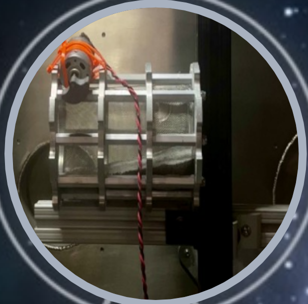
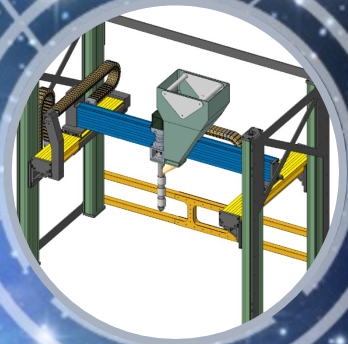
National Aeronautics and Space Administration





Development of the Advanced Regolith Ground Operations (ARGO) Test Bed:

A Robotic Excavation and Construction Test Facility with Simulated Lunar Environments

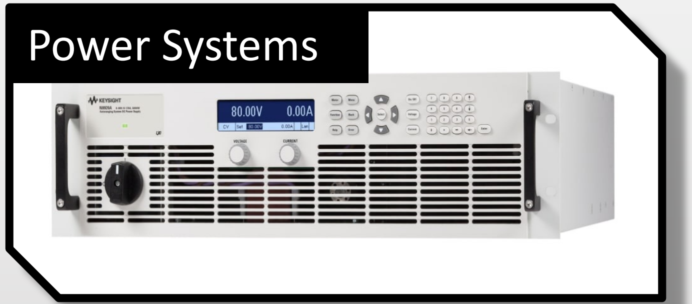
Presented by – Evan Bell

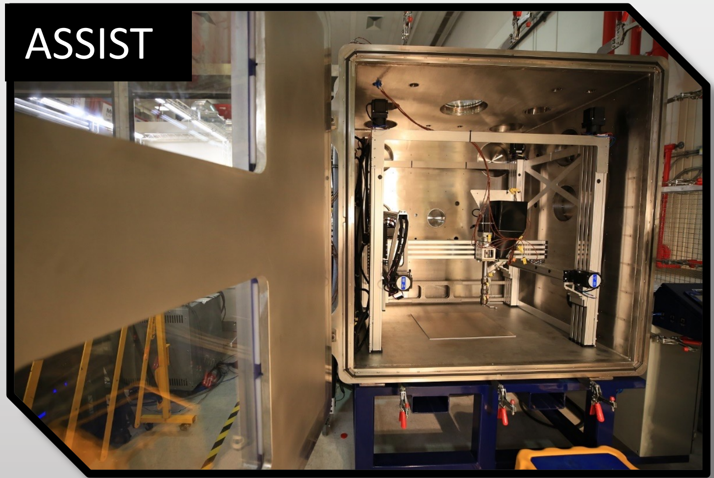

Exit

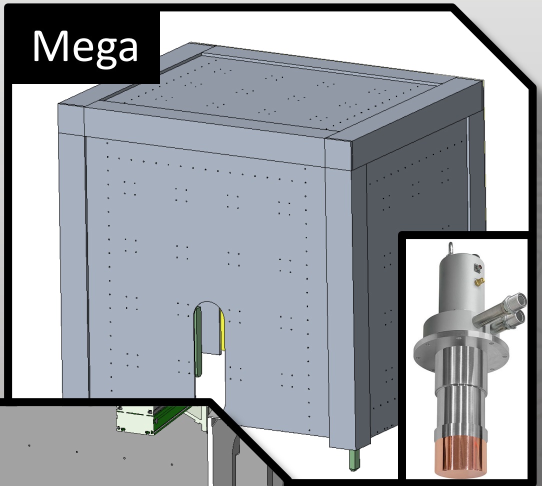
ARGO Overview

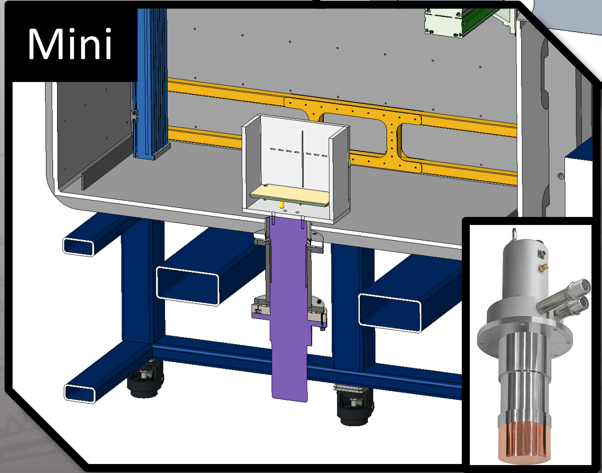
Advanced Regolith Ground Operations

- A system of capabilities
  - ASSIST
  - ARGO Gantry
  - Cryo Shrouds
    - Mini & Mega
  - Power Systems
    - 15kW PSUs
    - Induction
  - Data Acquisition
  - Implements
    - Extruder
    - More to Come!









ASSIST Chamber

Atmospherically Sealed Simulator for In-situ System Testing (ASSIST)

ASSIST Chamber

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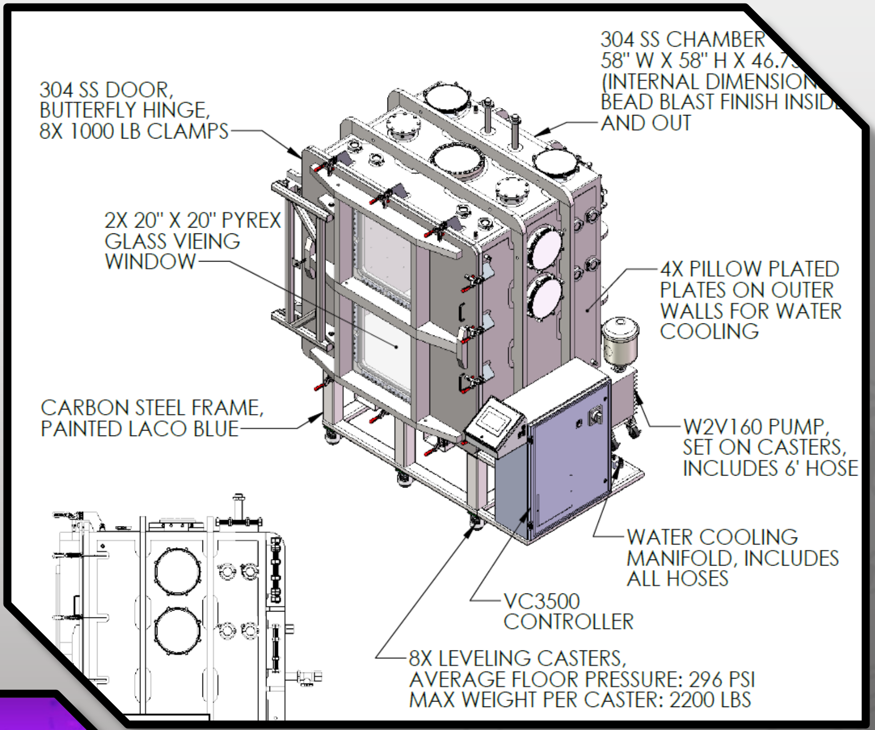
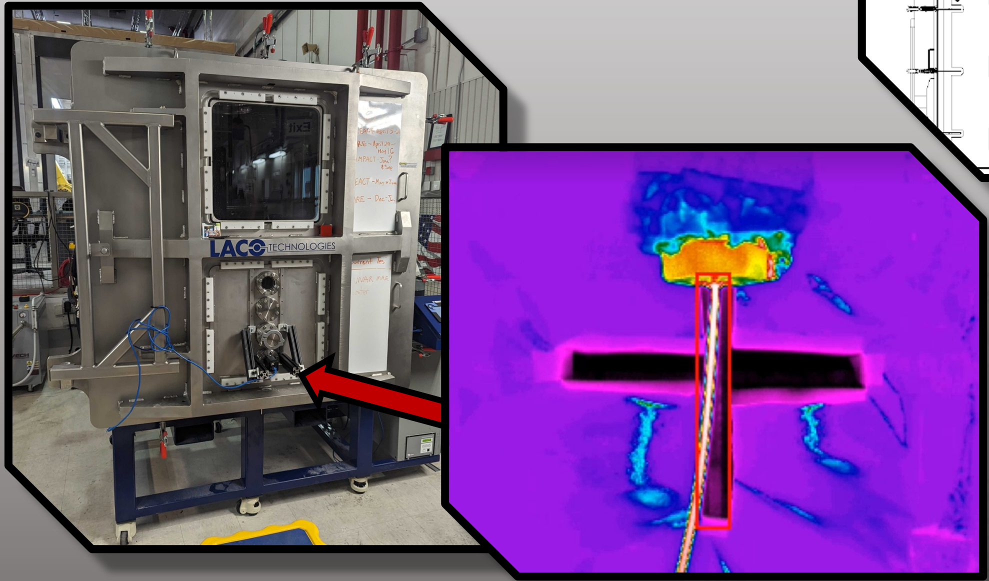
Atmospherically Sealed Simulator for In-situ System Testing (ASSIST)

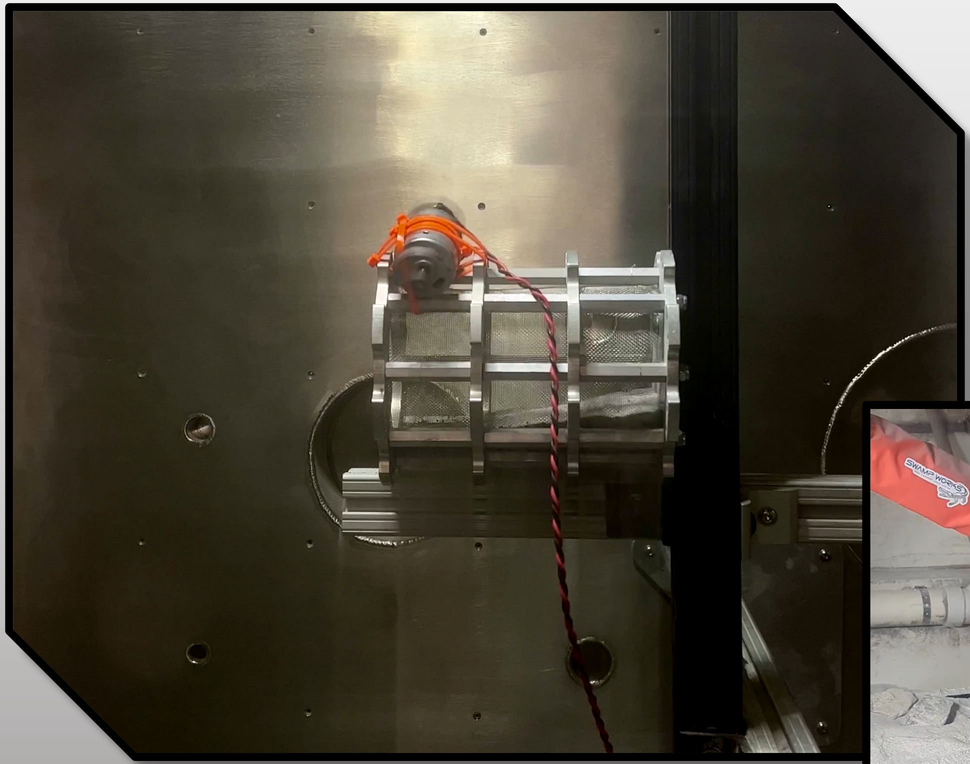
- Features
  - Dedicated dirty chamber
  - Large Internal Dimensions (1.5m x 1.5m x 1.2m)
  - ≤10^{-2} Torr to 1 Atm Pressure Range (Turbo TBC)
  - External Water Cooling for Chamber Walls
  - 10” Diameter Quartz Viewport (Top)
  - 2x Front Windows or 1xGlass + 1xIR Viewport

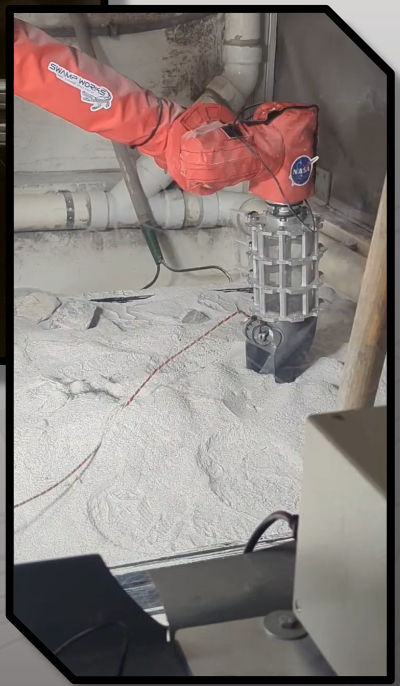




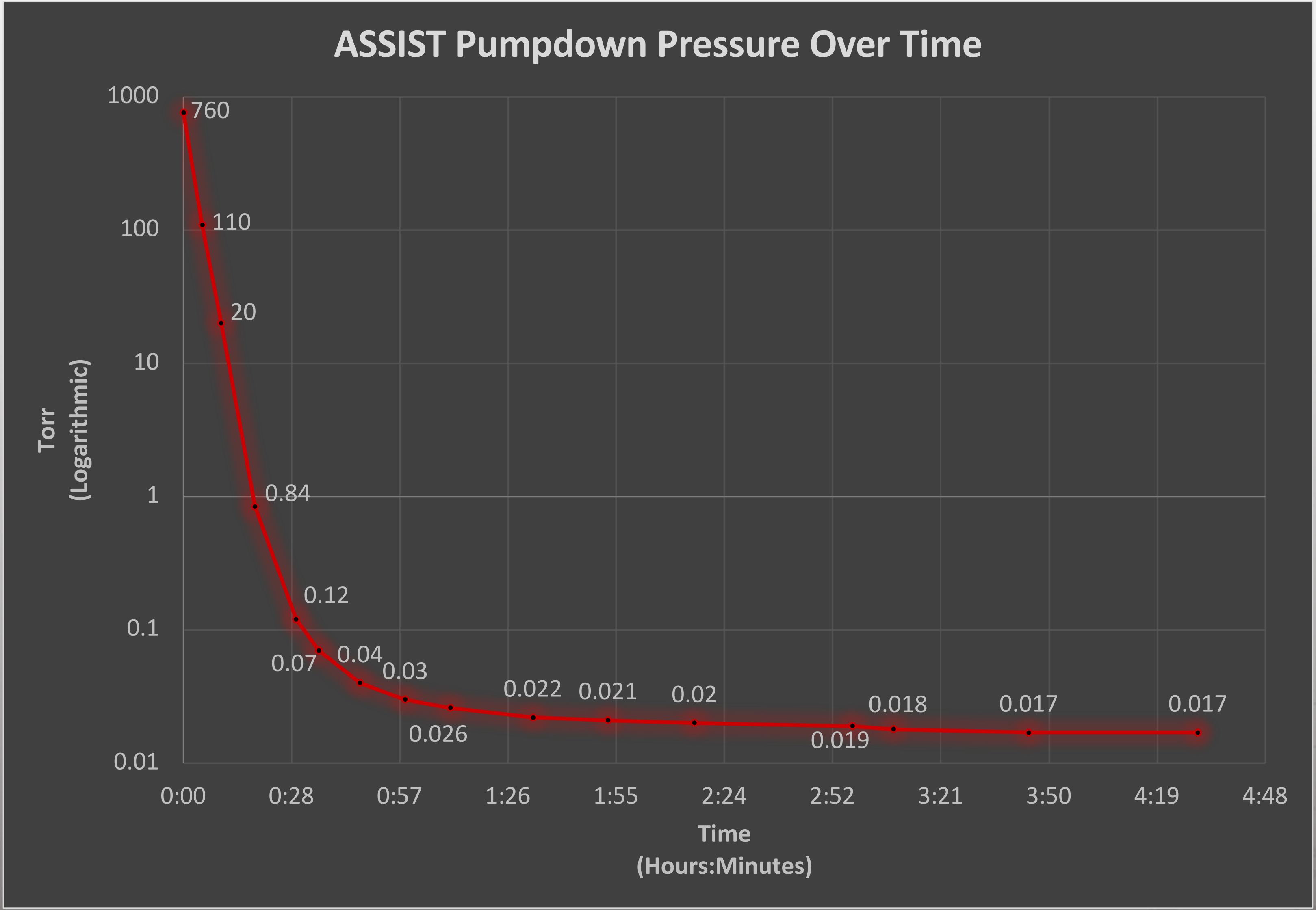
Fast Testing (MMPACT)

- Fast rough pump down rate
- 4x4” bolting grid
- High and Low Watt PSUs w/Feedthroughs
- Significant Filtration
- Vents Outside of Lab



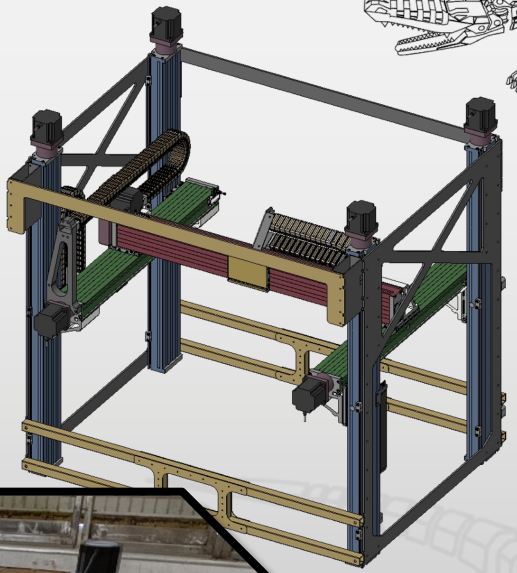


Pump Down Rate & Turbo Pump Upgrade



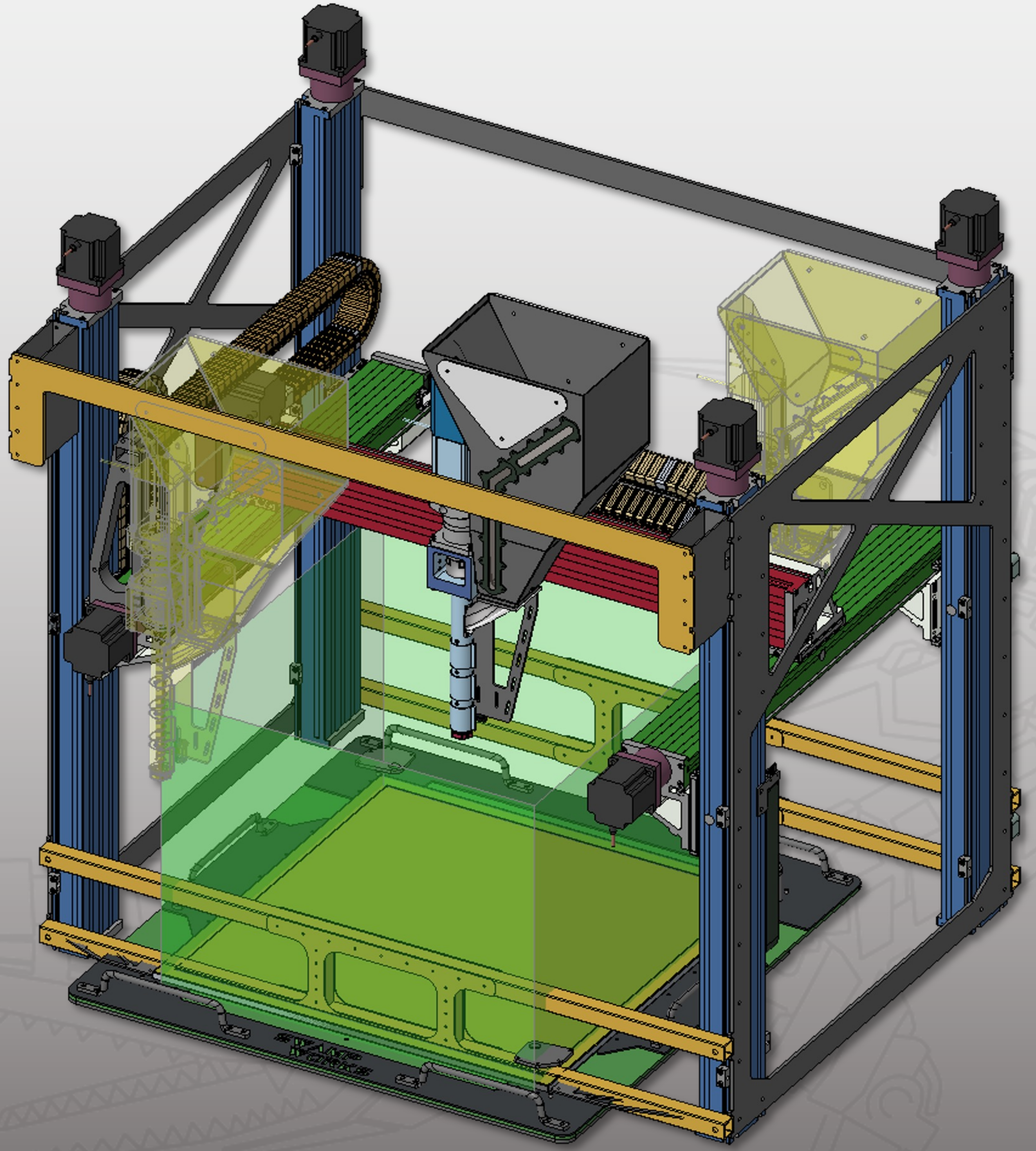
ARGO Gantry

- Designed for XYZ+E Manipulation
  - Additive Construction
  - Excavation/Site Preparation Tool Demos
  - Test Fixture Adjustment w/o Venting
  - Load Testing
- Gcode
- T-Slot Mounting
  - Mountable Forklift Points
- Dust Tolerant
- Crash Tolerant (“whoops” tested)



ARGO Gantry - Specifications

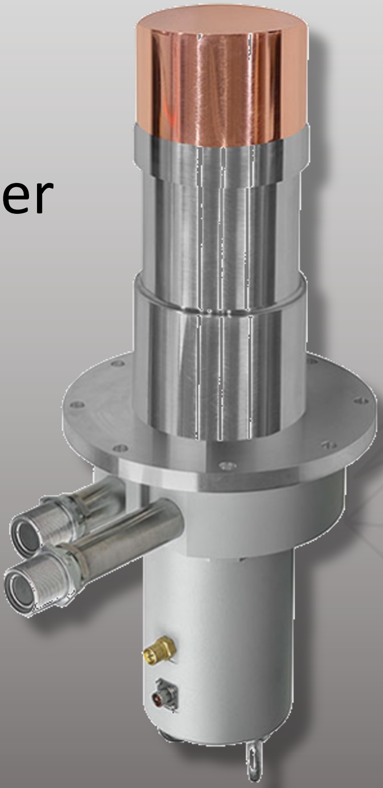
Specification	Current Estimated Value
Build Volume X/Y/Z	~754/754/804 mm (~29/29/31 in)
Space Claim Volume X/Y/Z	~1320/1070/1370 mm (~54/42.8/54 in)
Max Payload (Including Media)	90kg (~200lbs)
Max Velocity X/Y/Z	100/100/25 mm/s (~4/4/1 in/s)
Max Accel. X/Y/Z	1000/1000/1000 mm/s^2 (39.4/39.4/39.4 in/s^2)
Accuracy X/Y/Z (% of Travel)	0.033%
Repeatability X/Y/Z (Due to Lash)	±0.025/±0.025/±0.000 (Z axis orientation makes lash negligible)
Temperature Range	-10 to 80˚C (14 to 176˚F). *Cryoshroud/Bed may be colder/hot if motors are insulated.*
Dust Tolerance Measures	Metal Shielding Bands on Carriage Rails
Heated Bed	Ambient to 100˚C

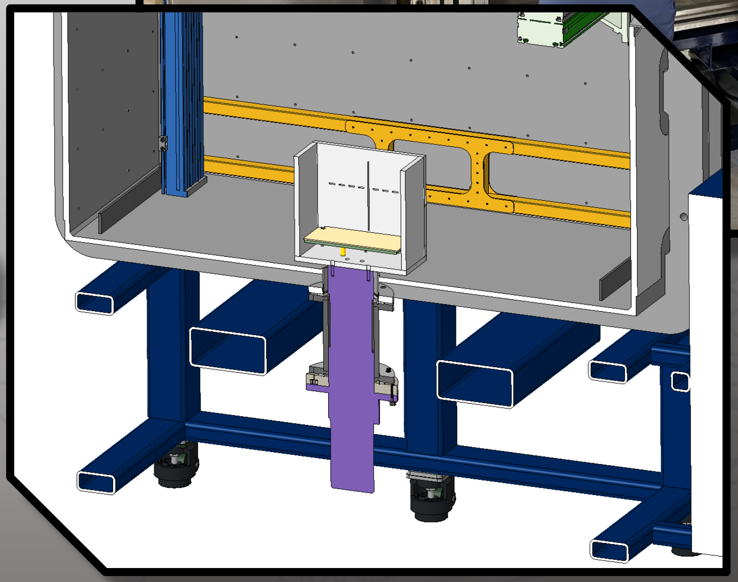


Cryo Capabilities

AL600/AL325

- Liquid Helium Refrigeration Loop
- AL600: 600W@80K (Base Temp 25K)
- AL325: 100W@25K
- Cryo Pumping Effect
  - ≤10^{-3}Torr Pressures
  - RGA Confirmed Mostly Water
- Mega Cryo Shroud
  - 1.4m x 1.1m x 1.4m
- Mini Cryo Shroud
  - 0.27m x 0.27m x 0.25m



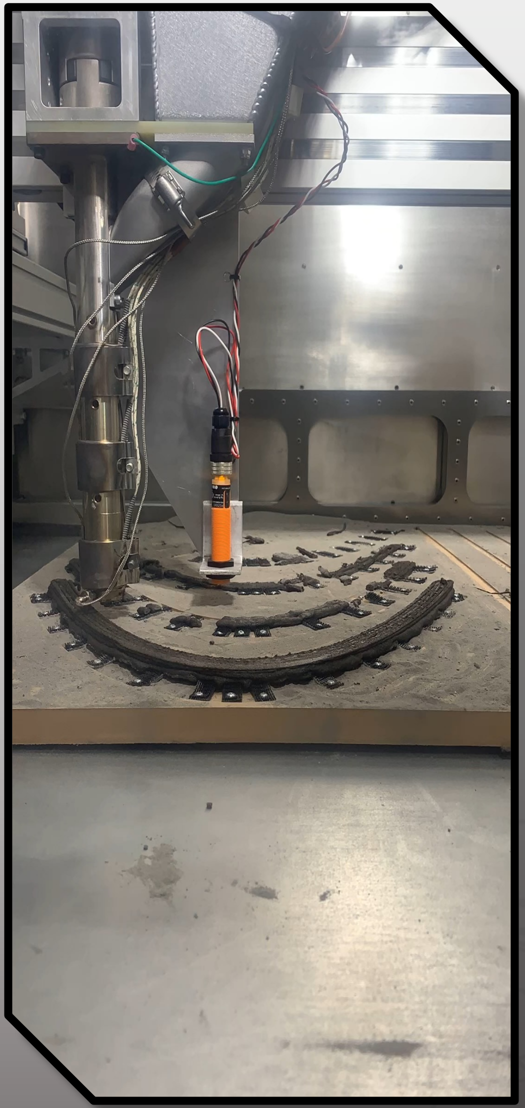


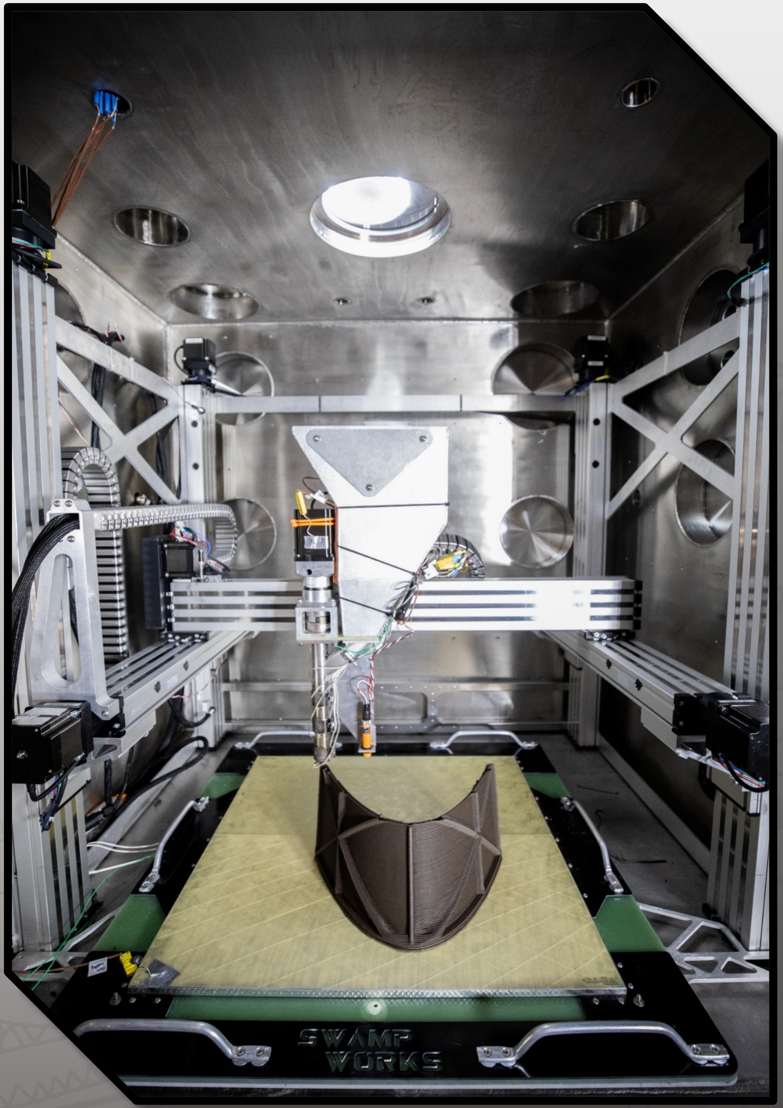
Power Capabilities

- 15KW Output PSUs
  - Keysight N8932A - 200V, 210A
  - Keysight N8931A - 80V, 510A
- Outlets
  - 480V 3Ph 30A (1x)
  - 208V 3Ph 60A (3x)
  - 120V 1Ph 20A (2x circuits)
  - Additional 480, 208, and 120 Throughout Lab
- Induction Coil PSU
  - 10KW Output
- Solar Simulator Lamp
  - 7.14KW / 280k Lumens (~40 lm/w)

REACT

Relevant Environment Additive Construction Technology





REACT

Relevant Environment Additive Construction Technology

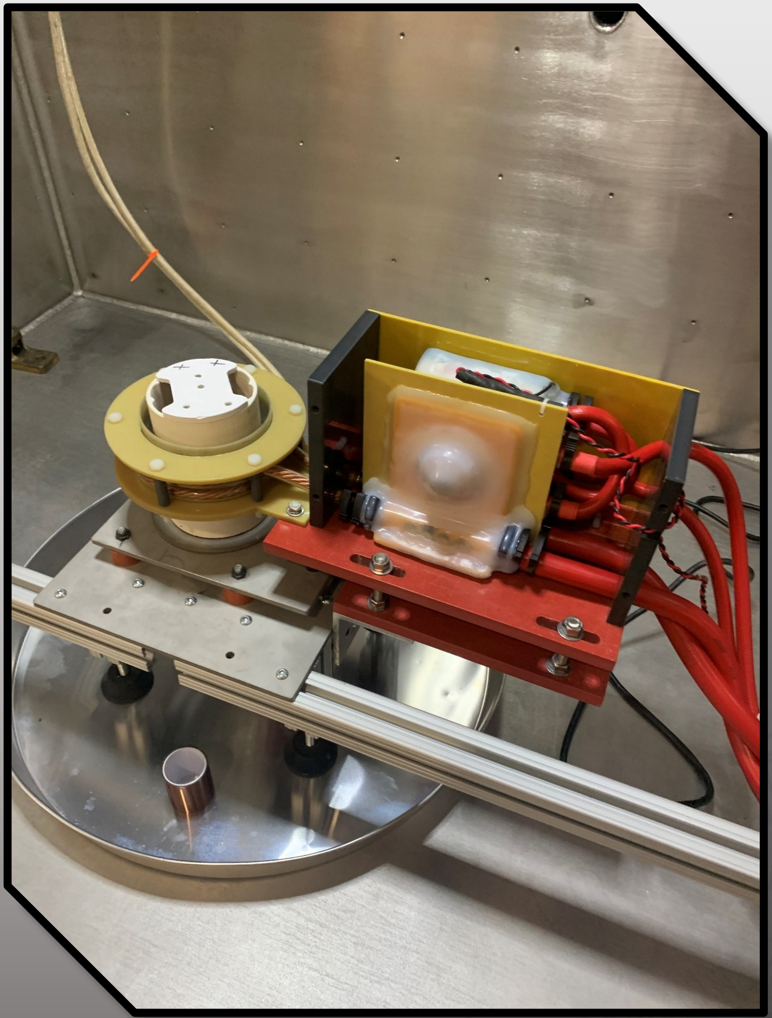
- ≤ -200˚C Wall
- ≤ -90˚C Print Surface
- 85% Simulant by Weight

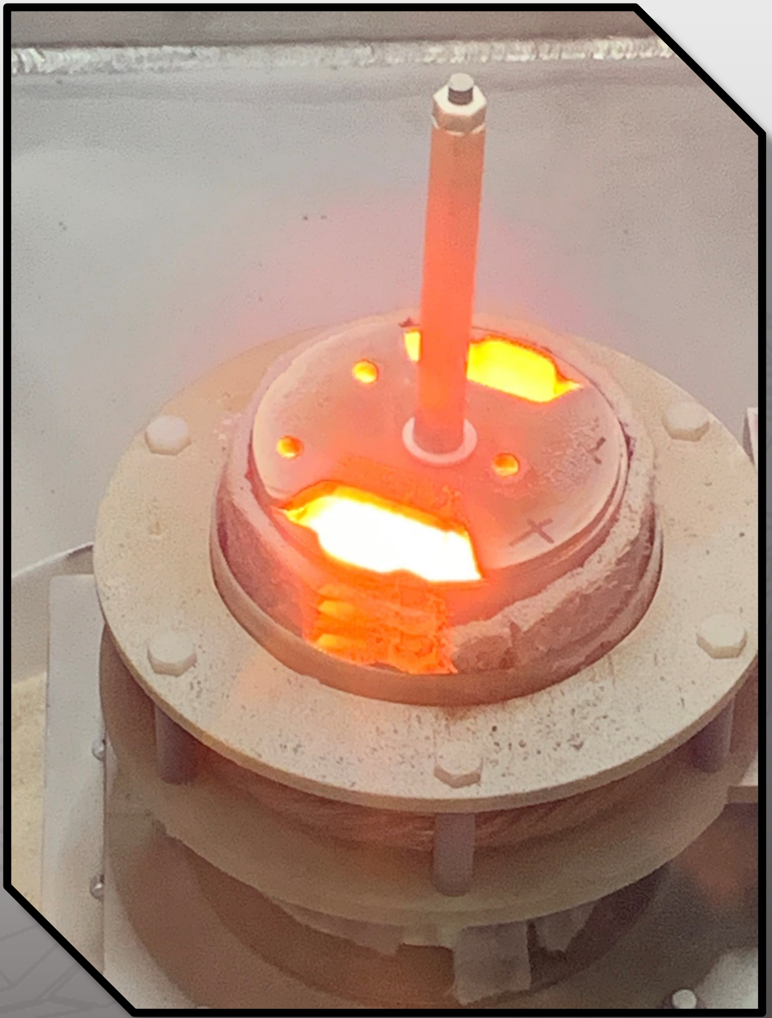
- Material strength testing in progress

GaLORE

Gaseous Lunar Oxygen from Regolith Electrolysis

- 1600˚C Reactor Temps
- Utilized High-Watt PSUs and Induction Coil System
- Purge O2 Production with GN2 Just Before Pump
- MRE project to integrate system





Thank You for Listening

Contact info:

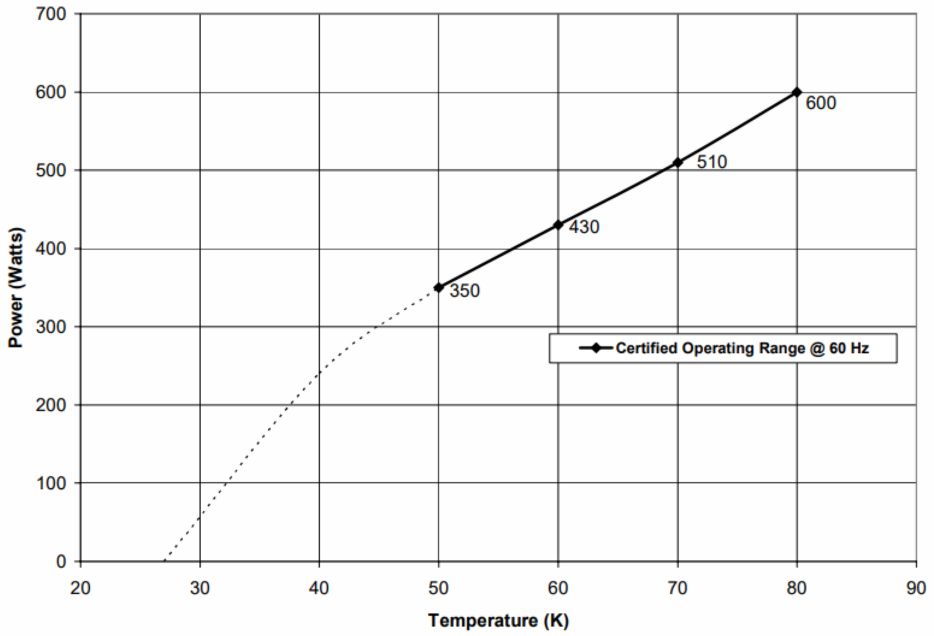
Evan Bell – Evan.a.bell@nasa.gov

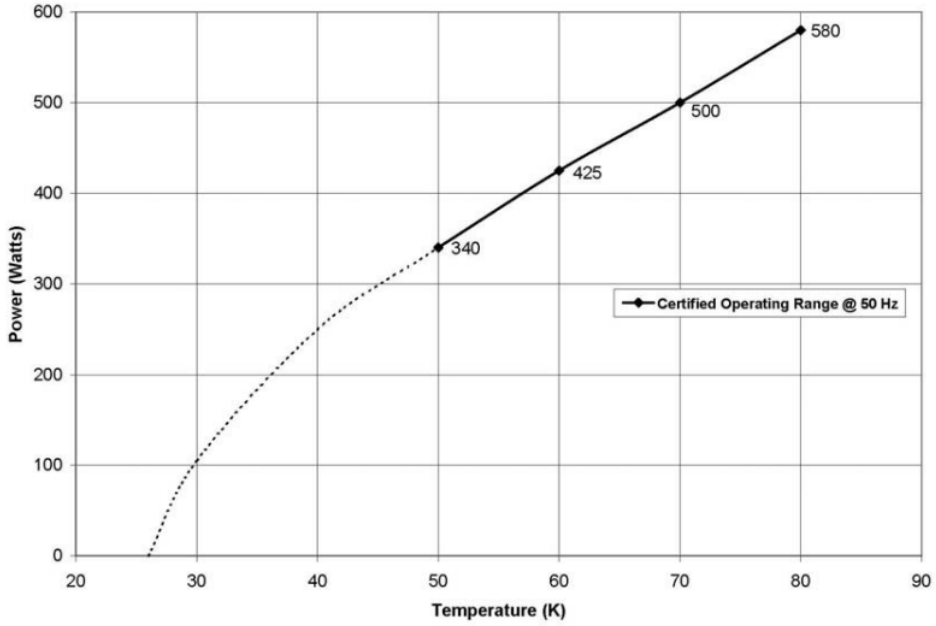
Backups

ASSIST Performance Pump down Log

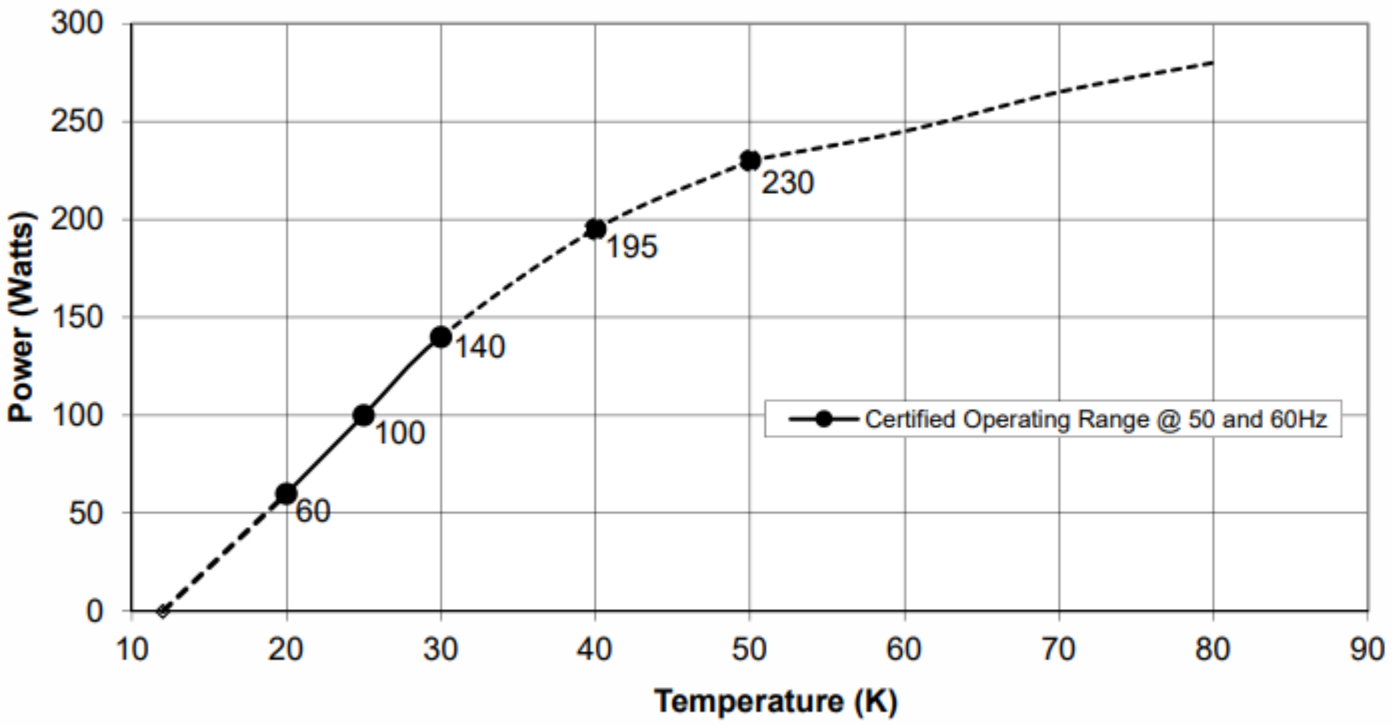
Time	Time (Elapsed)	Pressure (Torr)
10:30:00 AM	0:00	760
10:35:00 AM	0:05	110
10:40:00 AM	0:10	20
10:49:00 AM	0:19	0.84
11:00:00 AM	0:30	0.12
11:06:00 AM	0:36	0.07
11:17:00 AM	0:47	0.04
11:29:00 AM	0:59	0.03
11:41:00 AM	1:11	0.026
12:03:00 PM	1:33	0.022
12:23:00 PM	1:53	0.021
12:46:00 PM	2:16	0.02
1:28:00 PM	2:58	0.019
1:39:00 PM	3:09	0.018
2:15:00 PM	3:45	0.017
3:00:00 PM	4:30	0.017

AL600 Cryorefrigerator Capacity Curve





AL325 Cryorefrigerator Capacity Curve



Certified Performance: 100W @ 25K

Structural Analysis Summary

General (KSC) - K0000466712-GEN, REACT STRUCTURAL ANALYSIS REPORT, 22264, -.1 (nasa.gov)

Structural Analysis Description	MoS (or FS When Notated)
X-Carriage Forces and Moments (90 kg payload)	0.02
Gantry X, Y, & Z Carriage Loads FEA (90 kg payload)	0.02
Payload Mounting Screw Loads	1.3
Hopper Loading FEA	32
Forklift Beam Loading	0.11
Stepper Motor Selection X/Y	3 (FS)
Stepper Motor Selection Z	4 (FS)

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Gantry Analysis

Gantry System Specs

High Level Development Doc for the Gantry to pick out key loads and hardware specs.

$S_{req} := 100 \frac{mm}{s} = 3.94 \frac{in}{s}$ — Top Speed. Per Req #1.1.2

$a_{req} := 1000 \frac{mm}{s^2} = 39.4 \frac{in}{s^2}$ — Top Acceleration. Per Req #1.1.3

$M_{Payload} := 90\ kg$ — Over-estimated Mass of Payload Attached to the Carriage

$M_{carriage} := 15\ kg$ — Mass of A Single Nook Actuator

X-Carriage Forces and Moments

The highest force and moment loads are likely to be seen by the X-axis due to how the payload is mounted and that it is a single carriage where as the Y-axis and Z-axis are multiple. Additional FEA work will demonstrate the loads on all carriages and can be compared to these results to verify.

Given system Accelerations, Find Forces For the Given Payload

$F_X := a_{req} \cdot M_{Payload} = 90\ N$ — Force on the X-Carriage Due to the Payload Accelerations

$F_{g\_payload} := g \cdot M_{Payload} = 883\ N$ — Force on the X-Carriages Due to Payload Mass

$F_Y := a_{req} \cdot M_{carriage} = 15\ N$ — Force on the Y-Carriages Due to the Payload and X-Carriage Accelerations

$F_{g\_carriage} := g \cdot M_{carriage} = 147\ N$ — Force on a Carriage Due to Its Own Mass

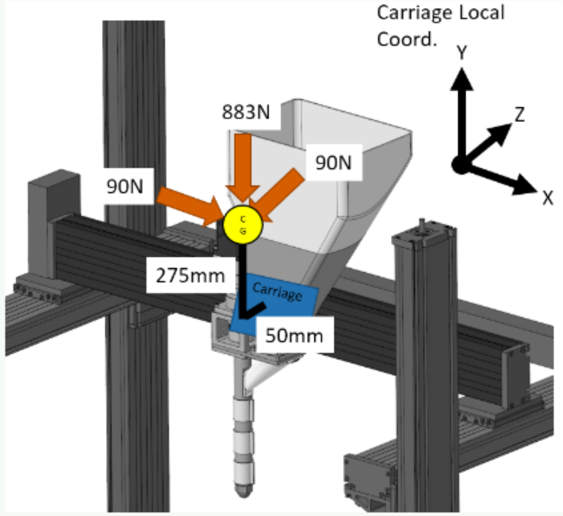
X-Carriage Forces and Moments

$F_X := 90\ N$
$F_Y := g \cdot M_{Payload} = 883\ N$
$F_Z := 90\ N$

$\Delta Y := 275\ mm$

$\Delta Z := 50\ mm$

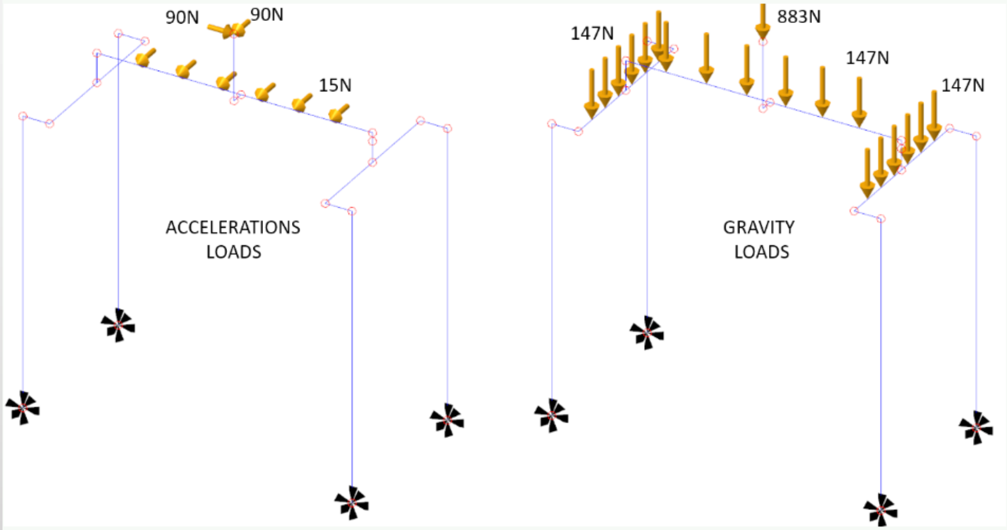
$M_X := (F_Y \cdot \Delta Z) + (F_Z \cdot \Delta Y) = 69\ N \cdot m$
$M_Y := F_X \cdot \Delta Z = 5\ N \cdot m$
$M_Z := F_X \cdot \Delta Y = 25\ N \cdot m$



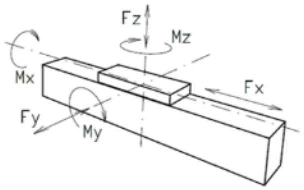
$$F_{allow} := \begin{bmatrix} 800 \\ 900 \\ 1000 \end{bmatrix} N \quad M_{allow} := \begin{bmatrix} 125 \\ 120 \\ 90 \end{bmatrix} N \cdot m$$

$$MoS := \frac{F_{allow_1}}{F_Y} - 1 = 0.02$$

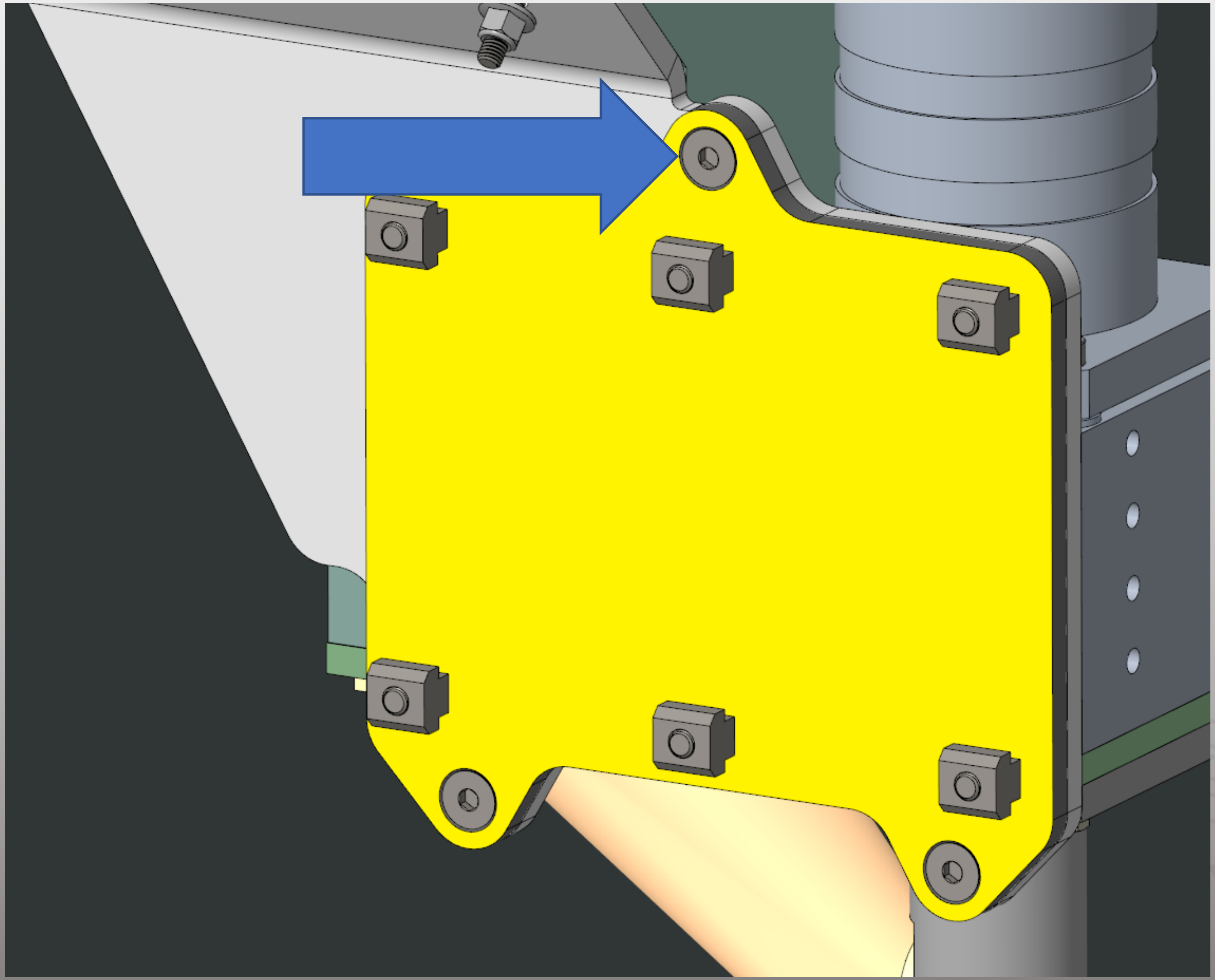
Loads are applied to the skeletal model based on system acceleration and gravity loads on the X and Y Axis. The load values are shown below. The system is constrained at the bottom of each Z Axis carriage.



The resultant forces and moment loads at each carriage joint are shown below in black and the maximum allowables for the gantry in blue. The corrdinate system shown is local to the individual carriage.



	Fx (N)		Fy (N)		Fz (N)		Mx (Nm)		My (Nm)		Mz (Nm)	
X Carriage	90	800	880	900	90	1000	68	125	4	120	25	90
Y Carriage	51	800	140	900	640	1000	97	125	42	120	1	90
Z Carriage	550	800	45	900	82	1000	5	125	98	120	54	90



Payload Mounting Screw Loads

The Payload is mounted to the carriage using three screws: two on the bottom of the carriage mounting plate and one on the top of the mounting plate. In a worst case loading scenario it is assumed that all loads are creating shear and tensile loads in the single top mounting screw. This calculation find the resultant stress in that screw. The bracket is used as a lever arm to resolve moment loads into tensile loads in that screw. The two other screws are ignored.

$\sigma_{screw\_SS} := 70\ ksi = 483\ MPa$ — Tensile Stress of 18-8 SS M6x1mm screw Mcmaster-92125A239

$TSA_{screw\_M6X1} := 20.1\ mm^2$ — Tensile Stress Area of M6x1mm Screw

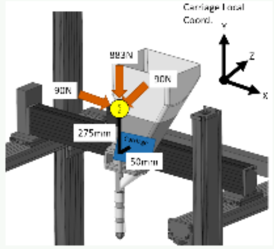
Given system Accelerations, Find Forces For the Given Payload

$F_X := a_{req} \cdot M_{Payload} = 90\ N$ — Force on the Mounting Plate Due to the Payload Accelerations

$F_{g\_payload} := g \cdot M_{Payload} = 883\ N$ — Force on the Mounting Plate Due to Payload Mass

$\Delta Y := 275\ mm \quad \Delta Z := 50\ mm$

X-Carriage Forces and Moments



$F_X := 90\ N$

$F_Y := g \cdot M_{Payload} = 883\ N$

$F_Z := 90\ N$

$M_X := (F_Y \cdot \Delta Z) + (F_Z \cdot \Delta Y) = 69\ N \cdot m$

$M_Y := F_X \cdot \Delta Z = 5\ N \cdot m$

$M_Z := F_X \cdot \Delta Y = 25\ N \cdot m$

$L_{X\_Screw} := 78\ mm$ — X Distance from mounting screw to edge of bracket

$L_{Y\_Screw} := 130\ mm$ — Y Distance from mounting screw to edge of bracket

$$\tau := \frac{F_X + F_Y + F_Z}{TSA_{screw\_M6X1}} = 53\ MPa$$

$$\sigma := \frac{\left(\frac{M_X}{L_{Y\_Screw}}\right)}{TSA_{screw\_M6X1}} + \frac{\left(\frac{M_Y}{L_{X\_Screw}}\right)}{TSA_{screw\_M6X1}} + \frac{\left(\frac{M_Z}{L_{X\_Screw}}\right)}{TSA_{screw\_M6X1}} = 45\ MPa$$

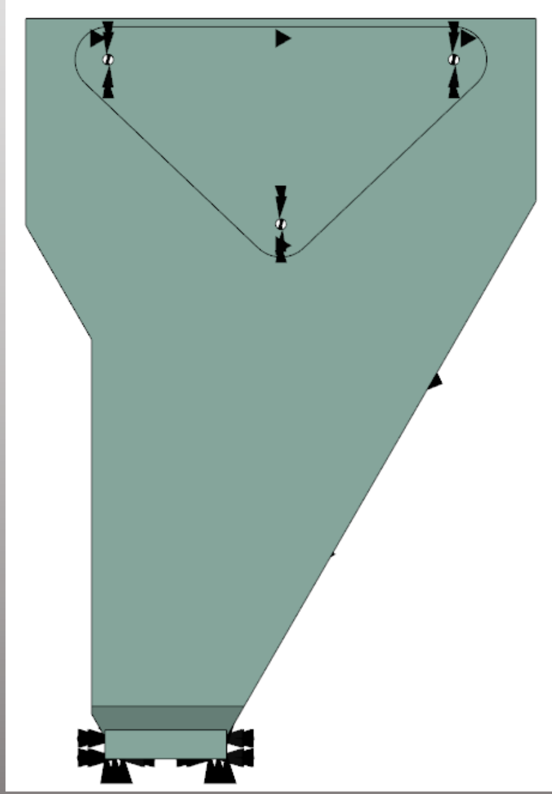
$$\sigma_{VM} := \sqrt{\sigma^2 + \tau^2} = 69\ MPa$$

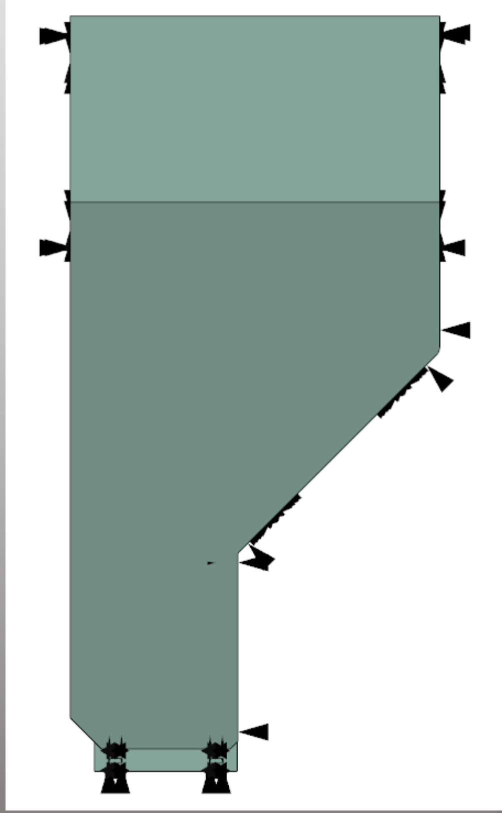
$$MoS := \frac{\sigma_{screw\_SS}}{3\ \sigma_{VM}} - 1 = 1.3$$

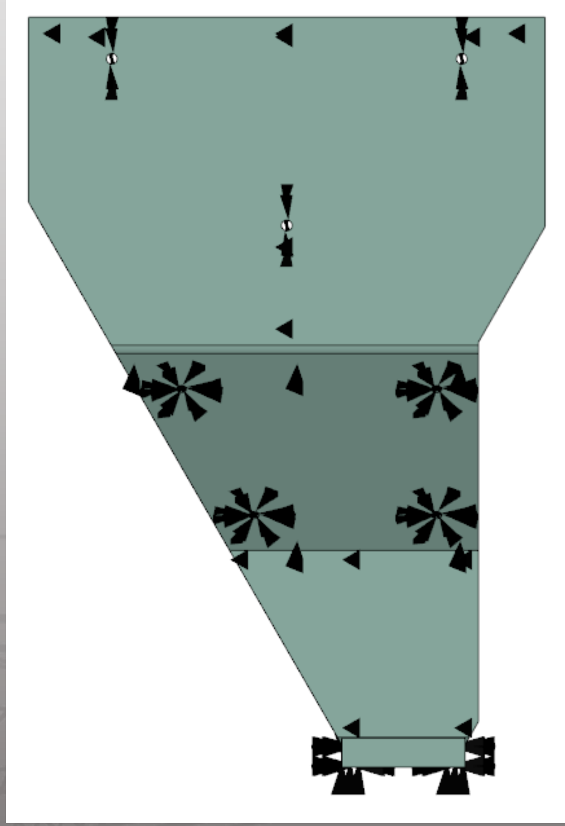
Hopper Analysis

Planar Constraints at Support Plates

Pin Constraints at Fasteners' Bearing Surfaces



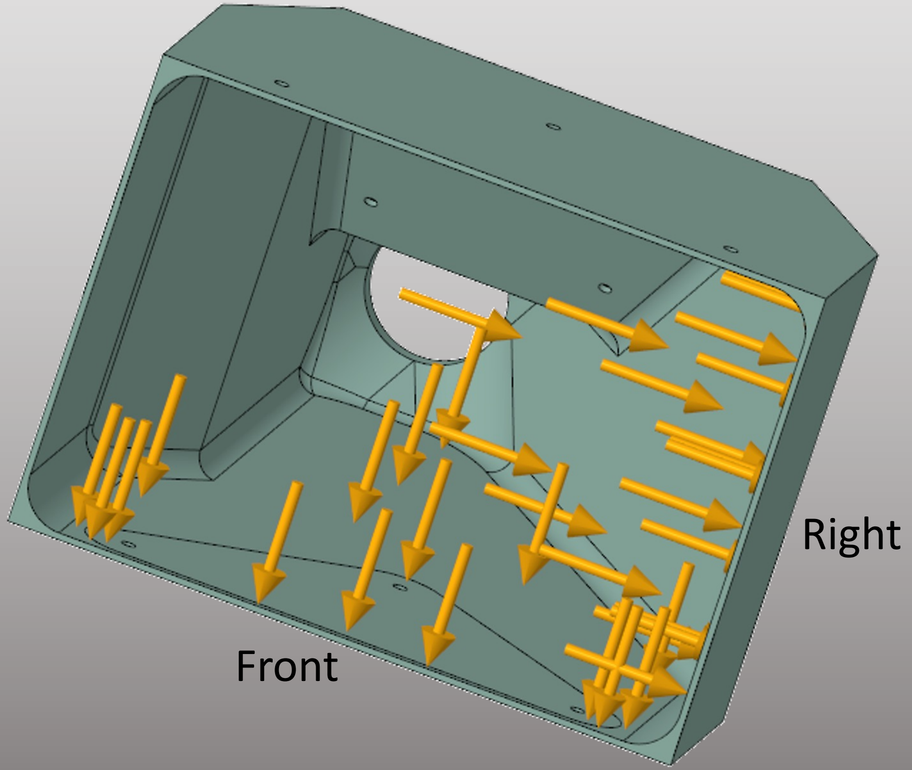


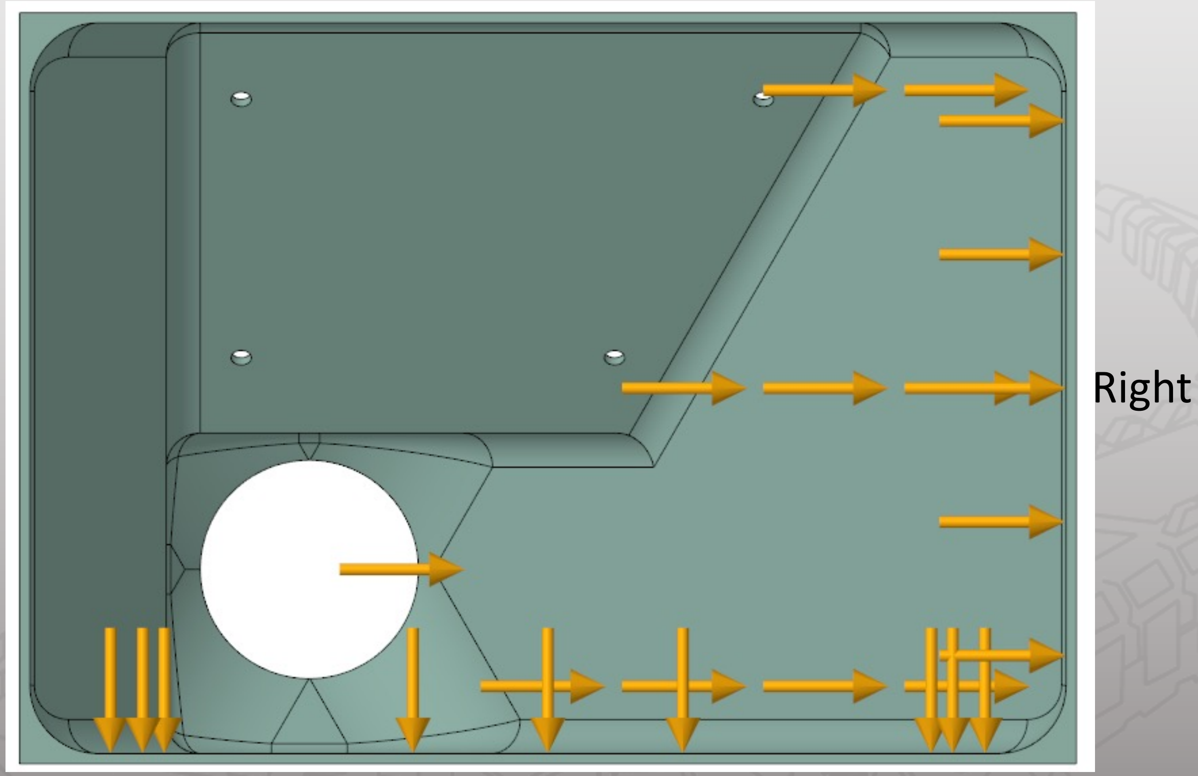


Hopper Analysis

Planar Constraints at Support Plates

Pin Constraints at Fasteners' Bearing Surfaces



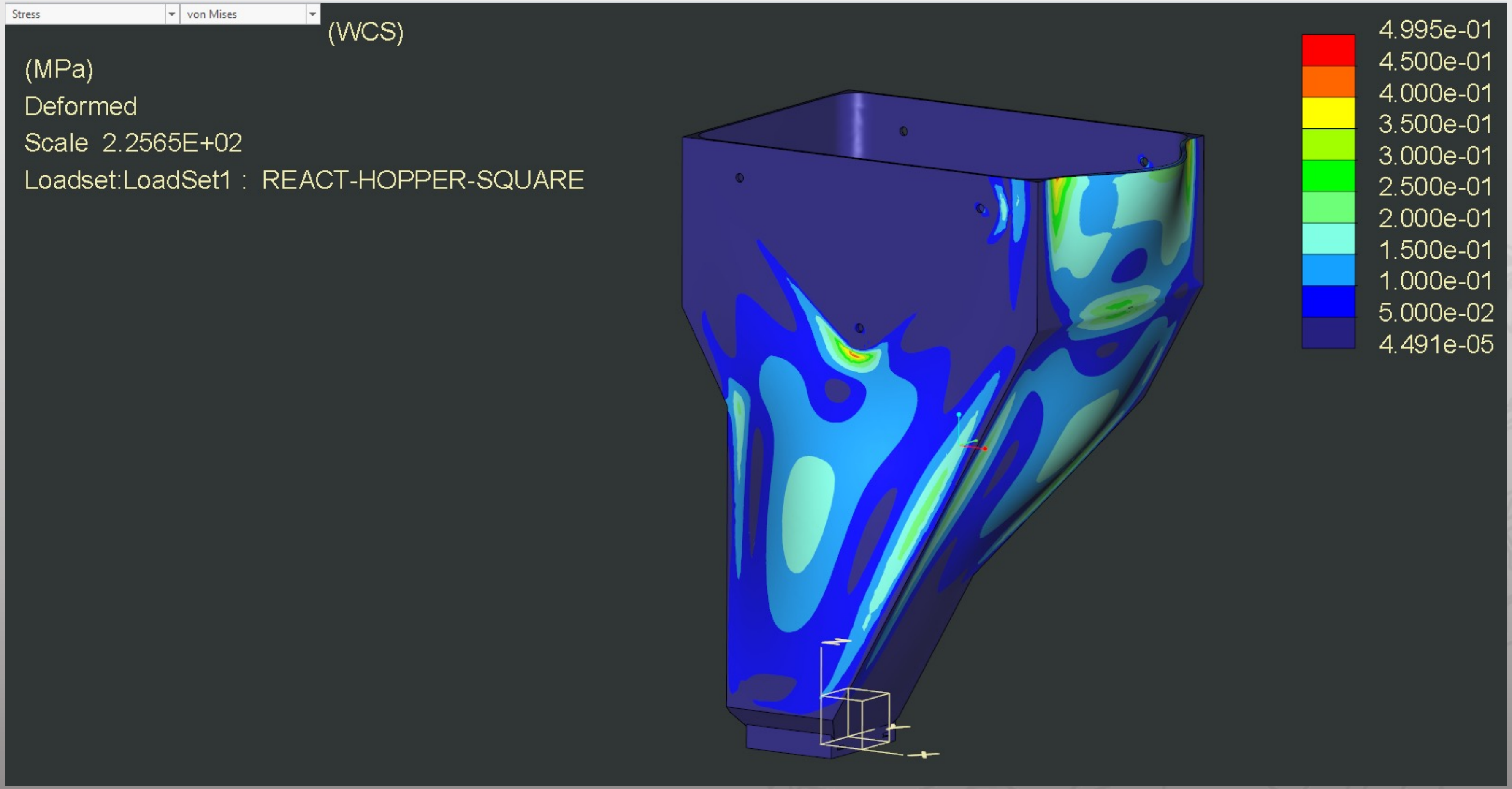


Hopper Analysis

PETG Filament

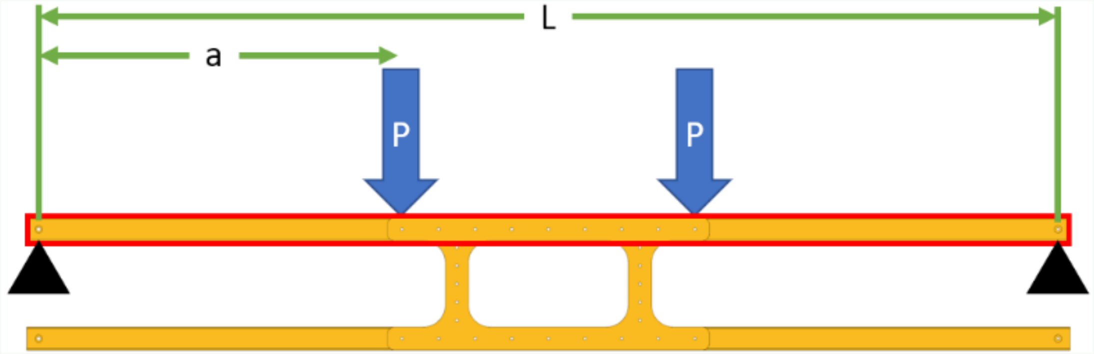
Tensile Strength @ Yield

50 MPa



Forklift Beam Loading

The gantry is lifted by a front and rear forklift point. This point is a stainless steel box tube that runs the width of the gantry. The boxtube is also supported by additional gusset plates and box tubing. For this calculation the additional supports are ignored and the box tube is treated as a simply supported beam with two loading points that split the weight of the gantry. The forklift can lift from any point along the beam, but here it is assumed to be in a worst case positioning, as far in as possible for the two prongs. The calculation also assumes that only 2 points of contact occur and ignores the second forklift beam.



$E_{ss304} := 28000\ ksi = 193\ GPa$ Modulus of Elasticity of 304 Stainless

$\sigma_{ss304} := 73200\ psi = 505\ MPa$ Ultimate Tensile Strength of 304 Stainless

$mass := 100\ kg + 90\ kg = 190\ kg$ Estimated Maximum Mass of the System with a 90kg (198lb) Payload. (7x7kg carriages and margin + 90kg Payload)

$P := \frac{mass \cdot g}{2} = 932\ N$ Forklifted Weight. Load is split between three points of contact.

$L := 1.392\ m$

$a := 0.496\ m$

$h := 1.25\ in = 31.8\ mm$ Outer Height of Square Tube

$h' := 1.01\ in = 25.7\ mm$ Inner Height of Square Tube

$A := h^2 - h'^2 = 349.935\ mm^2$ Area of Square Tube

$I := \frac{h^4 - h'^4}{12} = (4.859 \cdot 10^4)\ mm^4$ Area Moment of Inertia of Square Tube

$M_{max} := P \cdot a = 462.089\ N \cdot m$ Max Moment Load

$S_{max} := P = 931.632\ N$ Max Shear Load

$\sigma_{max} := \frac{M_{max} \cdot \left(\frac{h}{2}\right)}{I} = 151\ MPa$ Max Tensile Stress

$\tau_{max} := \frac{S_{max}}{A} = 2.7\ MPa$

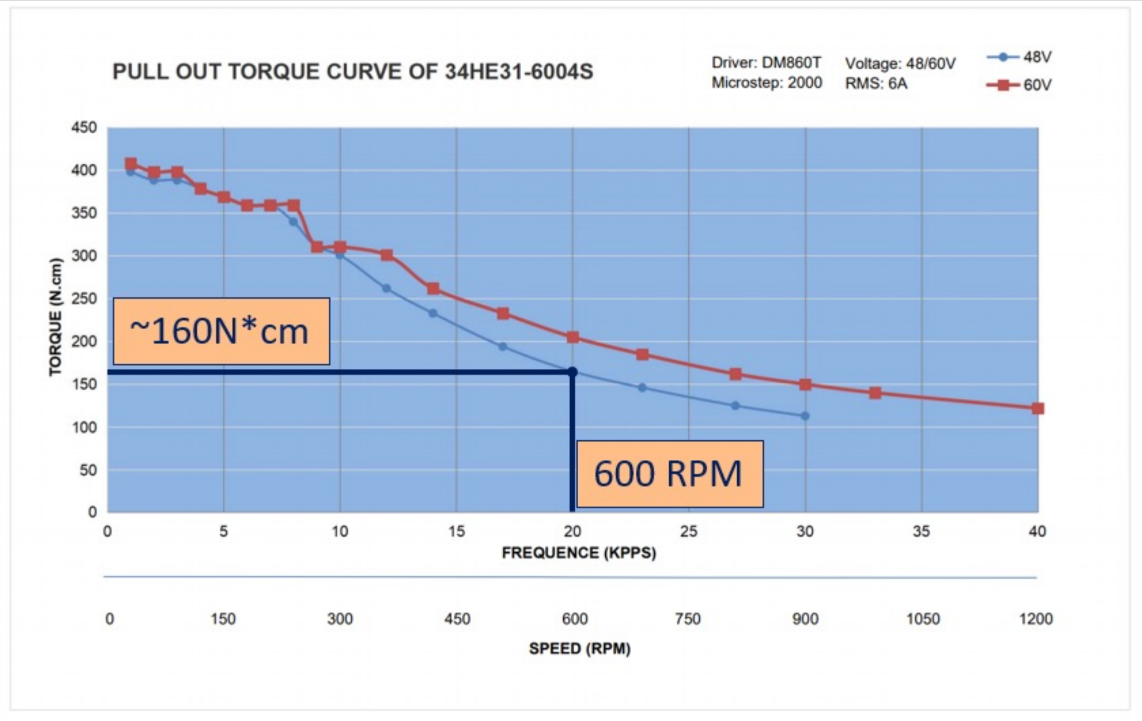
$\sigma_{VM} := \sqrt{\sigma_{max}^2 + \tau_{max}^2} = 151\ MPa$

$MoS := \frac{\sigma_{ss304}}{\sigma_{max} \cdot 3} - 1 = 0.11$

Motor Selection (X-Axis/Y-Axis)

Torque During Accel: 53N*cm

Speed:600rev/min



X/Y-Axis

Find Acceleration Load on X&Y

$F_{load} := M_{payload} \cdot a_{req} = 90\ N$ — Acceleration Load on X&Y

Screw Pitch	Coeff. Friction	Efficencty
$Ball\_Pitch\_10 = 10\ \frac{mm}{rev}$	$w_f = 1.22$	$\mu_{ball} = 0.9$

$$\tau_{load} := \frac{F_{load} \cdot Ball\_Pitch\_10 \cdot w_f}{2 \cdot \pi \cdot \mu_{ball}} = 3.1\ N \cdot cm$$

Driving Torque for Given Acceleration

$\tau_{running} := Ball\_running = 50\ N \cdot cm$

Torque Needed to Move the Payload at Constant Velocity (Ball Screw = 0.5Nm)

$\tau_{X\&Y} := \tau_{load} + \tau_{running} = 53\ N \cdot cm$

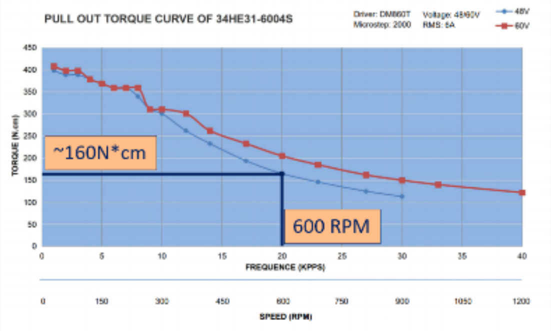
Total Torque to Accelerate the Carriage and Payload

$S_{req\_X\&Y} = 100\ \frac{mm}{s}$

System Required Velocity

$$\omega_{X\&Y} := \frac{S_{req\_X\&Y}}{Ball\_Pitch\_10} = 600\ \frac{rev}{min}$$

Rotational Velocity



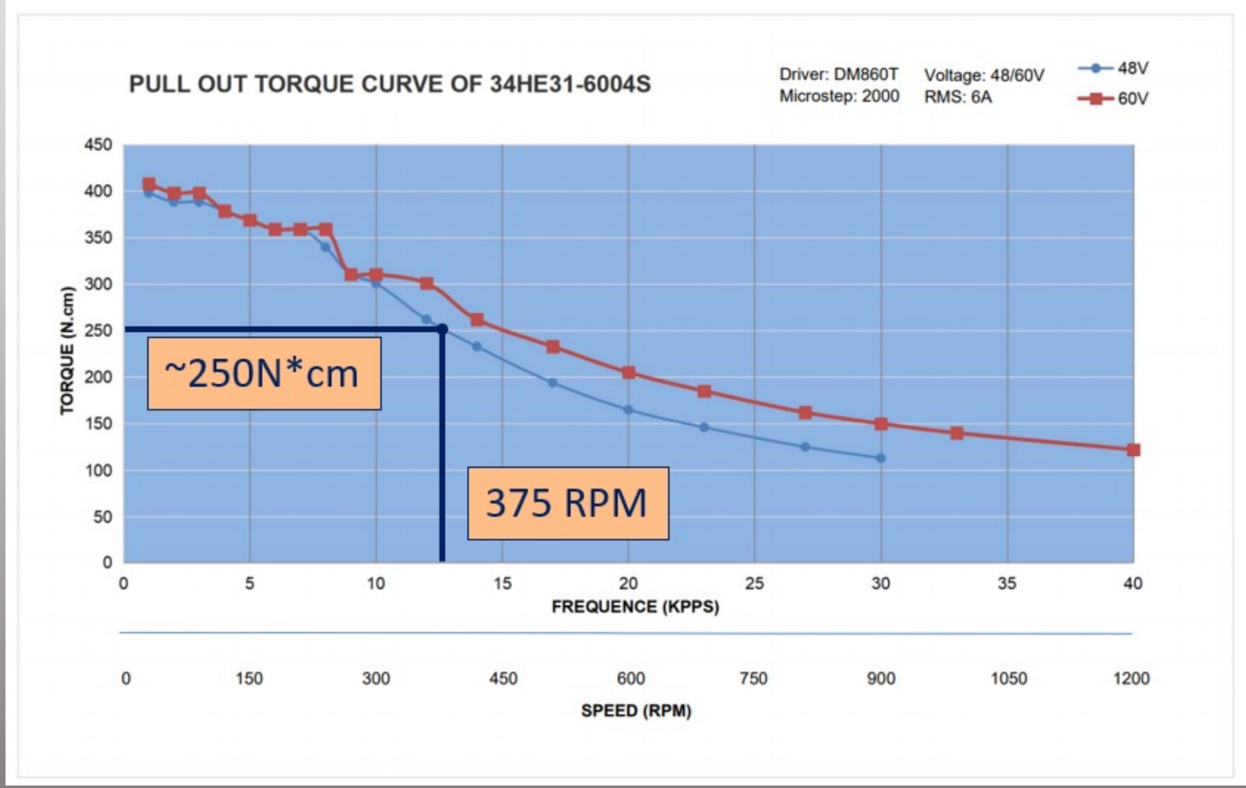
At 600 RPM and 48V the 34HE31-6004S Stepper Motor can Achieve a Torque of 160 N*cm. This is greater than required

$$FS := \frac{160\ N \cdot cm}{\tau_{X\&Y}} = 3$$

Alternative Motor Selection (Z-Axis)

Torque During Accel: 60N*cm

Speed:375rev/min



Z-Axis

Find Vertical Acceleration Load

$Mass_{X\&Y} := 3 \cdot (15\ kg) = 45\ kg$ — Mass of Carriage System for one X and two Y carriages

$M_{total} := Mass_{X\&Y} + M_{payload} = 135\ kg$ — Mass of Everything on the X Axis

$F_{Z\_Load} := \frac{M_{total} \cdot (g + a_{req})}{4} = 365\ N$ — Load to Accelerate the System Upwards Split Between the 4 Legs.

Screw Pitch	Coeff. Friction	Efficency
$ACME\_Pitch\_4 = 4\ \frac{mm}{rev}$	$w_f = 1.22$	$\mu_{ACME} = 0.4$

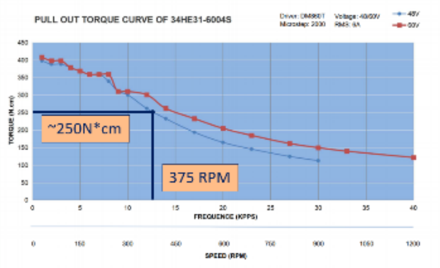
$\tau_{load} := \frac{F_{Z\_Load} \cdot ACME\_Pitch\_4 \cdot w_f}{2000 \cdot \pi \cdot \mu_{ACME}} = 0.011\ N \cdot cm$ — Driving Torque for Given Acceleration

$\tau_{running} := ACME\_running = 60\ N \cdot cm$ — **Torque Needed to Move the Payload at Constant Velocity (Lead Screw = 0.6Nm)**

$\tau_Z := \tau_{load} + \tau_{running} = 60\ N \cdot cm$ — Total Torque to Accelerate the Carriage and Payload

$S_{req\_Z} = 25\ \frac{mm}{s}$ — Max Speed of Z Axis

$\omega_Z := \frac{S_{req\_Z}}{ACME\_Pitch\_4} = 375\ \frac{rev}{min}$ — Rotational Velocity

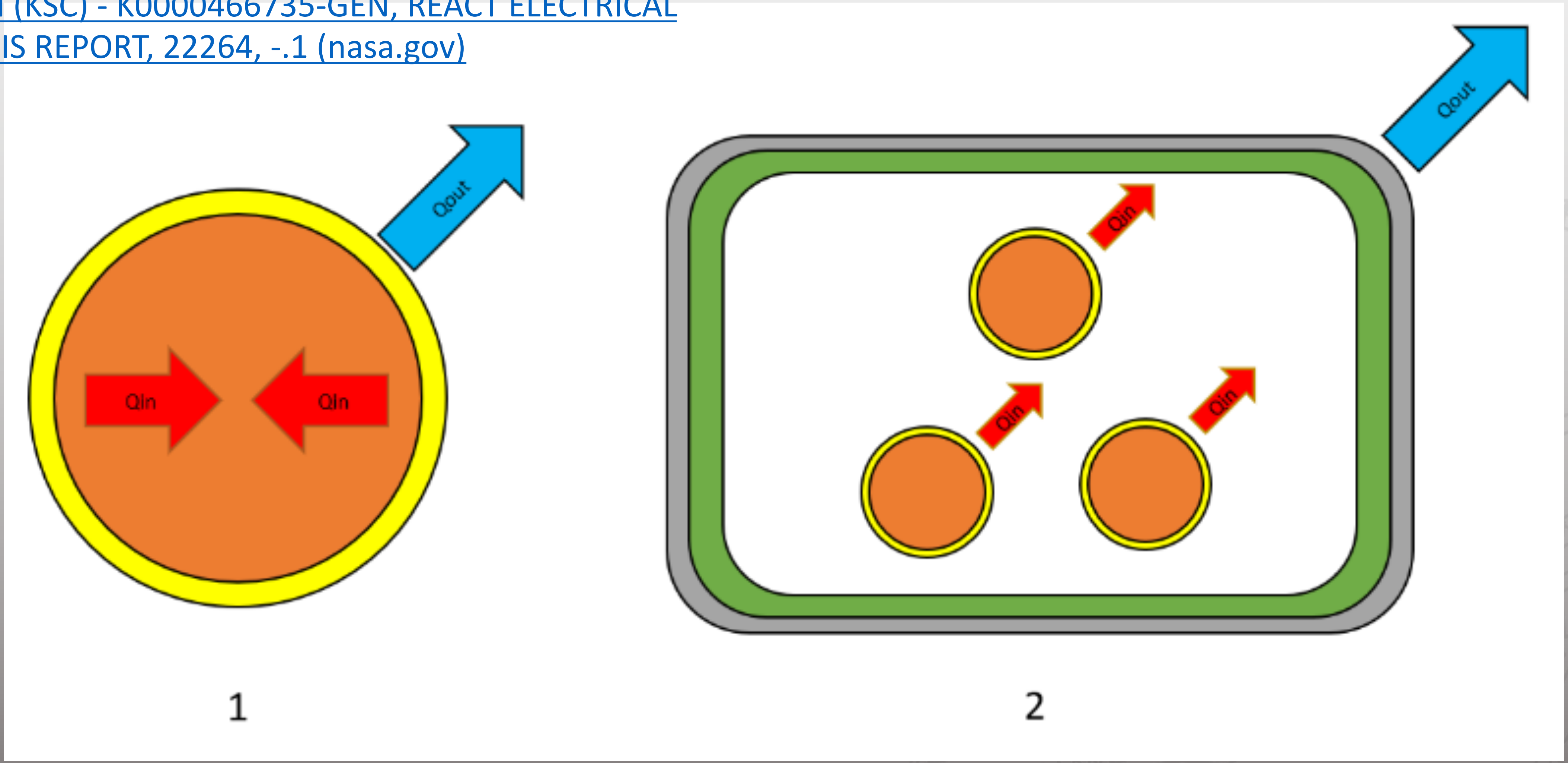


At 375 RPM and 48V the 34HE31-6004S Stepper Motor can Achieve a Torque of 250 N*cm. This is greater than required 60 N*cm

$FS := \frac{250\ N \cdot cm}{\tau_Z} = 4$

Wire and Wire Bundle Calcs

General (KSC) - K0000466735-GEN, REACT ELECTRICAL ANALYSIS REPORT, 22264, -.1 (nasa.gov)



Verify Wire In Vacuum Can Radiate Heat Faster Than Power Transmission Creates Heat

Identify the Diameter and Cross-Sectional Area of Each Transmission Wire in the E-Chain

$D_{wire\_Steppers} := 0.0508\ in = 1.29\ mm$ There are 16 Stepper Wires, 16AWG

$D_{wire\_Heaters} := 0.0403\ in = 1.024\ mm$ There are 3 Heater Wires, 18 AWG

$CSA_{wire\_Steppers} := \left(\frac{D_{wire\_Steppers}}{2}\right)^2 \pi = 1.308\ mm^2$ Cross Stection Area of A Stepper Wire

$CSA_{wire\_Heaters} := \left(\frac{D_{wire\_Heaters}}{2}\right)^2 \pi = 0.823\ mm^2$ Cross Stection Area of A Heater Wire

Find the Resistivity of Copper at the Max Wire Temperature

$T_{max\_insu} := 200\ °C = 473\ K$ Temperature Rating of Wire

$\rho_{cu\_ref} := 1.7 \cdot 10^{-8}\ \Omega \cdot m$ Reference Resistance of Copper (20 C)

$T_{ref} := 20\ °C = 293.15\ K$ Reference Temperature for Copper Resistance

$\alpha_{cu} := 0.004041 \cdot \frac{1}{K}$ Temperature Coeff. of the Resistance of Copper

$\rho_{cu\_450} := \rho_{cu\_ref} \cdot \left(1 + \alpha_{cu} \cdot \left(T_{max\_insu} - T_{ref}\right)\right) = \left(2.937 \cdot 10^{-8}\right)\ \Omega \cdot m$

$R'_{wire\_Steppers} := \frac{\rho_{cu\_450}}{CSA_{wire\_Steppers}} = 0.022\ \frac{\Omega}{m}$ Resistance of a Stepper Power Line

$R'_{wire\_Heaters} := \frac{\rho_{cu\_450}}{CSA_{wire\_Heaters}} = 0.036\ \frac{\Omega}{m}$ Resistance of a Heater Power Line

Calculate Worst Case Heat Load Due to Transmission Lines

$A_{wire\_Stepper} := 6\ amp$ Current Load on Stepper Motor Wire

$A_{wire\_Heater} := 3.5\ amp$ Current Load on Heater Wire

$Q'_{in\_wire\_Stepper} := R'_{wire\_Steppers} \cdot A_{wire\_Stepper}{}^2 = 0.8\ \frac{W}{m}$ Heat Load on a Stepper Motor Wire

$Q'_{in\_wire\_Heater} := R'_{wire\_Heaters} \cdot A_{wire\_Heater}{}^2 = 0.4\ \frac{W}{m}$ Heat Load on a Heater Wire

Calciulate Radiative Loss from Wire Insulation at Worst Case Temperature

$\varepsilon_{PTFE} := 0.92$ Emissitivty of PTFE (Teflon)

$T_{max\_chain} := 265\ °F = 402.6\ K$ Max Rated Temperature of E-Chain (Mcmaster-5608K71)

$D_{insu\_Steppers} := 0.08\ in = 2.0\ mm$ Outter Diameter of Stepper Motor Wire

$D_{insu\_Heaters} := 0.069\ in = 1.8\ mm$ Outter Diameter of Heater Wire

$A_{insu\_Steppers} := 2\ \pi \cdot \left(\frac{D_{insu\_Steppers}}{2}\right) = 63.837\ \frac{1}{m} \cdot cm^2$ Surface Area Per Unit Length of Stepper Motor Wire

$A_{insu\_Heater} := 2\ \pi \cdot \left(\frac{D_{insu\_Heaters}}{2}\right) = 55.06\ \frac{1}{m} \cdot cm^2$ Surface Area Per Unit Length of Heater Wire

$Q'_{out\_wire\_Stepper} := A_{insu\_Steppers} \cdot \varepsilon_{PTFE} \cdot \sigma \cdot \left(T_{max\_insu}{}^4 - T_{max\_chain}{}^4\right) = 8\ \frac{W}{m}$

$Q'_{out\_wire\_Heater} := A_{insu\_Heater} \cdot \varepsilon_{PTFE} \cdot \sigma \cdot \left(T_{max\_insu}{}^4 - T_{max\_chain}{}^4\right) = 7\ \frac{W}{m}$

Finally, Show that the Q per Length In is Lower than Q per Length In

$MoS := \frac{Q'_{out\_wire\_Stepper}}{Q'_{in\_wire\_Stepper}} - 1 = 9$

$MoS := \frac{Q'_{out\_wire\_Heater}}{Q'_{in\_wire\_Heater}} - 1 = 15$

Verify E-Chain In Vacuum Can Radiate Heat Faster Than All Power Transmission Creates Heat

Calculate all heat transfer per unit length into the E-chain. For the 4 stepper motors, there are 16 wires, but only half of them will be powered at any given time. For Heater Wires assume all 6 lines are powered.

$$Q'_{in\_Echain} := \left(\left(\frac{16}{2}\right) \cdot Q'_{in\_wire\_Stepper}\right) + \left(6 \cdot Q'_{in\_wire\_Heater}\right) = 9\ \frac{W}{m}$$

Heat Load on E-Chain from All Wires

Calculate the radiative losses E-chain per unit length

$h := 1.5\ in = 38.1\ mm$ — E-Chain Height

$b := 2.4\ in = 60.96\ mm$ — E-Chain Width

$A_{Echain} := 2\ h + 2\ b = 0.198\ \frac{m^2}{m}$ — Surface Area Per Unit Length of E-Chain

$\varepsilon_{SS} := 0.2$ — Emissivitvy of Stainless Steel E-Chain Shell

$T_{max\_Echain} := 265\ °F = 403\ K$ — Max Rated Temperature of E-Chain (Mcmaster-5608K71)

$T_{chamber} := 72\ °C = 345\ K$ — The ASSIST Chamber Will be Room Temp or Lower

$$Q'_{out\_Echain} := A_{Echain} \cdot \varepsilon_{PTFE} \cdot \sigma \cdot \left(T_{max\_Echain}{}^4 - T_{chamber}{}^4\right) = 125\ \frac{W}{m}$$

Heat Loss on E-Chain from Radiation

Finally, Show that the Q per Length In is Lower than Q per Length In

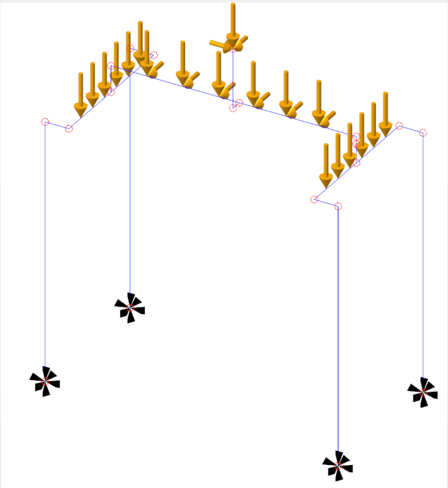
$$MoS := \frac{Q'_{out\_Echain}}{Q'_{in\_Echain}} - 1 = 13$$

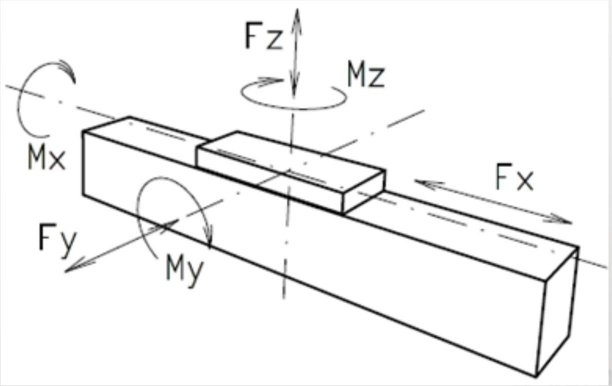
Gantry Carriage Loads

Gantry – Nook DLK120/DLT120

Loads Shown are Labeled Based on Carriage Local Axis System

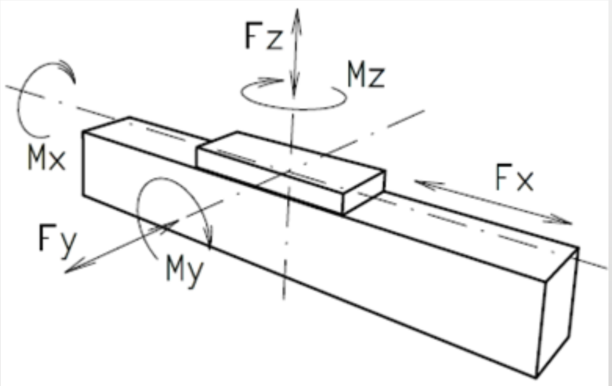
90 kg Payload





	Fx (N)		Fy (N)		Fz (N)		Mx (Nm)		My (Nm)		Mz (Nm)	
X Carriage	90	800	880	900	90	1000	68	125	4	120	25	90
Y Carriage	51	800	140	900	640	1000	97	125	42	120	1	90
Z Carriage	550	800	45	900	82	1000	5	125	98	120	54	90

REACT - Relevant Environment Additive Construction Technology

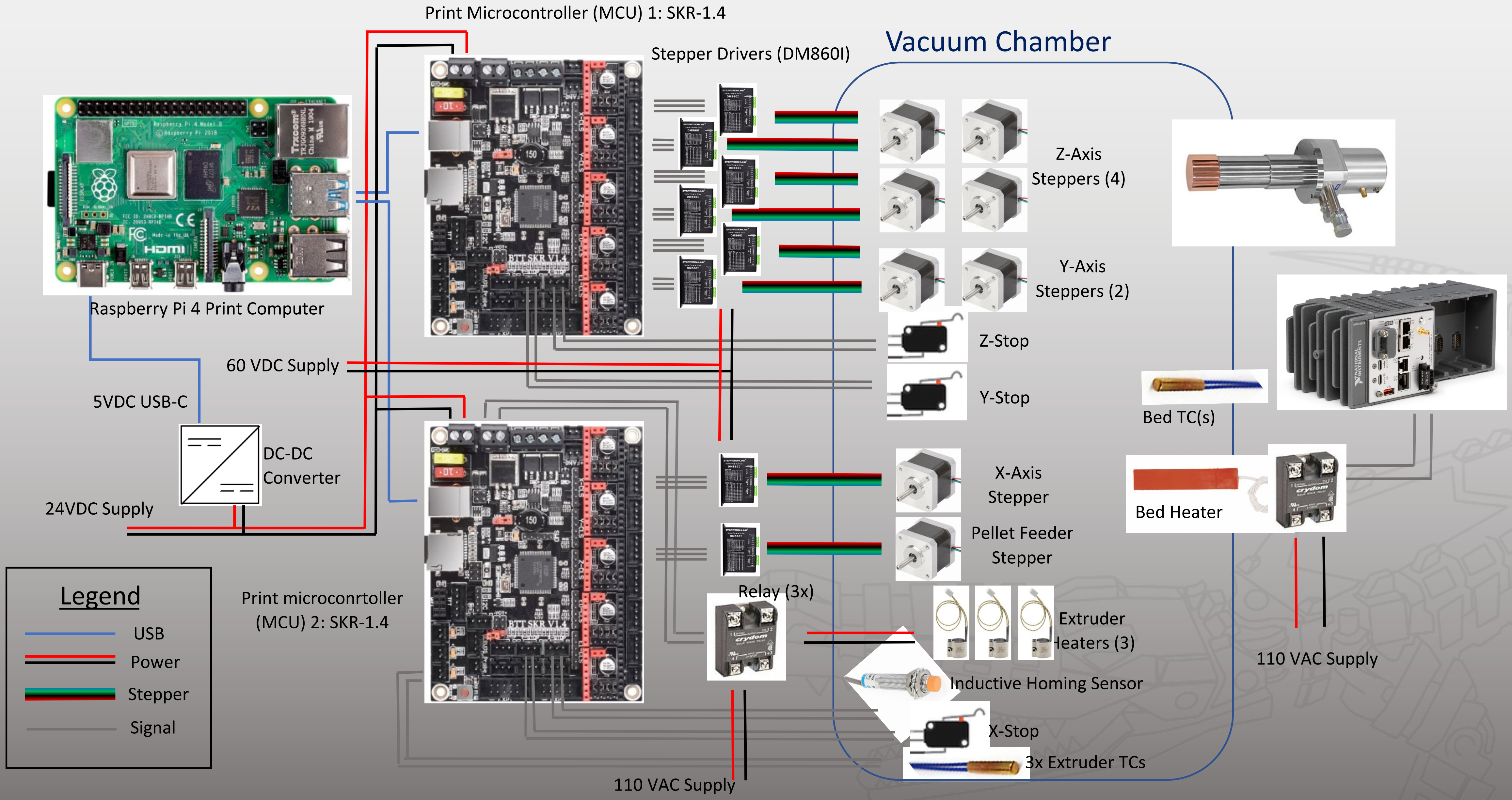


	Fx (N)		Fy (N)		Fz (N)		Mx (Nm)		My (Nm)		Mz (Nm)	
X Carriage	90	800	880	900	90	1000	68	125	4	120	25	90
Y Carriage	51	800	140	900	640	1000	97	125	42	120	1	90
Z Carriage	550	800	45	900	82	1000	5	125	98	120	54	90

REACT - Relevant Environment Additive Construction Technology

SWAMP WORKS
NASA KENNEDY SPACE CENTER

Printing Control System



SWAMP WORKS
NASA KENNEDY SPACE CENTER

Wires in Z echain	N wires	Gauge (awg)	cond dia (in)	insulator dia (in)	Max Current ea (A)
4x steppers (extruder + x +2y)	16	16	0.0508	0.08	6.0
3 K TCs	6	20	TBD	0.06	0.0
3x heaters (E)	6	18	0.0403	0.069	3.5
2x limits (x+y)	4	20 (or smaller)	0.032	0.058	0.0
Total	32		bundle size	0.407	
Length (m)	5.5				

https://www.remingtonindustries.com/content/PTFE%20Hook%20Up%20Wire%20Data%20Sheet.pdf

Motor Selection (X/Y-Axis)

NEMA 34 – 86x86x80mm

6.0A, 48V