Tug of War overview

At the time of writing, 21st October 2026, only one of the two "Tug of War" systems has been installed.

Each system comprises of a pair of pulleys, one motorised and one passive. The pulleys are linked with a steel rope, which carries a prop item back and forth. Each pulley drives a pair of mechanical arms with wooden hands. The motor is a 4Nm NEMA24 stepper, with 10:1 planetary gearbox fitted.

When powered up, the motorised pulley winds the steel rope until a cable mounted stop is detected. The stop is detected by a lever microswitch mounted behind the pulley. The setup then knows its home position, and can begin its choreographed sequences.

The distance across which each activation plays out is set once during installation. It will need to be re-calibrated if the Teensy is ever replaced, or if the distance between the pulleys is ever changed. To set the distance, turn the rotary selector switch to position 1 and cycle the power. Press button 1 - the motor will activate until the stop reaches the switch. With a direct line of sight to the prop and turnbuckle assembly, press and hold button 2. The prop will slowly move. Release button 2 when the prop has reached the desired max limit of travel. The distance is written to EEPROM memory, and the system will refer to this value from now on. Turn the rotary switch back to position 0 and cycle the power.

If the cable stop ever hits the limit switch during normal operation and not whilst looking for the home position, this is counted as cable slip or other mechanical failure, and an error mode will be activated. There is a second stop on the cable, which will also cause the system to stop.

In the unlikely event of a cable stop resting on the limit switch on startup, the system won't know which direction to turn, and so will shut down until someone has manually inspected and moved the stop.

If the limit switch fails, there is a watchdog pulse counter of the max distance plus 2000 pulses.

The choreography is currently set to carry out a series of moves to make it look as if the pairs of arms are fighting over possession of the prop, with one unit emerging victorious. The winner is selected pseudo-randomly, and aspects of the movements also have randomness built in.

Maintenance

Periodically check the steel rope for signs of damage or fraying, check the ferrules and thimbles for signs of damage, check the turnbuckle bolts are tight, check the bolts in the triangular prop mounting bracket are tight, check the fixing method to the prop is safe.

Check all fixings on bearings and any moving parts are tight. Check that the electrical cables aren't in the way of any moving parts. Check that the limit switch and lever assembly is in good condition.

Check the rubber grip tape on the drive pulley for signs of deterioration.

Checks should be carried out daily until confident there has been no change. Checks to then be carried out weekly, including a close up inspection via a scissor lift. The steel rope and associated fixings are the most important aspects to check.

Check the drive chain after a month, and oil if necessary. Clean and oil the chain every 6 months, or more frequently if there is evidence of dust building up. Clean with automotive brake cleaner or similar, oil with motorcycle chain oil or similar.

After 5 years, check the bearings. Add oil via the grease nipples if necessary.

Rotary switch modes

0: Run normal routine
1: Distance calibration mode. Press button 1 to move stop to limit switch. Press button 2 to play rope out, release switch at desired maximum.
2: Continuous min to max travel test
3: Same choreography as position 0, but with shorter pauses, useful for testing
4-15: Unused

Things to watch out for

The rubber strip on the pulley will likely wear over time.

During testing there were some instances of the motor pulse frequencies being too fast, which caused the motor to stall. This meant that positional accuracy was lost while the stepper motor driver automatically paused and re-started. Motor stalling is indicated by a flashing red LED on the stepper motor driver. The max speed has since been made slower.

Note that at the time of writing the control box has been installed upside-down, and so care must be taken to identify positions on the rotary switch etc.

Troubleshooting

The most likely issue might involve the system losing track of the position of the cable, which would lead to the cable stops triggering shutdown.

Factors that could cause the cable to slip might include the steel rope being too slack, worn out rubber grip tape, speed set too fast / motor stalling.

The pulleys were designed to be operated at the same height. The pulleys were fitted to the set on a slight incline, which isn't ideal. If there are persistent cable slipping issues, it would be worth levelling up the pulleys.

Excessive wear of the cable may be linked to misaligned pulleys. It has been requested (21st October 2026) that the pulleys should be re-aligned, as they are currently off by a few degrees.

Notable components

NEMA24 stepper motor kit, Stepper Online part number 4-CLTS40-V41
NEMA24 10:1 planetary gearbox Stepper Online part number EG24-G10
Lever roller limit switch, RS Components part number 902-6865

Colours

Generic black etch primer on steel work