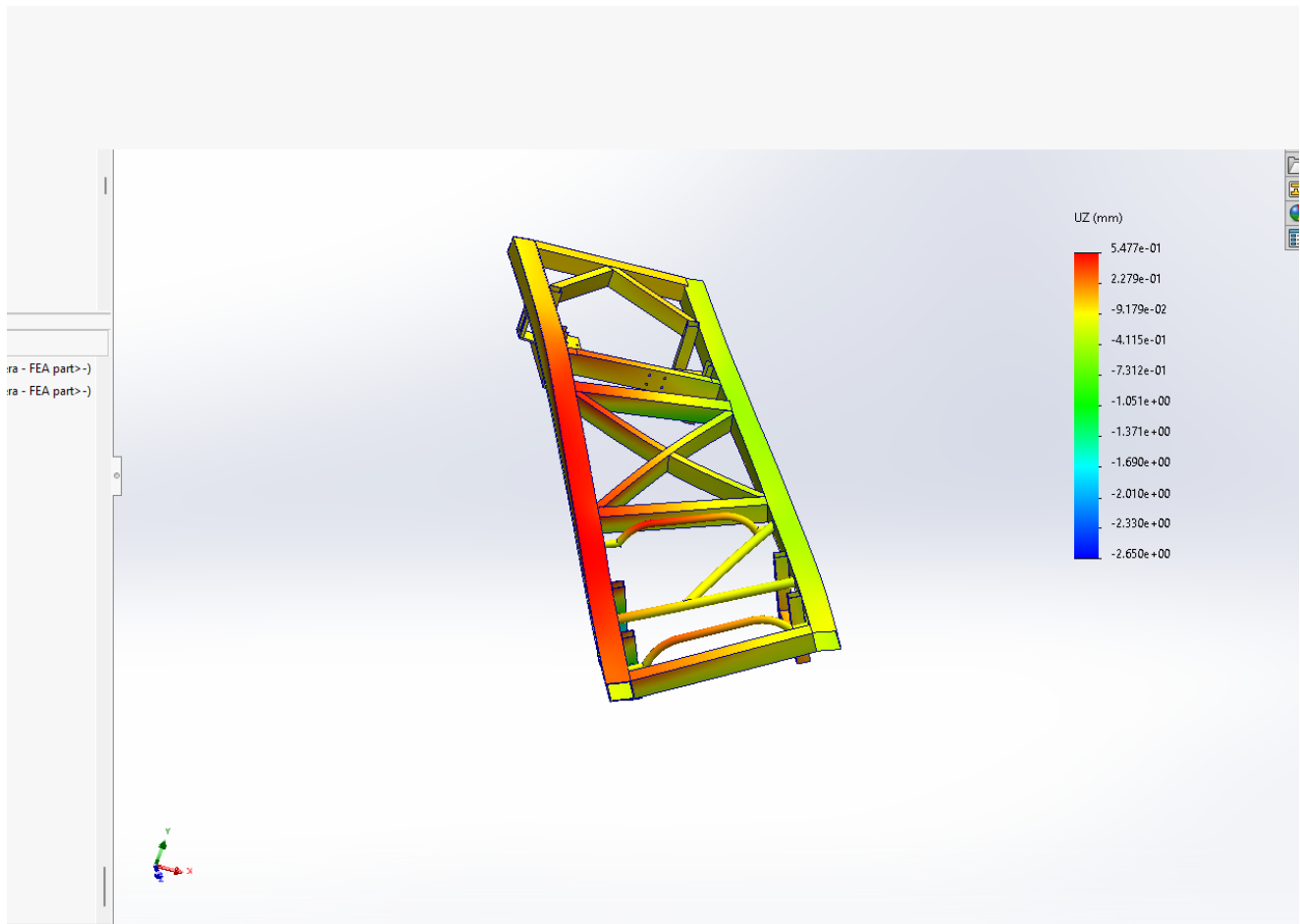
X-brace replaces the A-beam at the front. Improved, but still short of target.

Figure 11. FEA, iteration 3 torsion



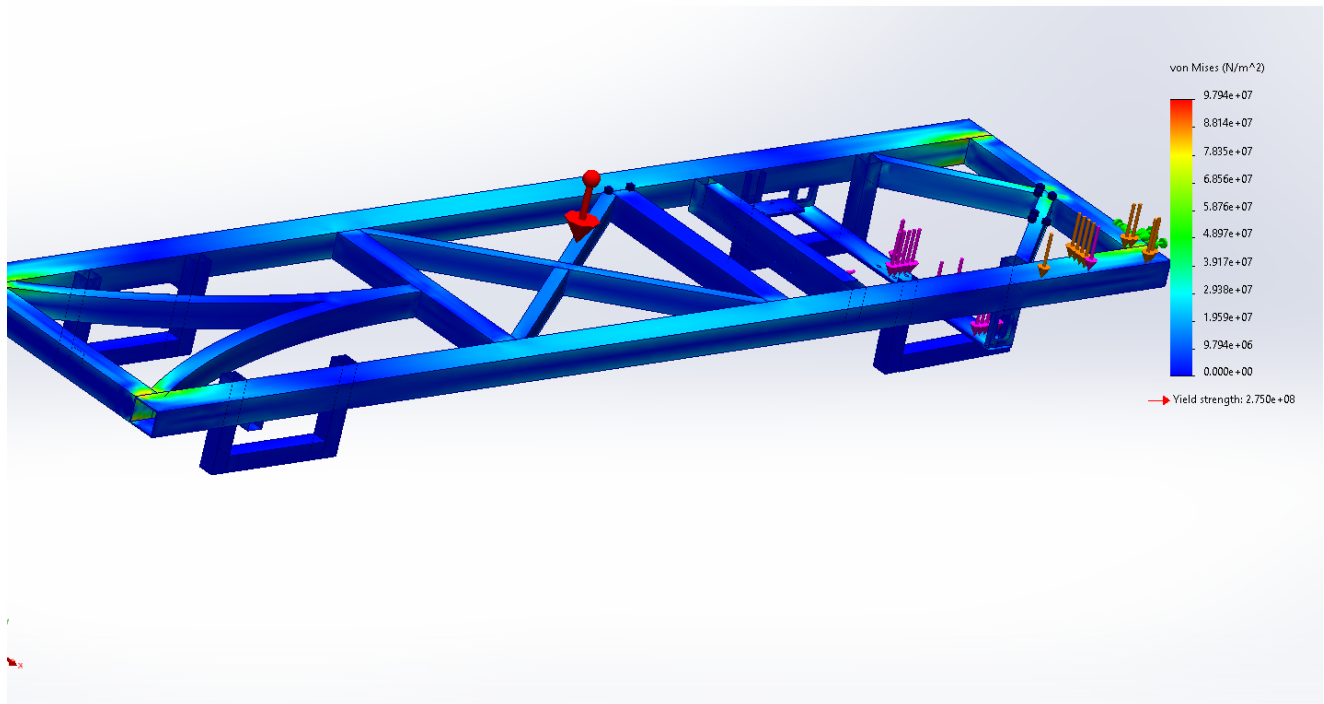
Front section revised again. A bent-tube front was trialled and gave no meaningful gain over straight members, so the production frame keeps straight stock. Torsional stiffness 4200 Nm/deg, 105% of target.

Figure 12. FEA, iteration 3 displacement



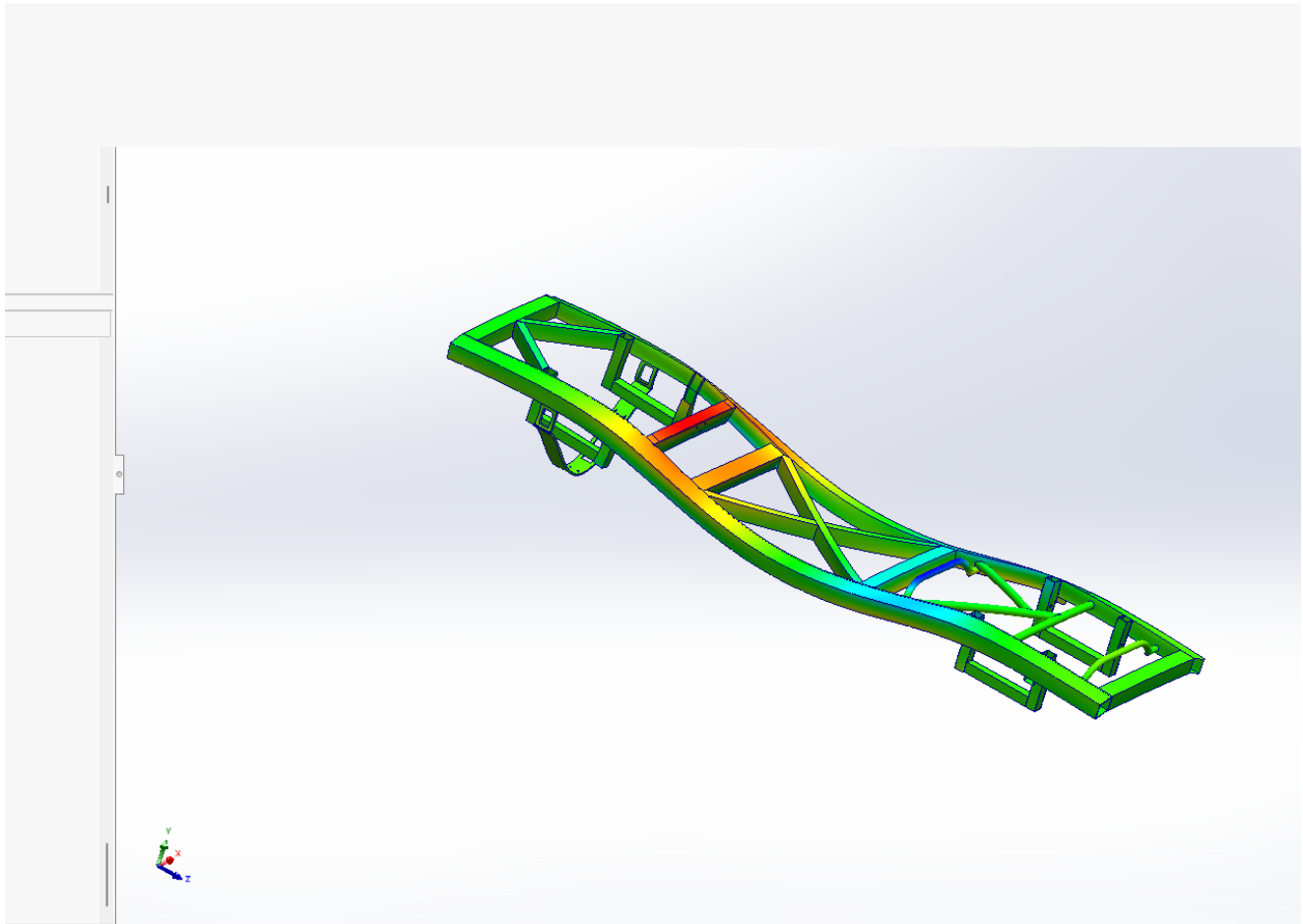
Torsion displacement plot of the final iteration, isometric view.

Figure 13. FEA, torsion stress



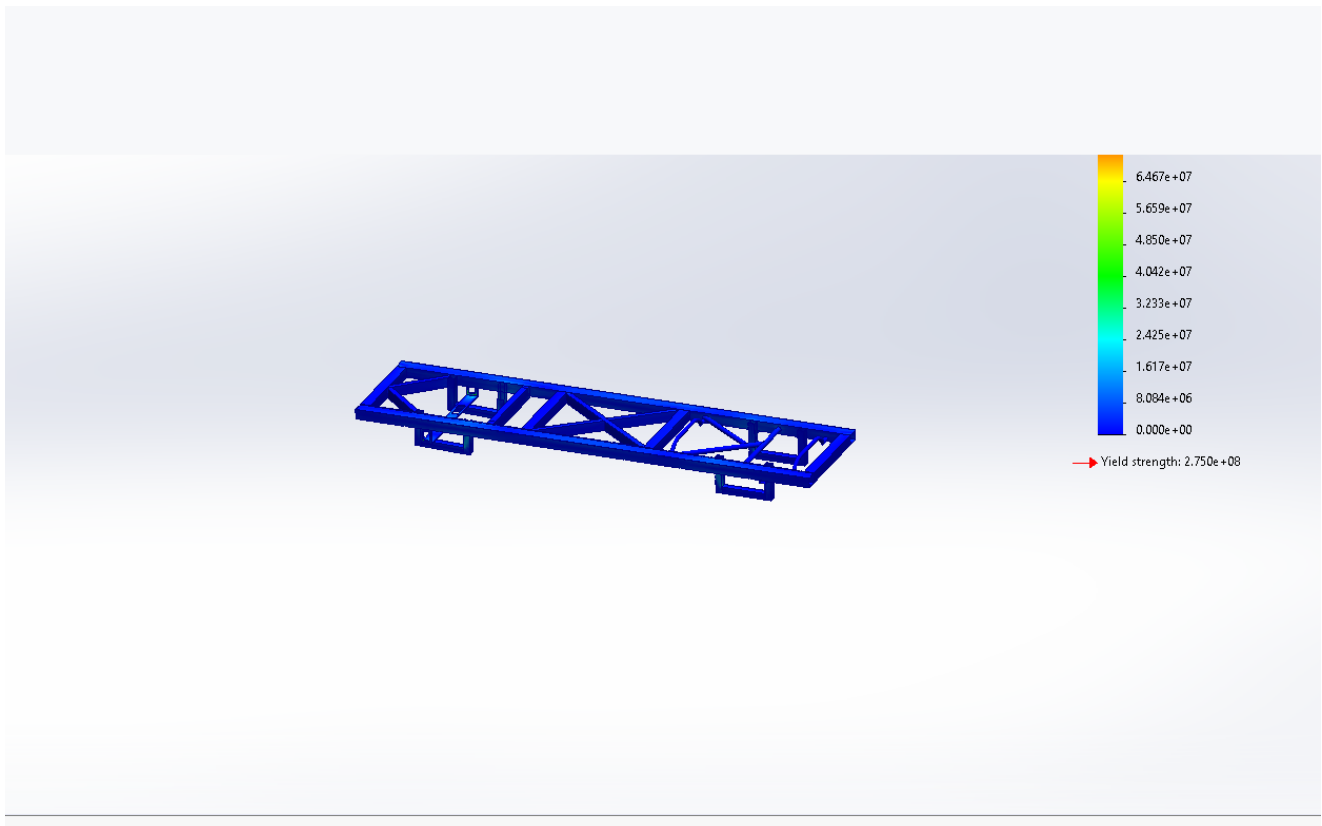
Von Mises stress under torsion, well below the 275 MPa yield of 6061-T6.

Figure 14. FEA, bending



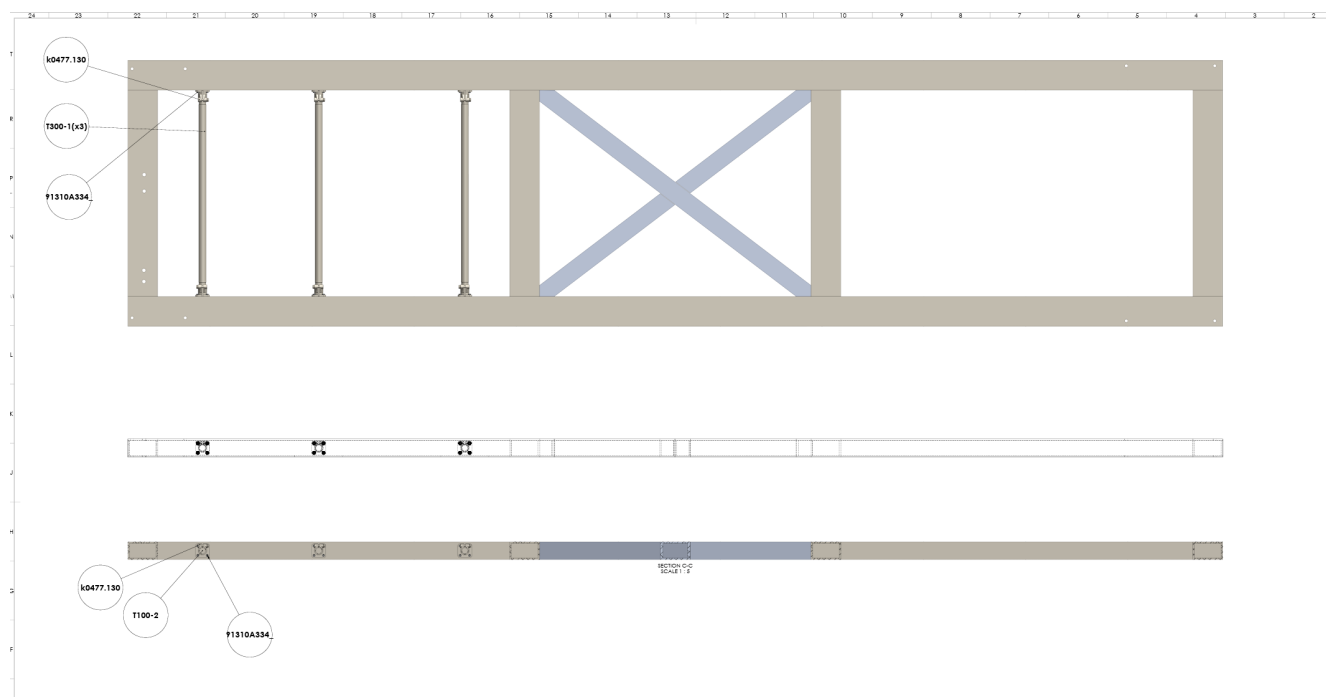
Bending case with 10 kN distributed loads: 10 kN/mm against a 3 kN/mm target.

Figure 15. FEA, combined case



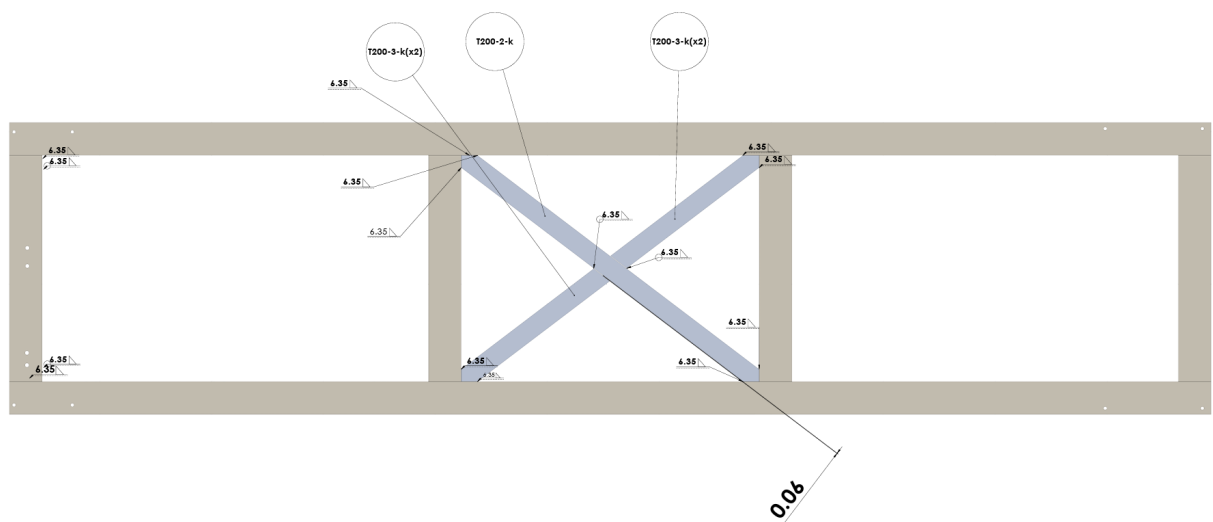
Combined bending plus torsion, von Mises stress. Safety factor 4.5.

Figure 16. Assembly instructions



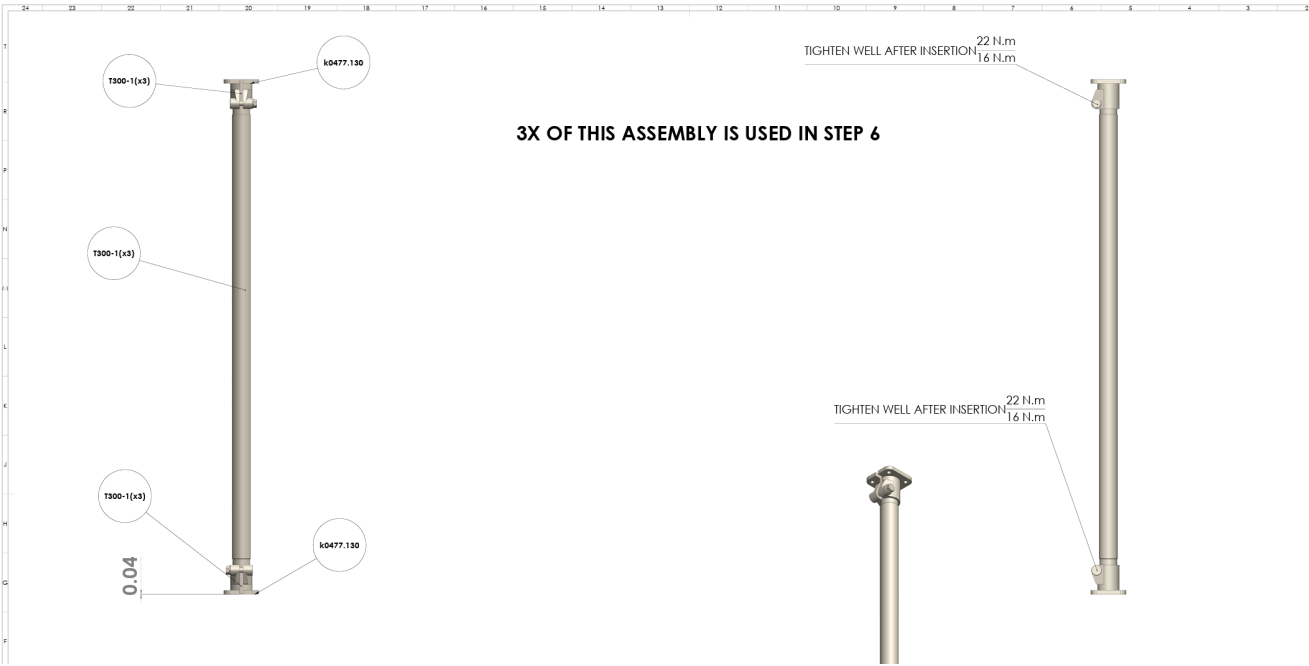
Instruction sheet: cross-tube positions and X-brace, part balloons keyed to the BOM, section C-C.

Figure 17. Weld instructions



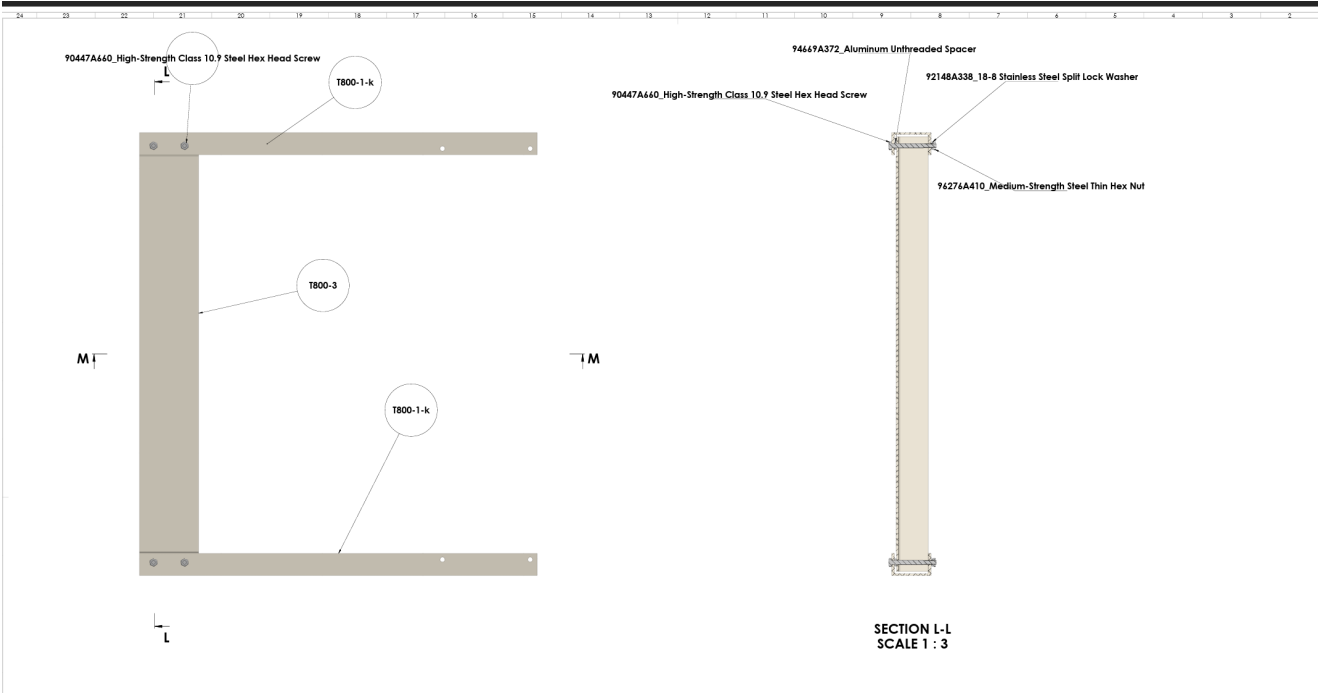
Weld sheet with 6.35 mm fillet callouts on the X-brace and crossmember joints.

Figure 18. Sub-assembly sheet



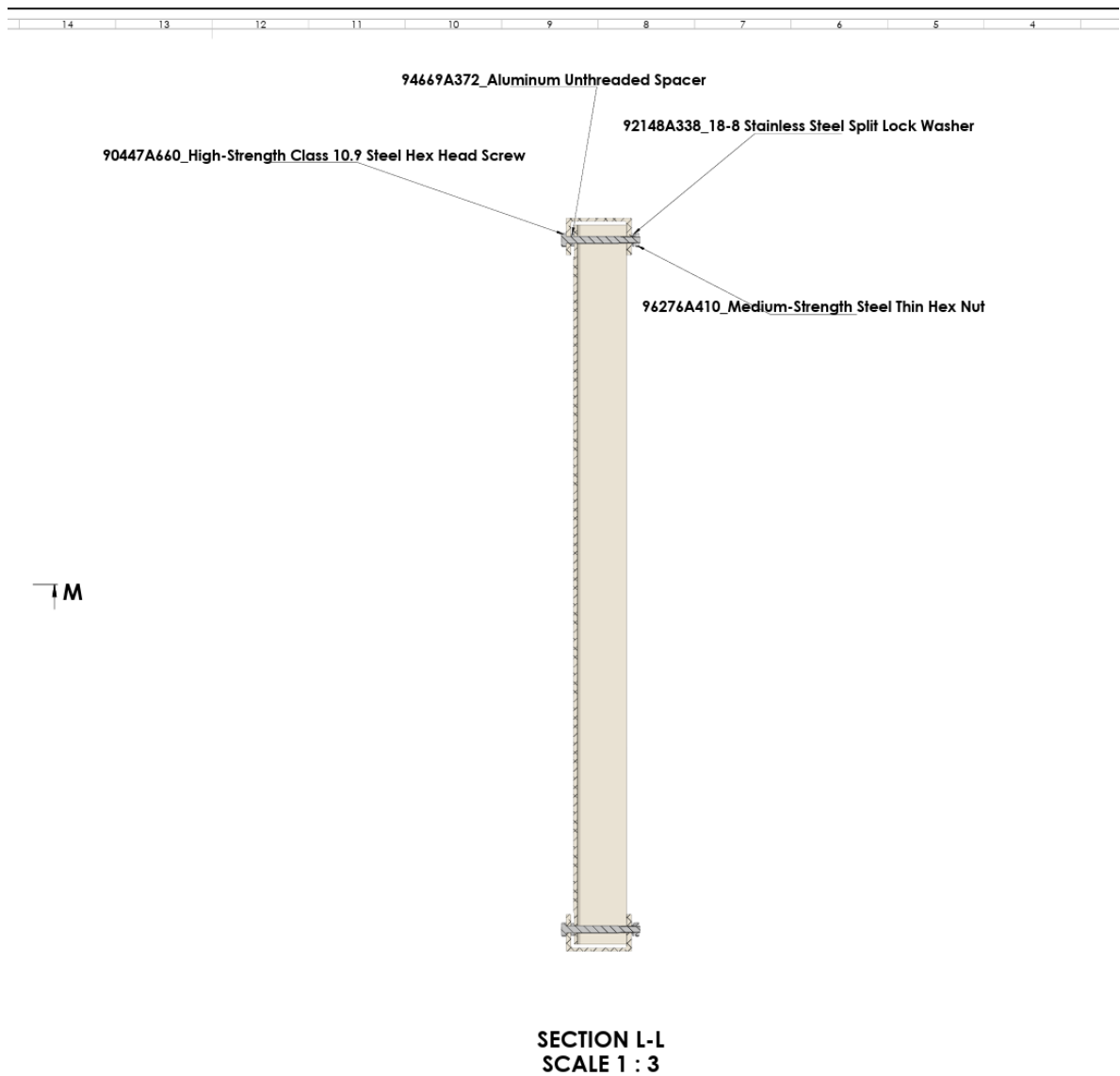
Torsion tube sub-assembly, built three times: tightening torques called out for the fitter.

Figure 19. Bracket and fastener stack



Bracket assembly and section L-L: screw, spacer, split washer and nut with supplier part numbers.

Figure 20. Bolted joint section



Section through the bolted joint in the rectangular-tube rail.