

#### Insulation Cutting and Measuring Module Design Release



#### <u>Objective</u>

• Design and build a module that scans a work order, determines the desired length, measures insulation to that length, and cuts it with minimal human input required.



#### Value Proposition

This project will add value to the Boeing Tubing, Duct and Reservoir Center (TDRC) by:

- Minimizing human error involved in cutting insulation
- Reducing cost of measuring and cutting insulation
- Minimizing time spent measuring and cutting job order

## Product Requirements

- This system should take less time than the current method of cutting
- The cutter may not alter the insulation's integrity
- Measure the insulation within +/- 0.270" tolerance

## Total System Drawing



#### Alternative Views



## Cutter Assembly



### Gutters





# Top Wheel









## Power Box Assembly





#### Motor Circuit





## Programming Considerations





## Manufacturing Plan

#### Laser Cut and Weld Together

- 02-00 Gutters
- 03-00 Power Box
- 04-00 Frame
- 05-00 Human Interface



#### 3D Print

- 01-01 Connector
- 04-06 wheels
- 04-07-8 Linear Bearings



#### Machine

- 01-02 & 01-03 L Plate
- 04-04 Axel Precise Holes on:
- 04-00 Frame



## Risk Management

- Sharp metal
  - We have rounded all corners to prevent this being an issue
- Heated Wire
  - Encapsulated in box to prevent hands from touching heated wire
- Rollers
  - Encapsulated in box to prevent hands from getting stuck in rollers
- Other Precautions
  - Emergency stop button has been added to completely stop energy from coming into the system

## BOM

apstone De	apstone Design										
Ombined BOM and Manufacturing Plan											
STIDING DOW											
Indented Bill of Manadala (BOM)			i i	Manufacturian Dim						set	
Inc	ented bill of materials (BOM)		· · ·	Source (or	Eabrication	ls	an Is	Who will	Target		251
Part No. or			Make or	Fabrication	Technique (if	the Drawi ng	the Mater	lead	Completion D	Unit Cost	Extended
Assy No.	Description	Quantity	Buy?	Location)	appl.)	Avail 2	ial Avail.?	(Name)?	ate	(\$)	Cost (\$)
Full Assembly	Measuring and Cutting Module										\$ -
Subassembly 1	Cutter										\$ -
01-01	Bottom Plate	1	free	(apart of servo)	N/A	Yes	Yes			\$ -	\$ -
01-02	Connector	1	Make	Amazon	3d print	Yes	No		I	\$-	\$ -
01-03	Cutter L Plate	1	Make	ME shop	weld	Yes	No			\$ 2.00	\$ 2.00
01-04	Lead Screw	1	Buy	McMaster-Carr	N/A	Yes	No			\$ 15.00	\$ 15.00
01-05	Moving Plate	1	free	(apart of servo)	N/A	Yes	Yes			\$ -	\$ -
01-06	Nema 23 (linear actuator)	1	Buy	Amazon	N/A	Yes	Yes			\$ 69.99	\$ 69.99
01-07	Pail	1	free	(apart of serve)	N/A	Vac	Vec			<i>Q</i> 05.55	\$
01-08	Top Dista	1	free	(apart of servo)	N/A	Vec	Vec				¢ -
01-08	Time Miles al	1	free	(apart of servo)	IN/A	Tes Vee	Tes Ver			¢	
01-09	Tiny wheel	1	free	(apart of servo)	N/A	Yes	res			\$ -	\$ -
01-10	wire Cutter	1	виу	Amazon	N/A	Tes	res			\$ 23.99	> 23.99
01-11	Nema 17 (angle cutter)	1	Buy	Amazon	N/A	Yes	Yes			\$ 10.99	\$ 10.99
ubassembly 2	Gutter										Ş -
02-01	Gutters	2	Make	ME shop	lathe mill	Yes	No			\$ 30.00	\$ 30.00
02-02	Gutter Connection	2	Make	ME shop	weld	Yes	No			\$-	\$ -
02-03	Gutter Screws		Buy	McMaster-Carr	N/A	Yes	No			\$ 10.00	\$ -
ubassembly 3	Power Box										\$ -
03-01	12V Power Supply	1	Buy	Amazon	N/A	Yes	Yes			\$ 11.99	\$ 11.99
03-02	24V Power Supply	1	Buy	Amazon	N/A	Yes	Yes			\$ 6.99	\$ 6.99
03-03	Outlet Extension Cord	1	Buy	Amazon	N/A	Yes	No			\$ 10.00	\$ 10.00
03-04	Raspherov Pi	2	Buy	Amazon	N/A	Vec	Vec			\$ 59.99	\$ 59.99
03-06	Stepper Driver (Nema 17 and 22)	1	Busy	Amazon	N/A	Voc	Vor			¢ 14.22	\$ 14.22
03-00	Stepper Driver (Nema 17 and 25)	1	Dury	Amazon	IN/A	Tes Ver	Vee			\$ 14.25	\$ 14.23
03-08	Stepper Driver (Nema 34)	1	buy	Amazon	IN/A	Tes .	res			\$ 05.85	\$ 05.85
03-09	Sheet Metal Box	1	Маке	ME shop	weld	Yes	NO		ļ	\$ 100.00	\$ 100.00
03-10	Surface Hinge	1	Buy	ME shop	weld	Yes	No			\$ 5.00	\$ 5.00
ubassembly 4	Wheels and Frame	1									\$ -
04-01	Box Sides	2	Make	ME shop	weld	Yes	No			\$ -	\$ -
04-02	Inlet Panel	1	Make	ME shop	weld, saw	Yes	No			\$-	\$ -
04-03	Outlet Panel	1	Make	ME shop	weld, saw	Yes	No			\$ -	\$ -
04-04	Lid	1	Make	ME shop	weld	Yes	No			\$ 25.00	\$ 25.00
04-05	Bottom Plate	1	Make	ME shop	saw	Yes	No			\$ 25.00	\$ 25.00
04-06	Wheel	2	Make	Amazon	3d print	Yes	Yes			\$ 59.98	\$ 59.98
04-07	Keved Bottom Shaft	1	Buy	McMaster-Carr	N/A	Yes	No			\$ 15.00	\$ 15.00
04-08	Linear Bearing	- 2	Make	Amazon	3d print	Ves	No			\$ _	\$ -
04-09	Purchased Part	1	Bus	McMaster Carr	N/A	Ves	No			¢ -	¢ .
04-10	Pall Rearing	1	Bung	McMaster-Carr	N/A	Voc	No			¢ - •	¢ 22.00
04-10	bail bearing	3	Dury	wiciviaster-carr	IN/A	Vez	Vez			\$ 32.89	\$ 32.89
04-11	iverna 34	1	виу	Arnazon	IN/A	tes	tes			\$ /7.50	\$ 77.50
04-12	Keyed Axel	2	Buy	McMaster-Carr	N/A	Yés	NO			\$ 15.00	\$ 30.00
04-13	Shaft Key	2	Buy	McMaster-Carr	N/A	Yes	No			\$ 15.00	\$ 30.00
04-14	Spacer	4	Buy	acme plastics	N/A	Yes	No			\$ 30.00	\$ 30.00
04-15	Motor Plate	1	Make	ME shop	weld	Yes	No			\$-	\$-
04-16	Bearing Plate	1	Make	ME shop	N/A	Yes	No			\$ -	\$ -
04-17	Shaft Coupling	1	Buy	McMaster-Carr	lathe mill	Yes	No			\$ 20.00	\$ 20.00
04-18	Button Screw		Buy	McMaster-Carr	N/A	Yes	No			\$ 10.00	\$ 10.00
04-19	Surface Hinge	1	Make	ME shop	N/A	Yes	No			\$ 5.00	\$ 5.00
ubassembly 5	Human Interface										\$ -
05-01	Barcode Scanner	1	free	Boeing	N/A	Yes	Yes			\$ -	\$ -
05-02	Scapper Holder	1	free	Boeing	N/A	Ves	Ves			\$ _	¢ -
05-02	Emergency Step Putter Nut	1	Dung	Mahdastas Cr	N/A	Vec	No			÷ = 00	÷ -
05-03	Emergency Stop Button Nut	_	виу	wicMaster-Carr	N/A	Tes	NO			\$ 5.00	> - Ç
05-04	Emergency Stop Button	1	Buy	Amazon	N/A	Yes	No			\$ 10.00	\$ 10.00
05-05	Keypad	1	Buy	Amazon	N/A	Yes	Yes			\$ 10.34	\$ 10.34
05-06	Front-Back Plate	1	Make	ME shop	weld, saw	Yes	No			ş -	ş -
05-07	LCD Screen	1	Buy	Amazon	N/A	Yes	Yes			\$ 5.99	\$ 5.99
sert more lines	as needed										
									Total BO	M Cost	\$ 812.72

Bill of Materials/Manufacturing Plan

## Budget

#### Key Purchases:

- Absolute Encoder \$56
- Raspberry Pi \$60
- Linear Actuator \$70
- Nema 34 Motor and Driver \$145
- Nema 17 Motor and Driver \$25

Expense Items	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	Total					
						I								
Equipment/Tools:														
Absolute Encoder						\$56 <mark>.</mark> D3			\$56.03					
Stepper Motor Nema 34			\$77.50						\$77.50					
Stepper Motor Driver				\$65.85		1			\$65.85					
Motor Power Supply				\$6.99		1			\$6.99					
Wire Cutter		\$23.99							\$23.99					
Small Stepper Motor Nema 23				\$10.99					\$10.99					
Small Stepper Motor Driver				\$14.23					\$14.23					
Raspberry Pi		\$59.99							\$59.99					
LCD screen				\$5.99					\$59.99					
Keypad				\$10.34					\$10.34					
SD Card		\$9.95							\$9.95					
Linear Actuator				\$69.99					\$69.99					
						· · ·				\$465.84	1	Equipmen	t/Tools S	ubtotal
Travel:														L
Trip to Seattle	\$560.37					I		\$750.00	\$1,310.37					
						I				\$1,310.37		Travel S	Subtotal	
						I								
Supplies / Parts / Services:						1								
HDMI Cable		\$11.99				1			\$11.99					
Sheet Metal Box						\$200 00			\$200.00					
Ribbon Cable		\$5.95							\$5.95					
3d Printer Filament			\$29.99			\$29 99			\$59.98					
Casing Materials (polycarb)						\$200 00			\$200.00					
Ball Bearing 1/2" diameter						\$32 89			\$32.89					
Raspberry Pi Power Supply		\$11.99				1			\$11.99					
Cutter L Plate							\$2.00		\$2.00					
Lead Screw							\$15.00		\$15.00					
Gutter Screws							\$10.00		\$10.00					
Outlet Extension Cord							\$10.00		\$10.00					
Surface Hinge							\$10.00		\$10.00					
Lid						1	\$25.00		\$25.00					
Bottom Plate							\$25.00		\$25.00					
Keyed Bottom Shaft						1	\$15.00		\$15.00					
Keyed Axel							\$30.00		\$30.00					
Shaft Key							\$30.00		\$30.00					
Spacer							\$30.00		\$30.00					
Shaft Coupling							\$20.00		\$20.00					
Button Screw						1	\$10.00		\$10.00					
Emergency Stop						1	\$10.00		\$10.00					
Emergency Stop Nut						1	\$5.00		\$5.00					
Shan Usaga (ast. Usa):									Hours			-		
Shop Usage (est. Hrs):		2			-		10	-	nours					
Cutting Assembly	-	3	-	-	5	5	10	5	28					
Gutter Assembly	-	-	-	-	5	5	10	5	25					
Power Box Assembly	-	-	-	-	5	5	10	5	25					
wheels and Frame Assembly	-	3	-	-	5	5	20	5	38					
Interface Assembly	-	-	-	-	5	5	20	5	35					-
						-			151					
						Gradua	te Studen	t Support	\$ 1,034	including	fringe			
							Shop	Overhead	\$ 500					
						U	niversity	Overhead	\$ 238	5% of all	expenses			
								Tatala	\$ 4 31	¢ = 000	¢			
								lotals	ə 4,51	\$ 5,000	\$ 682			-
										Budget	Excess			

## Gantt Chart

#### Key Milestones:

- Boeing Design Review -2/19
- Machining 2/24
- Wiring 3/09
- Component Installation -3/09
- Testing 3/16
- Expo 5/1

Ga	ntt	Ch	art
<u><u> </u></u>	TILL	CII	art

PRO JECT TITLE	Insulation Station				
	Christmas Break		12/23/19	01/08/20	100%
3.7	Solidworks Modeling	Group	01/08/20	02/19/20	95%
3.7.1	Casing Modeling	Rennie, Ian	01/08/20	01/15/20	100%
3.7.2	Cutter Modeling	Rennie, Ian	01/16/20	01/20/20	100%
3.7.3	Intlet Modeling	Rennie, Kyle	01/20/20	01/24/20	100%
3.7.4	Outlet Modeling	Rennie, Kyle	01/20/20	01/24/20	100%
3.7.5	Roller Modeling	Rennie, Ian	01/27/20	01/31/20	100%
3.7.6	Power Box Modeling	Rennie, Ian	02/03/20	02/07/20	100%
3.7.7	Motors, Encoder Modeling	Rennie, Ian	02/10/20	02/14/20	100%
3.8	Programming	Alyssa	02/05/20	02/25/20	75%
3.8.1	Motor programming	Alyssa	02/05/20	02/12/20	80%
3.8.2	Angle Motor programming	Alyssa	02/13/20	02/18/20	80%
3.8.3	Encoder programming	Alyssa, Kyle	02/18/20	02/25/20	50%
3.9	Modeling Revisions	Group	02/14/20	02/19/20	50%
3.10	Drawings	Group	02/17/20	02/19/20	100%
3.11	Boeing Design Review	Group	02/19/20	02/19/20	0%
3.12	Machining	Group	02/24/20	03/11/20	0%
3.12.1	Cutter Machining	Group	02/24/20	03/11/20	0%
3.12.2	Gutter Machining	Group	02/24/20	03/11/20	0%
3.12.3	Power Box Machining	Group	02/24/20	03/11/20	0%
3.12.4	Wheels and Frame Machining	Group	02/28/20	03/11/20	0%
3.13	Wiring	Group	03/09/20	03/13/20	0%
3.14	Component Installation	Group	03/09/20	03/16/20	0%
4	Validate				
4.1	Design Validation Plan	Alyssa	03/16/20	03/23/20	0%
4.2	Intake Testing	lan	03/16/20	03/21/20	0%
4.3	Cutting Testing	Rennie	03/17/20	03/21/20	0%
4.4	Casing Testing	Alyssa	03/22/20	03/26/20	0%
4.5	Program Testing	Alyssa	03/27/20	03/31/20	0%
4.6	Measurement Testing	Kyle	04/01/20	04/05/20	0%

#### Discussion