Design Progress Report

Design Report Group 4

MAE 4344

Spring 2018

Lane Serup (Team Lead)

Miguel Ornelas

Andrew Latham

Problem Statement

Georg Fischer contacted Oklahoma State University about creating a machine designed to automatically winder copper coil around a Core Pin. This process is necessary in the making of Electro-Fusion Coil Couplers, a very profitable pipe fitting sold by Georg Fischer to the natural gas industry. This process currently has no automated solution meaning that all coils must be wound by hand. This process is very tedious and requires a worker be very involved and resulting in a winding time of up to five minutes per coil. Georg Fischer has requested Oklahoma State create a machine that can automate this process cutting the winding process to under 65 seconds per coil.

Figure 1. Georg Fischer's Electrofusion coupler.

Plan of Attack

The main deliverable that was assigned to our group was the completion of machine capable of winding a coil in 65 seconds. This deliverable was given by Georg Fischer and was given as the slowest time acceptable; however, reaching under this time would be desirable. Additionally, it was required of our group to meet send our sponsor at Georg Fischer a weekly update over the work completed each week.

Work Completed

Our project was given to us with work partially completed by the group that had been assigned this project last semester. However, the machine was not near running condition, most all electronics had been purchased and wired and a frame had been constructed. Our group began by reading over the information left by last semester's group and understanding the direction they were moving and their plan of attack for the machine. After reading over their material and talking with Georg Fischer and Dr. Taylor, our group decided that a different approach would be better and more reasonable. Instead of using a gripping arm that was attached to a rail, we elected to use a bar to run the wire to the core pin. Additionally, we decided that it would be better to change the orientation of the Core Pin from horizontal to vertical so as to meet the general convention at Georg Fischer.

After deciding the direction we wanted to take on our project, it was decided that we would need to completely rewire the motors and driver and bring all wiring in to an electrical box which the first group did not have. Georg Fischer asked our group to have more of a focus on user safety than the previous group which included the addition of doors and safety meshing.

In the last month, the team has continued with the construction of the project. The first step that needed to be completed was creating CAD drawings for our vision of the final product. In creating a model of the final design, it became very easy to rule out design decisions that were not possible. The biggest challenge faced in the preliminary design phase turned out to be finding a way to fit all needed electronics into an electrical cabinet capable of being purchased from McMaster-Carr. The electrical cabinet that was found to best fit the needs of the team had dimensions of 24”x24”x6”.

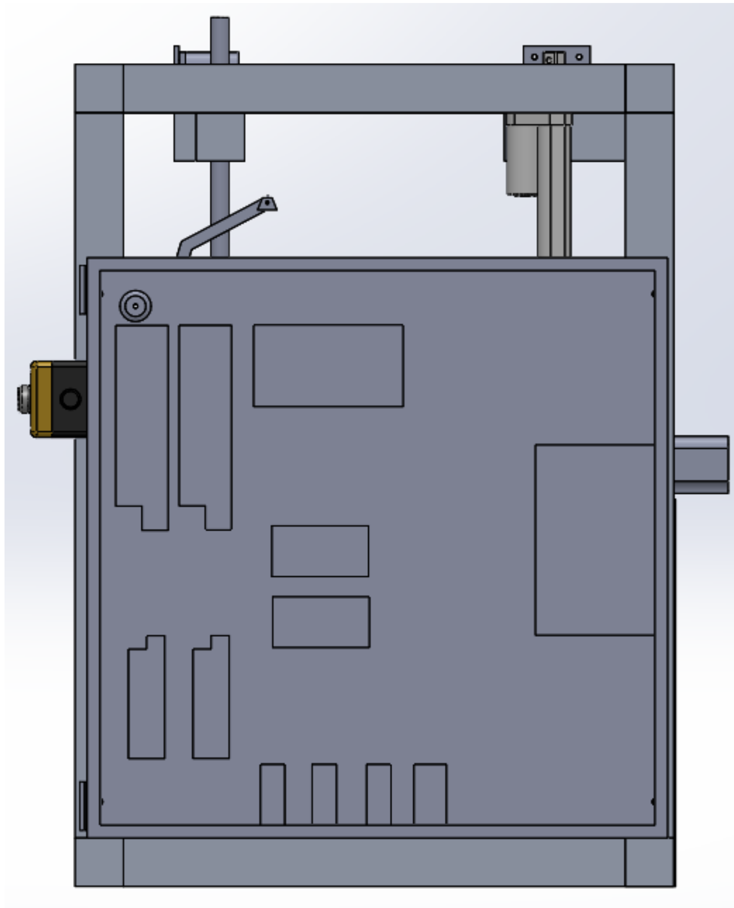


Figure 2. EF Coil Winder Electrical Box Layout.

The need for such a large electrical box sparked the need for a redesign from the initial CAD model created in the first month of the project. However, we were able to find a new design that met all the needs of the project.

After creating a basic design of the project using SolidWorks, the next step was build out and design realization. In order to reach a realized design, the group had to create more CAD drawings of components designed to retain the spinning core pin and house our various motors. After designing these pieces, the CAD drawings were sent to Georg Fischer to be manufactured. This was done because our sponsor wanted the Georg Fischer machine shop to make all important components as the quality of production would be higher. After the designs were created, the group had all components 3D printed using campus resources to ensure that designs sent to Georg Fischer would fit and not waste the time of Georg Fischer employees by needing to be remade.

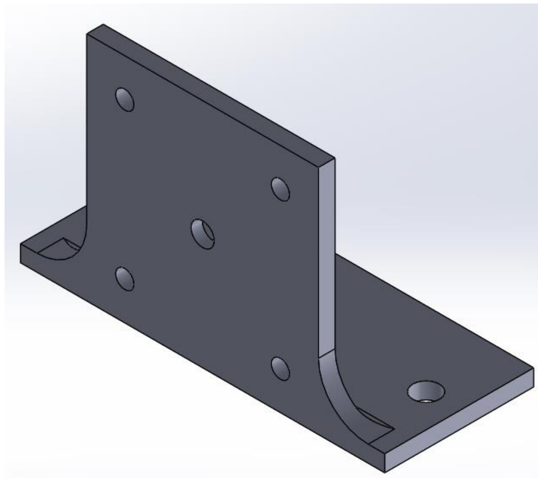


Figure 3. One of the motor mounts developed.

After our motor mounts and core pin retainers were finished being machined and printed, the group began working on the assembly of the project. This involved a lot of creative thinking and finding out how to ensure things stay put. The first issue encountered in this step was the need to drill a 1” hole through a piece of ¼” thick steel. Due to the thickness of the piece and the size of the hole, it was necessary to mark out all holes needed to be drilled through the piece and bring the steel from the NPDC to the DML. This piece of steel was selected for its rigidity as it is being used to hold our largest motor which weighs around 30 pounds. For the same mounting system, it became necessary to tap ¾” holes into the center of four pieces of aluminum extrusion, in order to do this, all aluminum was first cut using a reciprocating saw at the NPDC and then brought to the DML. Our group encountered a problem at the DML as all taps are exclusively imperial while the aluminum extrusion is metric requiring the center hole of the extrusion to be drilled out before being tapped. After the initial running back and forth, full assembly began. Because everything had already been CAD modeled, the process of building moved rather quickly. This includes mounting all of our motors, creating a piping system to run the coil wire, wiring and placing conduit on all electrical wiring, adding doors, and adding metal mesh around the frame to keep worker's hands out.

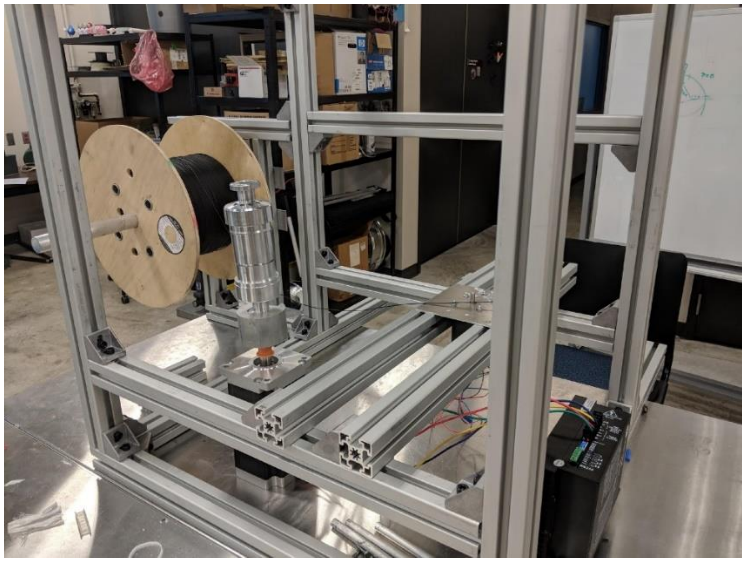


Figure 4. Progress as of progress report 1.

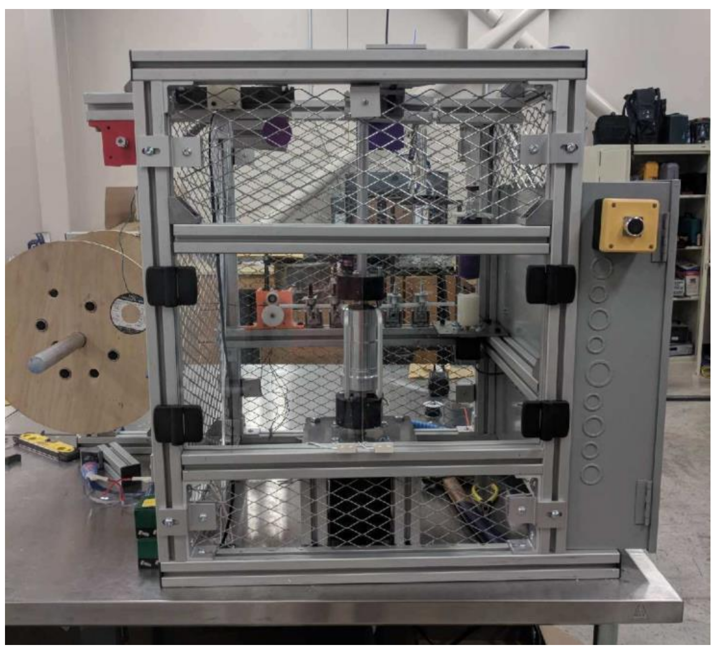


Figure 5. Project by progress report 2.

The group also conducted iterative calculations to determine how we could meet our 65 second design goal whilst still completing all steps necessary in order to wind the coil. This was done by selecting the most time-consuming processes and basing other times on these times. As a result of this, we discovered that we would need to find an alternative method to mate the wire to the core pin. Original designs used a linear actuator to bring the extruded wire to the core pin. The actuator would be too time consuming, so we decided to use a stepper motor and carriage system.

Table 1. Iterative calculation of approximate component times.

Timing Calculations	
Components	Times (s)
First Extruder	8
Linear Actuator/Wind	3
Winding	15
Stepper(Mate CorePin)	10
Servo Gripper	2
Core Pin Wind	15
Stepper(Heater)	6
Cutting Mechanism	1

Limiting Time Factor	65
Total Time	60

Other calculations included running all components at the same time in order to determine whether or not the AC power draw from components would be too high for a standard 15A circuit. After this test, we determined that the machine would be operable on a standard 120V/1ph circuit. Although this will not be a necessary requirement of Georg Fischer, as they will be operating the machine on a 480V/3ph circuit through a step-down transformer, but it will be necessary to run the machine on standard 15A circuit during presentations.

Key Conclusions and Decisions

Initial design called for the large motor that holds the core pin to be centered inside of the machine; however, after setting the motor in that location and mounting it, it became clear that it would be considerably more difficult for the user to remove the core pin from the machine. Because this would be an inconvenience on the user end, and the room was available, we decided to move the main motor to be flush with the front of the machine to minimize the distance inside of the machine the worker will have to reach. By decreasing the reach, the group was also able to slightly increase the safety of the machine by minimizing exposure to any components that have the ability to spin or move.

After testing the spin of the machine, the group found that the orientation of the core pin was not ideal for the design we had envisioned. The remedy for this was to flip the design for our core pin retainers. Doing this made it possible for the gripping arm we had created to function as intended. However, the retainers had already been machined the incorrect way causing a need for Georg Fischer to re-machine six pieces. After receiving the corrected retainer pieces, they were simply switched out and easily replaced.

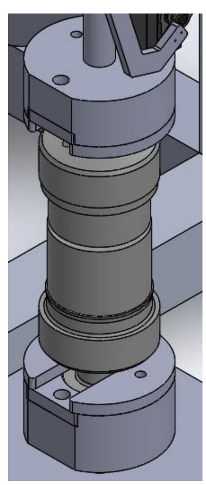


Figure 6. Core Pin retainers.

When deciding how to best extrude wire from the first stepper motor to the rest of the machine, it was believed that simply adding a bearing to the extrusion motor top would successfully extrude wire. While this method worked correctly, it was found that there was a tendency for the wire to slip off of the bearing preventing the wire from being extruded any farther. After brainstorming, the group decided that a good work around would be to add a v-groove to the bearing. Adding this groove would make the wire stay centered on the bearing and prevent any slippage; however, the first iteration led to too much distance between the bearing and the motor, this prevented any extrusion from occurring. The next iteration of this design simply required the depth of the v-groove be less with added thickness to the piece. After printing this design, and a new motor mount to accommodate the added thickness to the bearing, we observed that the motor was able to extrude wire when there was slack, but, had difficulty printing under tension. This problem has yet to be completely resolved.

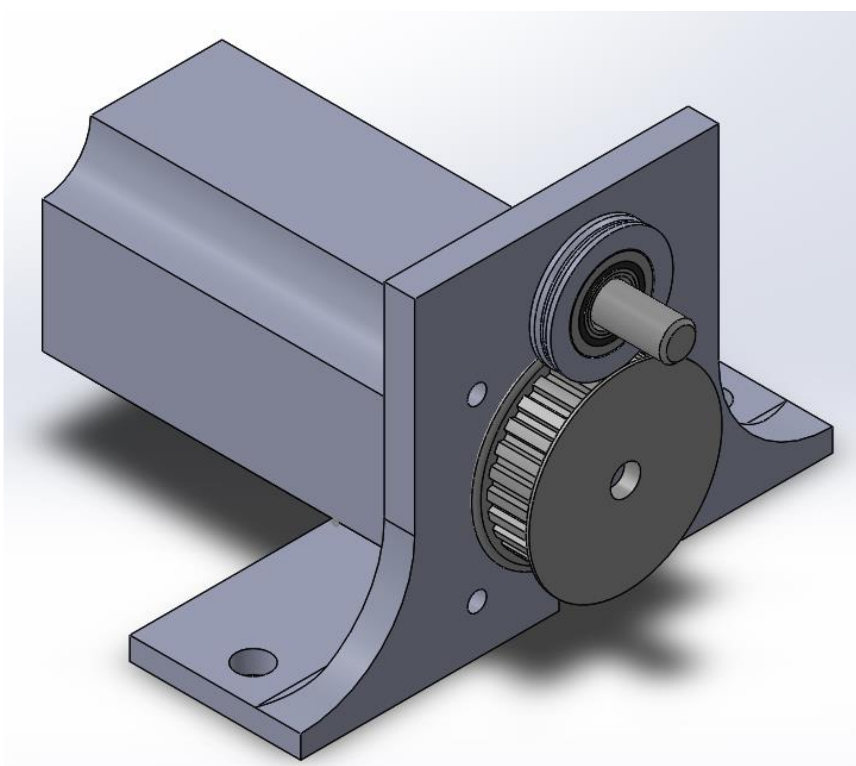


Figure 7. Main Extruder assembly. Note grooved attachment for bearing.

The group also realized a need for a mechanism to ensure the wire being extruded from the spool reached the wind/unwind motor every iteration. The solution that the group developed was to mount short pieces of plastic tubing to guide the wire from one motor to the other. The group also developed funnels in order to ensure that the wire is successfully transferred the next tube without being lost in the machine.

After getting the machine to consistently extrude wire, the big goal was to get the timing running right so that the wire can be extruded well and there will be no wire build up in the machine to get the project running. Unfortunately, after all motors and servos were running consistently, the motor driver for the core pin motor blew. This driver has a 2 week lead time and was not able to be replaced before the end of the semester meaning that while the code was there, the machine would not be able to completely function until the new driver was put in.

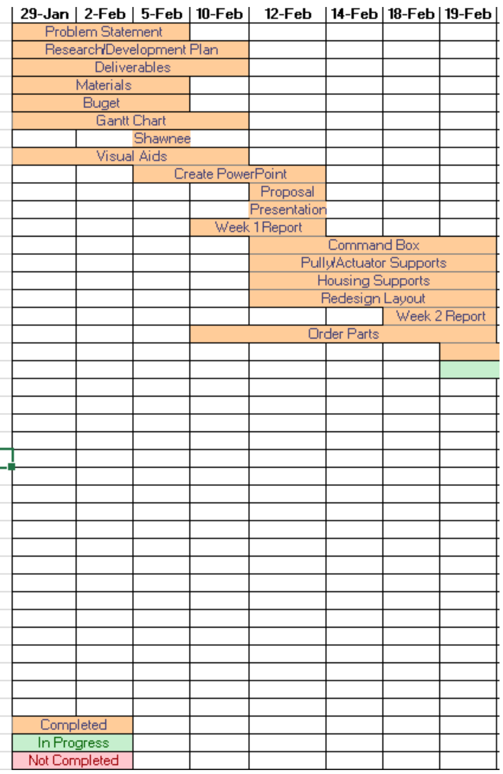
The goal of the semester was to create a machine capable of coiling wire in under 65 seconds, our final machine was capable of meeting the requirements in just under 40 seconds if the new motor were to be implemented.

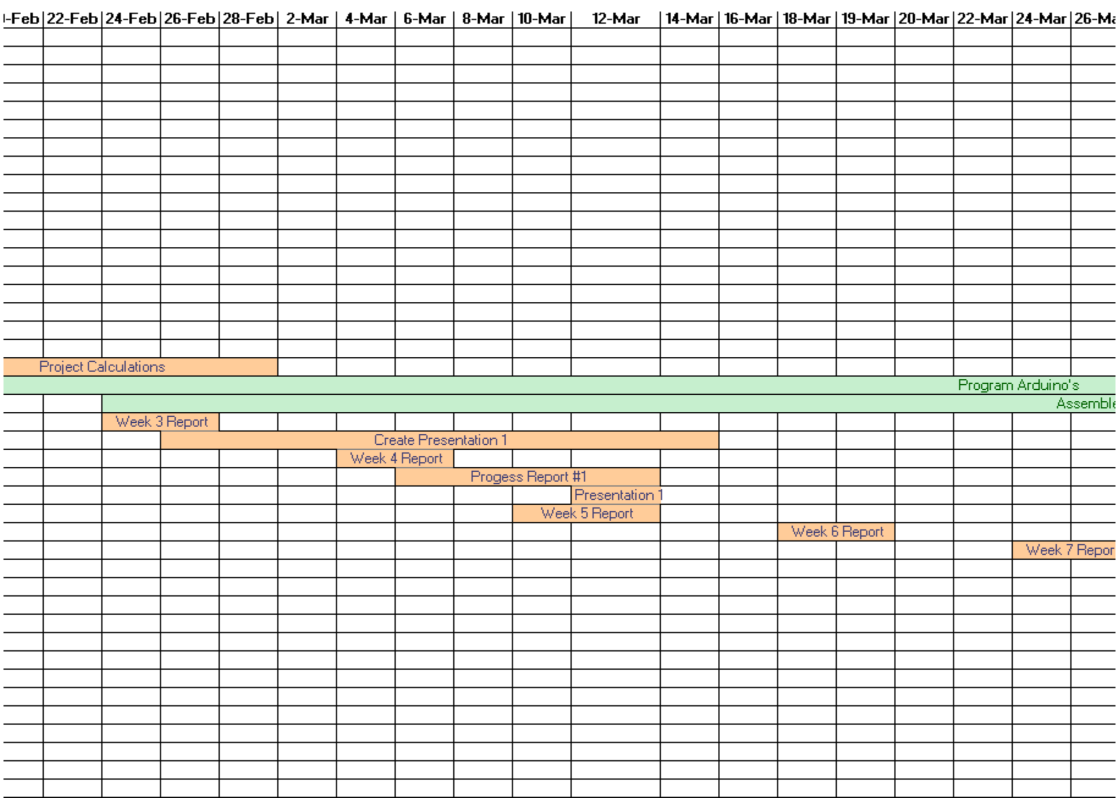
Future Work

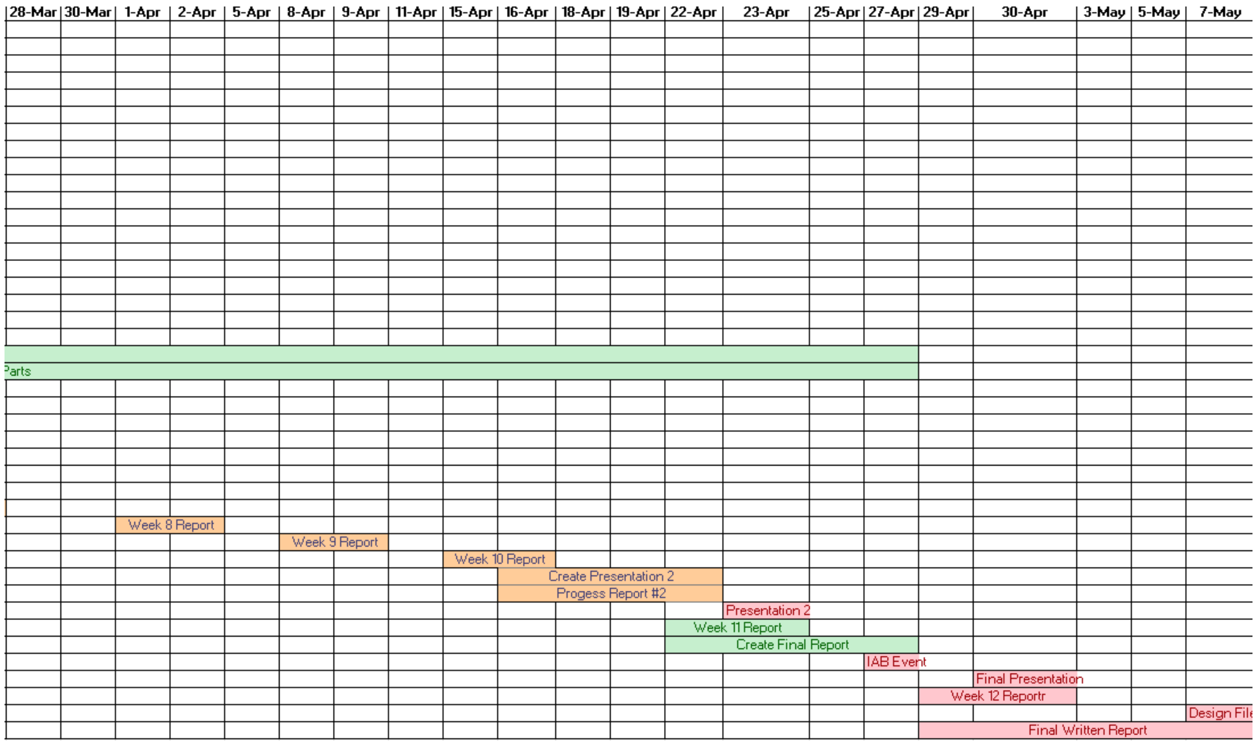
Future work needed on this machine would be the fine tuning of the mechanical components. Everything currently works when the button is pressed; however, because our timing has not been perfected, there is a buildup of wire in the machine that would not be desirable in a finished product. Additionally, there is a need to replace the motor driver for our core pin motor which blew in the final week of building.

Revised Gantt Chart

Assigned To:	Description of task	Start Date	Finished Date	Due Date
Lane		29-Jan-18	5-Feb-18	6-Feb-18
Miguel/Lane/Andrew		29-Jan-18	5-Feb-18	6-Feb-18
Lane		29-Jan-18	5-Feb-18	6-Feb-18
Andrew		29-Jan-18	5-Feb-18	6-Feb-18
Andrew		29-Jan-18	5-Feb-18	6-Feb-18
Miguel		29-Jan-18	10-Feb-18	10-Feb-18
Miguel		29-Jan-18	5-Feb-18	6-Feb-18
Miguel/Lane/Andrew	Ask Questions	5-Feb-18	5-Feb-18	5-Feb-18
Miguel/Lane/Andrew		6-Feb-18	11-Feb-18	12-Feb-18
Miguel/Lane/Andrew		12-Feb-18	12-Feb-18	12-Feb-18
Miguel/Lane/Andrew		12-Feb-18	12-Feb-18	12-Feb-18
Lane		10-Feb-18	11-Feb-18	12-Feb-18
Miguel	Command Box	12-Feb-18	19-Feb-18	19-Feb-18
Andrew	Pully/Acuator Supports	12-Feb-18	19-Feb-18	19-Feb-18
Lane	Housing supports	12-Feb-18	19-Feb-18	19-Feb-18
Miguel/Lane/Andrew		12-Feb-18	19-Feb-18	12-Mar-18
Lane		18-Feb-18	19-Feb-18	19-Feb-18
Andrew		10-Feb-18	19-Feb-18	19-Feb-18
Miguel		19-Feb-18	28-Feb-18	#######
Miguel/Andrew		19-Feb	27-Apr	27-Apr
Miguel/Lane/Andrew		24-Feb	27-Apr	27-Apr
Lane		24-Feb	26-Feb	26-Feb
Miguel/Lane/Andrew		26-Feb	12-Mar	12-Mar
Lane		4-Mar	5-Mar	5-Mar
Miguel/Lane/Andrew		6-Mar	12-Mar	12-Mar
Miguel/Lane/Andrew		12-Mar	12-Mar	12-Mar
Lane		10-Mar	12-Mar	12-Mar
Lane		18-Mar	19-Mar	19-Mar
Lane		24-Mar	26-Mar	26-Mar
Lane		1-Apr	2-Apr	2-Apr
Lane		8-Apr	9-Apr	9-Apr
Lane		15-Apr	16-Apr	16-Apr
Miguel/Lane/Andrew		16-Apr	23-Apr	23-Apr
Miguel/Lane/Andrew		16-Apr	23-Apr	23-Apr
Miguel/Lane/Andrew		23-Apr	23-Apr	23-Apr
Lane		22-Apr	23-Apr	23-Apr
Miguel/Lane/Andrew		22-Apr	27-Apr	27-Apr
Miguel/Lane/Andrew		27-Apr	27-Apr	27-Apr
Miguel/Lane/Andrew		30-Apr	30-Apr	30-Apr
Lane		29-Apr	30-Apr	30-Apr
Miguel/Lane/Andrew		7-May	7-May	7-May
Miguel/Lane/Andrew		29-Apr	7-May	7-May







Revised Budget Table

Row Labels	Controls	Electrical Components	Framing	Mechanical Components	Grand Total
10 A Max Terminal Block (x6)		$ 71.58			$ 71.58
10A Time Delay Glass Tube Fuse(x2 pkg)		$ 12.32			$ 12.32
15mm Guide Rail(x500mm)				$ 35.00	$ 35.00
18-8 SS Ring-Grip Pin, 3/8" D, 2" Useable x4			$ 10.68		$ 10.68
22 AWG Wire 50 ft(x5)		$ 29.55			$ 29.55
23 Teeth Roller Chain Sprocket				$ 27.24	$ 27.24
24x24x6" Electrical Enclosure W/ Knockouts		$ 164.55			$ 164.55
2A Dual Motor Controller for Actuator	$ 17.05				$ 17.05
3/8" Aluminum Conduit(25 ft)				$ 15.25	$ 15.25
3/8" Dowel(10 pack, 1 1/2")				$ 6.83	$ 6.83
6061 Aluminum Round Tube(2 ft)				$ 11.84	$ 11.84
6x6x1/4" Low carbon steel sheet			$ 19.81		$ 19.81
8 pin socket for cartride heater		$ 5.00			$ 5.00
8x8x1/4" Low carbon steel sheet			$ 30.63		$ 30.63
Aluminum Handles(x2)			$ 7.70		$ 7.70
Arduino Mega	$ 38.50				$ 38.50
Black-Oxide Steel U-Bolt, 3/4" ID(x2)			$ 2.00		$ 2.00
Cartridge Heater		$ 32.00			$ 32.00
Clear Polycarbonate Sheet(12x24x3/16")			$ 20.87		$ 20.87
Controller for Heating Element	$ 115.00				$ 115.00
Corner Brackets for 45mm Rail(x16)			$104.16		$ 104.16
Delrin Tube 3/8" OD, 1/4" ID, 3ft			$ 8.64		$ 8.64
Drop in fasteners x12			$ 21.12		$ 21.12
End Caps(x20)			$ 37.20		$ 37.20
End Feed Fasteners(4pkg)			$ 13.32		$ 13.32
Heat Shrink Tube(4 ft. White)		$ 1.86			$ 1.86

Lubricated Ball Bearing(3/8")				$ 13.98	$ 13.98
M3 Bolts x 12mm L				$ 7.98	$ 7.98
M4 Bolts x 16mm L				$ 9.49	$ 9.49
Magnetic contact switch(x2)		$ 7.90			$ 7.90
Magnetic Latch for 45mm Rail(x2)			$ 18.82		$ 18.82
Mounting adapter DIN Rails(x4)				$ 8.40	$ 8.40
Mounting adapter(plastic) (x4)				$ 8.28	$ 8.28
Pushbutton		$ 9.96			$ 9.96
Pushbutton Housing				$ 13.14	$ 13.14
Quick release pin(0.5" useable,3/8" dia, x2)				$ 4.84	$ 4.84
Rail to Panel Hinge(x4)			$ 59.92		$ 59.92
Roller Chain No. 25(x4 ft)				$ 20.56	$ 20.56
Screw on hanger for mesh panels(x20)			$ 164.00		$ 164.00
Servo for gripper		$ 19.95			$ 19.95
Servo for wire cutting		$ 19.95			$ 19.95
Sleeve Bearing Carriage for 15mm rail				$ 31.13	$ 31.13
Slip Ring 22mm 6 Wire		$ 17.50			$ 17.50
Snap Close Cable Holders(x12)		$ 36.00			$ 36.00
Square Mounting Plate for frame(x4)			$ 60.36		$ 60.36
Steel DIN Rail 2m				$ 9.00	$ 9.00
Steel Raised Expanded Panel(48x48)			$ 47.27		$ 47.27
Terminal End Cover		$ 0.58			$ 0.58
Terminal End Stop(x2)		$ 1.76			$ 1.76
Timing Belt Pulley(2"OD, 5/16" Shaft)				$ 8.75	$ 8.75
Wire Cutters				$ 18.05	$ 18.05
Grand Total	**$ 170.55**	**$ 430.46**	**$ 626.50**	**$ 249.76**	**$ 1,477.27**