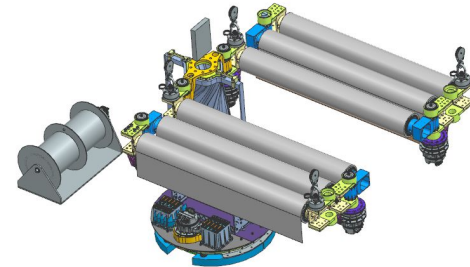# Tower 1 GSE
Critical Design Review

Teamcenter PN: 407000-000

Overview

- Carbon fiber boom for M0 is weak
  - Breaks @ stem
- "Stabilizer" must be capable of fully supporting the banner throughout M0
- Challenges
  - COG moves in x,z directions
  - End of banner moves in x, y, z directions, must be supported
- As low-profile as possible

Requirements

System	Tower 1
Subsystem	Ground Support Equipment
RE	Conor Zachar
Updated	11/12/24

Number	Category	Statement	Source
0	systems	GSE shall support the full weight of the banner in the vertical direction	czachar
1	systems	GSE shall allow a minimal (<5Nm) moment at the base of the boom	czachar
2	systems	GSE shall allow a minimal (<2cm) vertical deflection of the end banner hinge	czachar
3	systems	GSE shall prevent catastrophic mechanical failure of the Tower in the event of a boom or hinge motor malfunction	czachar
4	build	GSE shall cost less that $60,000 in hardware/operational expenses	czachar
5	environmental	GSE shall function within the confines of the Starpath HQ Shop	czachar
6	systems	GSE shall be of an appearance to inspire the public	czachar
7	systems	GSE shall not interfere with Rover or Plant operations	czachar
8	build	Mechanical design shall be completed on/before December 13th, 2024	czachar

Design - CAD Overview
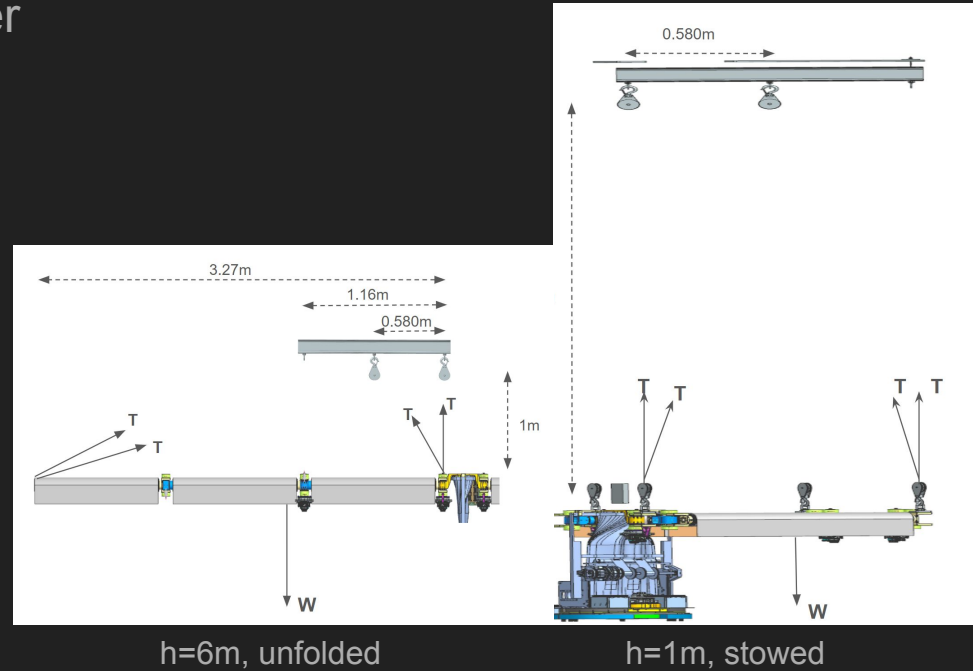
Overview:

- 2x rotating I-Beams mounted to roof via cantilever pin joint
  - Opens passively as banner unfolds
  - Shoulder bolt + linear ball bearing minimize friction
- SP Actuators hoist cables via winch
  - Manage tension in cable via load cells
- 4x attachment points on Tower

Banner stowed config

Banner opened config
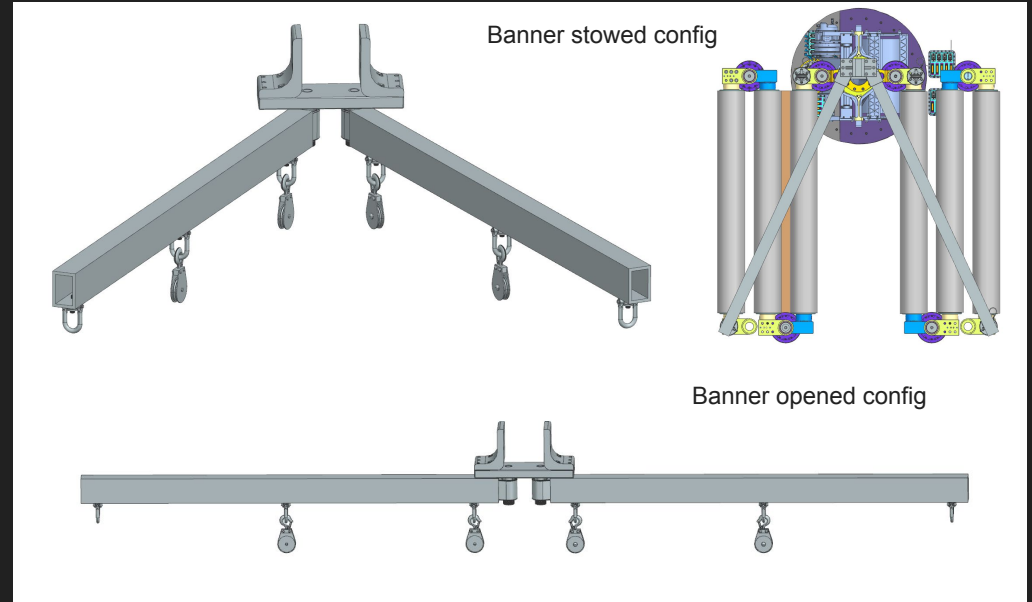
Design - Load Cases

- Constant +z force of 500N / banner
- h=1m, stowed: T=125.6N
- h=2m, stowed: T=125.8N
- h=2m, unfolded: T=131.74N
- h=6m, unfolded: T=189.3N

Hand Calcs: Loads Table

h=6m, unfolded   h=1m, stowed
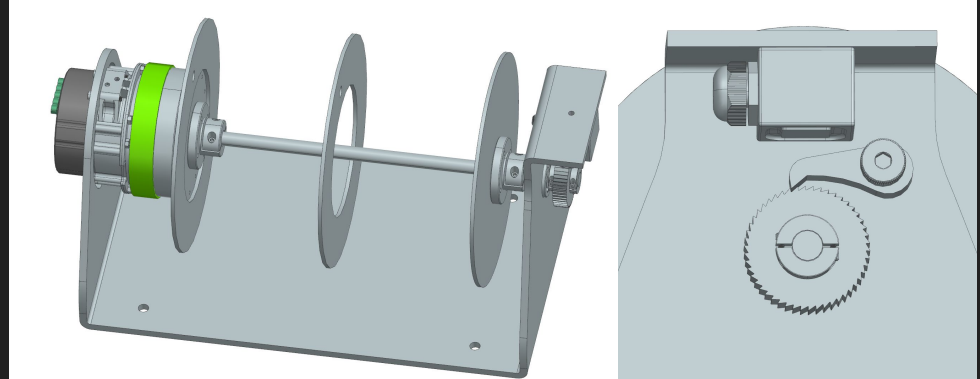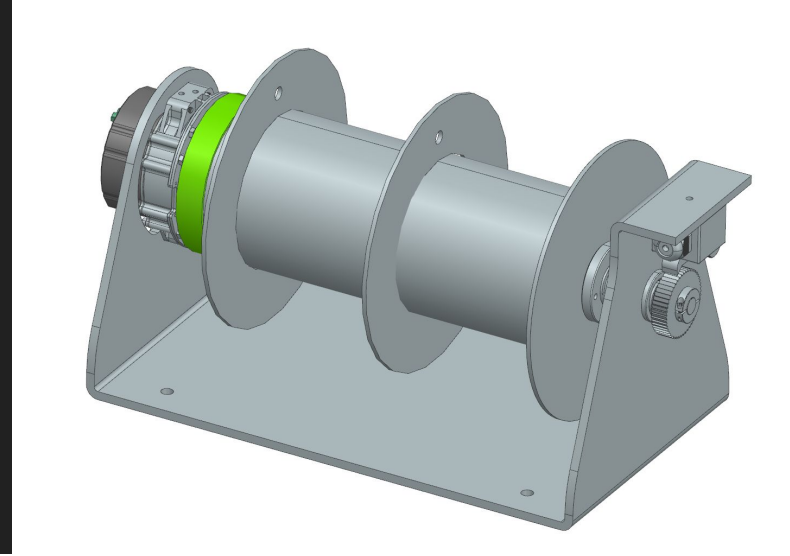
# Design - Winch

Overview

- 3/16" Synthetic Rope
  - 3000N strength, FOS=15.8
- Up to 10RPM & 120Nm required
  - Using R8 Steer Actuator
- Motor control to provide Constant 500N upward force on Load Cells
- Ratchet for safety stop
  - Electromagnet, power on to disengage ratchet
- 6061 Al, laser cut & weld together

Design - Tower Mount

Tower Mount

- 2x M6 Bolts to Banner Hinge
- Load Cell
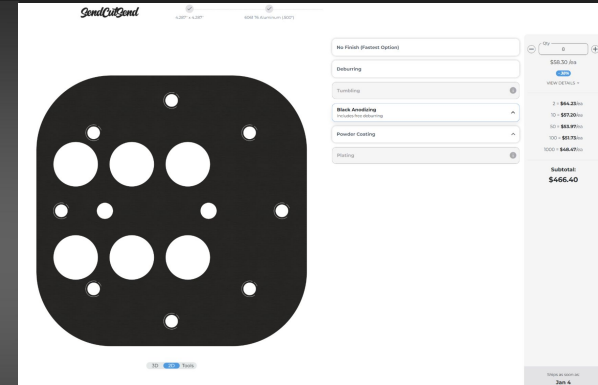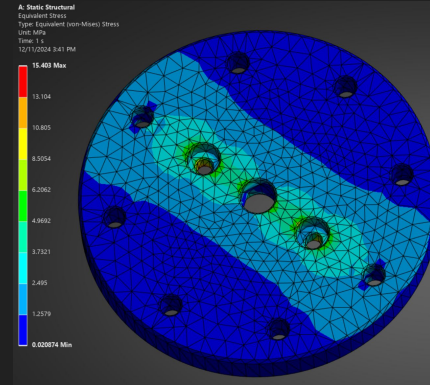- 360deg swivel 180deg pivot hoist ring
- Snatch Block
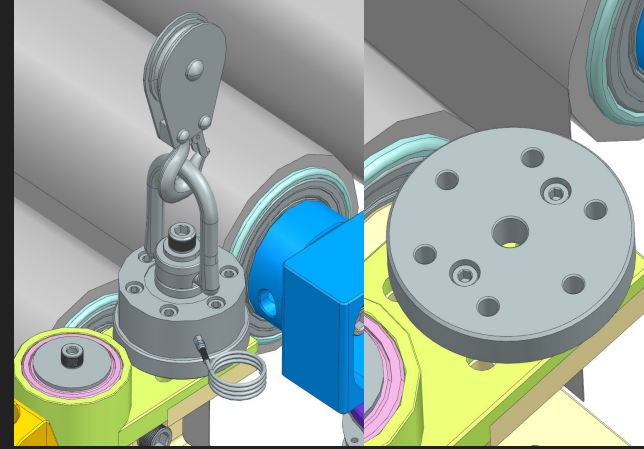
Hoist Base

Load Condition
        600N (>3X Max T) +z
        @ mount holes

Material Properties: Al 6061T6
        Yield Strength: 214MPa
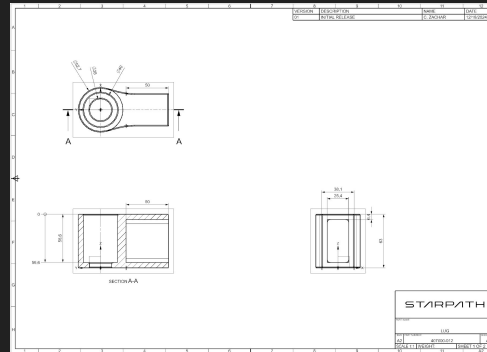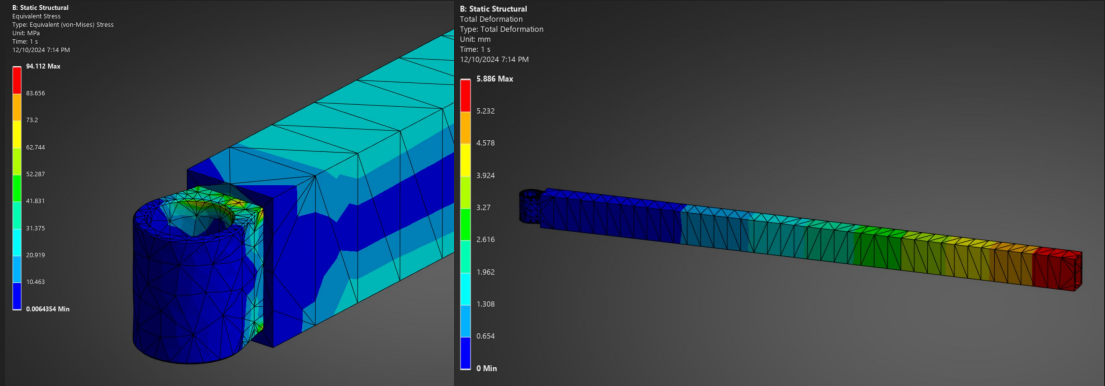   **FOS**: 13.9

Design - Stabilizer

Lug & Beam
Load Condition
    500N (>2X Max T) -z
    @ each pulley

Material Properties: Al 6061T6
    Yield Strength: 214MPa
    FOS: 2.27
    Max Deflection: 5.89mm

Design - Stabilizer
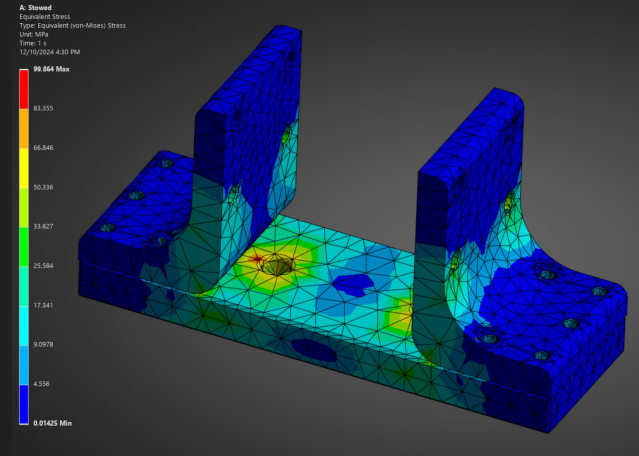

Ceiling Mount- Stowed Config.
Load Condition
    2000N -z @ (L/2, 0, 0)

Material Properties: A36 Steel
    Yield Strength: 248 MPa
    FOS: 2.48

Ceiling Mount- Extended Config.
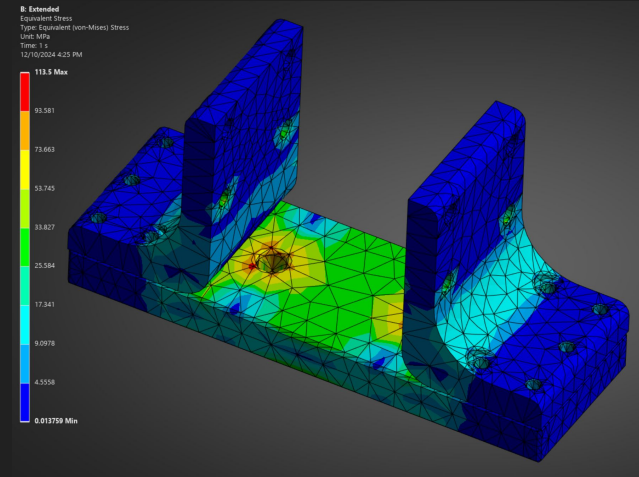Load Condition
    1500N -z @ (0, L/2, 0)
    1500N -z @ (0, -L/2, 0)

Material Properties: A36 Steel
    Yield Strength: 248 MPa
    FOS: 2.19

Manufacturing & Materials

- Parts Ordered - Dec 20
- Mfg. to begin early Jan

Expected Total Cost: <10k
see Tower GSE [BOM](#)

Component Type	Source	Method	Material
Box Beam	McMaster	Bandsaw / Drill Press	Al 6061
Lug	In-House	CNC	Al 6061
Roof Mount Brackets	McMaster, In-House	CNC	A36 Steel
Roof Mount Plate	In-House	CNC	A36 Steel
Hoist Base	SendCutSend	Laser Cut	Al 6061
Fasteners	McMaster	n/a	Steel
Starpath Actuator	?	n/a	n/a
Load Cell	ATO	n/a	n/a
Cable/Pulleys/Eyelets	McMaster	n/a	Steel
Winch Spool	SendCutSend	Laser Cut & Weld	Al 6061

Testing - High-Level ConOps

Pre-Op
- Manufacture a 2nd "Test Hinge" to act as banner
  - Bolt holes to affix the 4x load cells
- Rent scissor lift
- Acquire 4x 50kg weights

Op
1. Bolt stabilizer to roof w/scissor lift
2. Affix cable to stabilizer, cable through all pulleys
3. Lower test hinge to 1m off ground & affix 4x 50kg loads
4. Lift to 2m, rotate hinge to open position
5. Lift to 6m (~1m below ceiling)

Future GSE - Ideas

As Tower scales… Tower 2… Tower 3… ceiling mounting
becomes less practical

To lift 100kg…
$$V = m / (\rho\_air - \rho\_He)$$
$$= 97.4m^3$$
Equivalent of 6x balloons, ea. w/ r = 1.57m
8x balloons, ea. w/ r = 1.43m