



EXTINGUISHER PRO

Final Report

Engineering Design

Engineering and Computer Science Department

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1. Executive Summary:

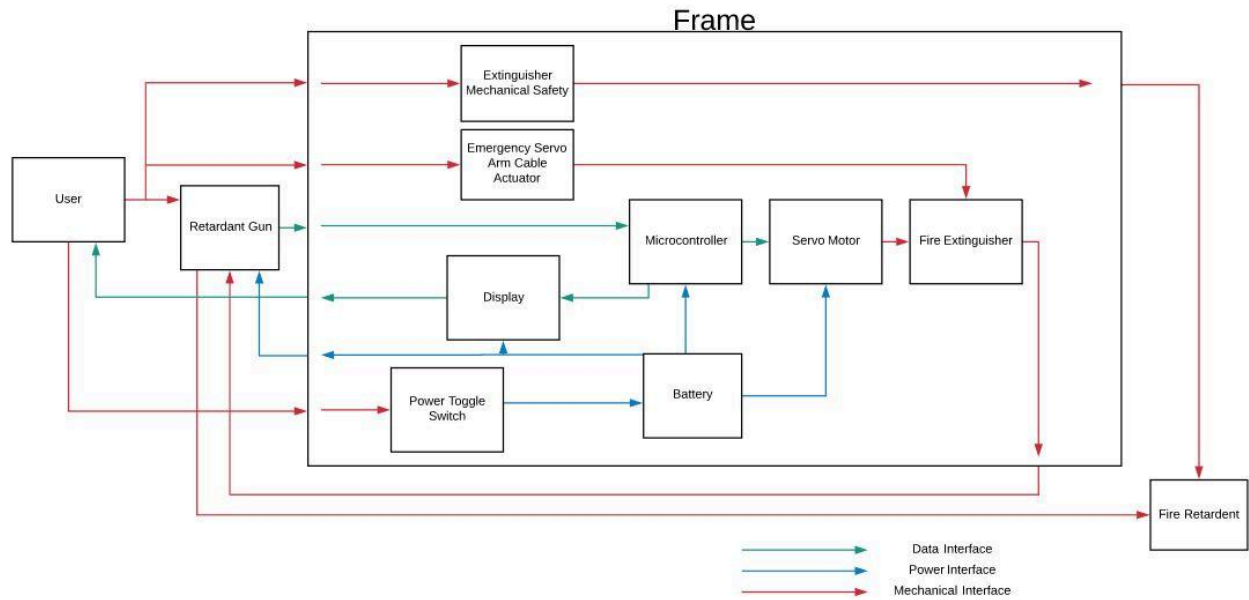
Fire watch personnel are a vital yet forgotten member of heavy industry environments. A Fire Watch Employee is required to stand for upwards of 8 hours a day while needing to be vigilant to maintain readiness to stop or report a fire. The current system of holding a single fire extinguisher presents posture related health issues, slow emergency reaction time, and limited fire extinguishing capacity. To improve upon all facets of the fire watches current disadvantages, we are shutting a light on a new solution involving mounting two fire extinguishers in a backpack frame that has been prototyped and tested. The prototype, called 'Extinguisher Pro', and it has exceeded expectations and improved upon all Fire Watch concerns in the question. Extinguisher Pro allows the user to distribute the weight of the fire extinguisher, have both hands free for outside of emergency environments, all that while maintaining the ability to respond efficiently in an emergency situation compared to a traditional extinguisher.

Everything included in the design is housed in a metal frame backpack and an extinguisher gun. The backpack is able to hold two fire extinguishers that are actuated by a servo motor. Activation of the servo motor is done through a micro processor and momentary switch relay located in the extinguisher gun. The fire retardant then is routed through a tube that comes out of a nozzle integrated into the extinguisher gun that the user holds. The gun has two toggle switches, one for power acting as an electronic safety and the other allowing for switching between the extinguishers. In case of an electrical failure, the backpack also has a mechanical pull system that the user may use in case of an emergency to manually pull the servo arm and activate the extinguisher. Finally, to insure no accidental extinguisher activation occurs, a mechanical safety has been installed that physically blocks the pathway of retardent to the nozzle .

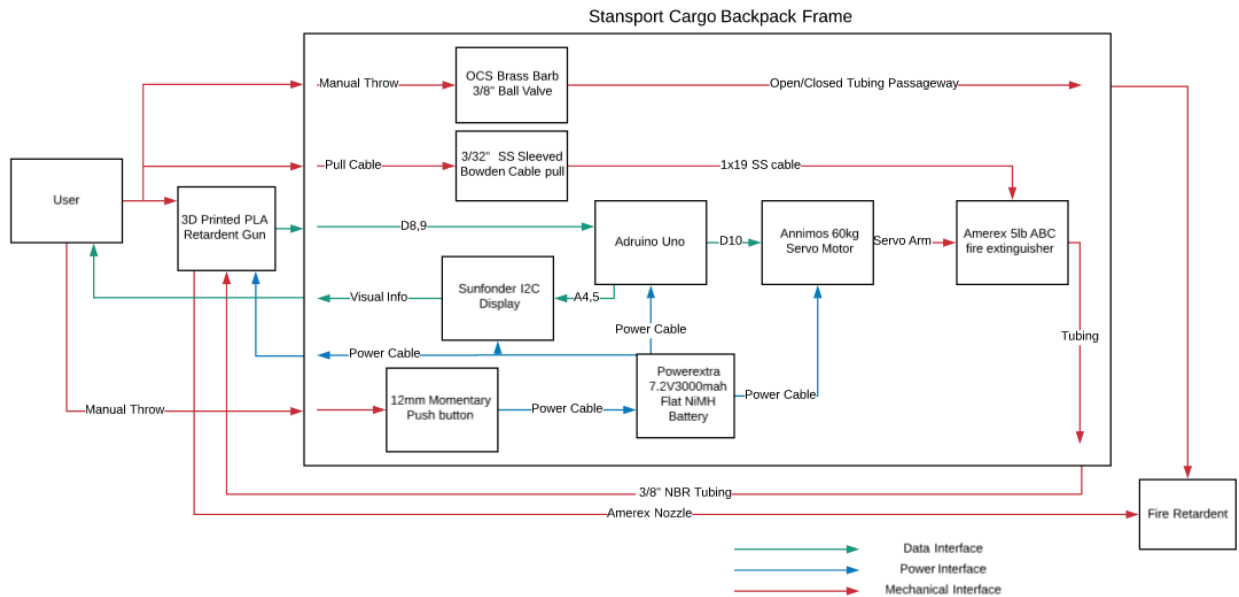
Due to the apparatus being used in emergency situations the battery must last a full 8 hour working day. After calculations the apparatus has a 14 hr battery life. Also, the pack is very ergonomic being shoulder/hip mounted and has an easily achievable 60:40 hip to shoulder weight split. Additionally, the total weight of the pack is 28lbs, significantly under the OSHA recommended limit of 40lbs. The pack fits the full gambit of male employees from the 5th to 95th percentile in height. In terms of response time, the pack can switch between extinguishers in 2.1 seconds and has a total response time of 6.83 seconds to turn on and activate.

This initial prototype is a proof of concept but the base design could be used for a final end use product. The product meets every spec and is ready for a second version with a streamlined design, better aesthetics and greater functionality.

2. Functional block diagram:



3. Detailed block diagram:



a. Block Details

i. Backpack

1. The backpack is a prebuilt backpack frame that will have all the elements mounted on it. This will make it an ergonomic and comfortable experience for the user. The backpack selected is a Stansport Deluxe Freighter Aluminum Pack Frame.



ii. Trigger button:

1. A push button that is mounted near the index finger on the handle. The user will press this button to trigger the cylinder. The selected button is a red 12MM Waterproof Momentary Push Button Switch by Awpeye.

12mm Momentary Switch



iii. Selection Switch:

1. This is a toggle switch that will switch between the two different cylinders. This allows the user to have a tactile way to switch between the two cylinders.



iv. I2C display:

1. A display that will be the feedback for the user on what cylinder that is selected and how much time is left for each cylinder. This display is connected to the Arduino uno using I2C which reduces the number of wires that have to be

connected from 8 to 4. SunFounder IIC I2C TWI 1602 Serial LCD Module Display



v. Power Switch:

1. A tactile on-off toggle switch that will turn off the entire system. This is the same as the power switch.



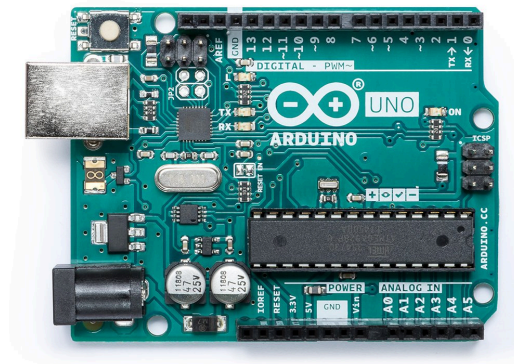
vi. Battery

1. A NiMH battery that will power the entire system. The battery is mounted on the backpack using double-sided tape. Powerextra 7.2V 3000mAh High Capacity 6-Cell NiMH Battery Pack



vii. Arduino Uno:

1. Connects all the inputs, switches, buttons that control the servo to fire the selected cylinder. An Arduino Uno was selected due to its simplicity and ease of use.



viii. Inline Ball Valve:

1. A valve that will be in line with the hose that will allow the user to block the flow of retardant so there is not a premature expulsion of retardant.



ix. Emergency Pull

1. It is a wire that can slide in a sleeve that is strapped around the user's shoulder that pulls manually on the servo arm. This can be used in case the electronics have failed.

x. Retardant Storage:

1. Off the shelf fire extinguisher that will have the hose connected to the backpacks hose to route the retardent flow. This is an example of the cylinder used for testing. The user will select the brand that they prefer. The cylinder used is a 5Lb Amerex cylinder.



xi. Servo:

1. A large 60kg servo that is used to press on the handle of the cylinder to trigger the flow of retardant. Selected Servo: ANNIMOS 60KG Digital Servo 8.4V High Voltage Stainless Steel Gear Large Torque High Speed Waterproof Baja Servos - 270 Degrees



xii. Nozzle:

1. The nozzle for the hose that will be mounted in the retardent gun. The nozzle will direct the flow of the retardant.

4. Power budget:

a. Battery Usage:

The battery being used is a 7.2V 3000mAh NiMH. The system in standby (not pressing handle) will draw an average of 97.2 mA and when triggered (pressing handle) will draw an average of 260 mA. It is estimated that 95% of the time the backpack will be in standby and 5% of the time in triggered mode. This means that the average current that is drawn is 105.34 mA. If the battery capacity is 3000mAh the backpack will last for roughly 28.5 Hours.

5. Test plan:

1. Comfort

- 1.1. The apparatus shall have a 50:50 weight distribution between the hip straps and the shoulder straps. The apparatus should have a 60:40 weight distribution between the hip and shoulder straps.

Procedure: Weigh the entire backpack to determine its full weight, then use a flat scale to measure the weight at the shoulder pads. This should

have either 50% of the weight or 40% of the weight depending on how well the specification is accomplished.

Results: On a man of 6ft 2" in height the apparatus could distribute as much as 100% of the weight or 14 lbs per strap. Alternatively, if the hip straps were fastened correctly the shoulder straps could potential have as little as 1.5 lbs per strap applied to them. This allows for an adjustability that far exceeds our design spec.

- 1.2. The apparatus shall have 3 points of contact for mounting the fire extinguisher.

Procedure: Visual observation.

Results: Each extinguisher is held by two straps and supported by a metal bracket in the back. The extinguishers successfully have 3 points of contact .

2. Reliability

- 2.1. The system shall successfully actuate the extinguisher and deploy retardant 90% of the time for first design iteration prototype. The success rate should improve to 99%-100% for the final product since it is to be a possible life-saving device.

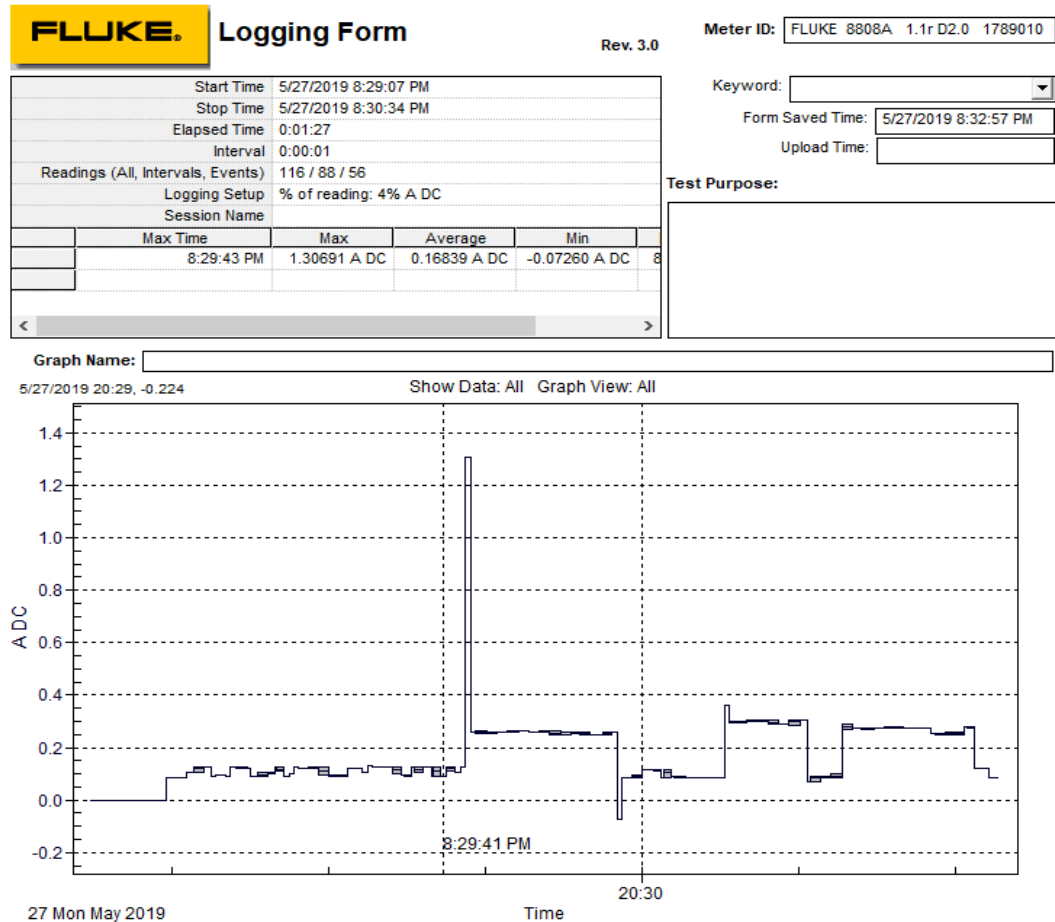
Procedure: Repeatedly spray the retardant 10 times to acquire data and derive a percentage of success (successfully used/total uses).

Results:After testing and spraying the retardent 10 times our left cylinder rig the cylinder activated 10 out of 10 tries. When testing the right extinguisher, on the 10th try the extinguisher slipped a roughly 1/2" and was not successfully activated yielding a yielding a 9/10 reliability. Total system reliability of 19/20 for 95%.

- 2.2. The apparatus shall have a battery life of 8 hours between charging but should have a battery life of 14 hours before requiring a recharge.

Procedure: Measure current draw using a meter and determine the power that will be used per hour. Calculate run time based on measurement.

Results:



This figure shows the Fluke logging form of the backpack operation. The higher current draw at 260mA is triggered and 97.2mA is in standby. The battery being used is a 7.2V 3000mAh NiMH. The system in standby (not pressing handle) will draw an average of 97.2 mA and when triggered (pressing handle) will draw an average of 260 mA. It is estimated that 95% of the time the backpack will be in standby and 5% of the time in triggered mode. This means that the average current that is drawn is 105.34 mA. If the battery capacity is 3000mAh the backpack will last for roughly 28.5 Hours.

3. Dual Extinguisher Mounts

- 3.1. The system shall have mounts for two separate fire extinguishers, sized at five pounds each.

Procedure: Visual observation.

Results: Built into the backpack are two locations for two fire extinguishers.

4. Interface

- 4.1. The system shall have a mechanism that switches between fire extinguishers in 5 seconds. The system should have a mechanism that switches between fire extinguishers in 2 seconds.

Procedure: Time how long it takes for the mechanism (servo) to switch between the fire extinguishers. The testing of this will be the user using cylinder A, stop using cylinder, switch to B and then use cylinder B.

Results: A total of five tests were conducted to average a switching time of 2.1seconds. It should be noted that after further testing it was found that the user did not have to depress the trigger to switch. This would put the time under 2 seconds for switching.

- 4.2. The system shall have an interface that displays the amount of retardant left in each extinguisher.

Procedure: Visual Inspection

Results: The UI showed the total percentage that was left in the cylinder, the time left was dependent on the type of cylinder and its condition.

5. Safety

- 5.1. The system shall have one mechanical safety for each extinguisher. The system should have both mechanical and electrical safety.

Procedure: Turn on and off electronic safety and try to use the system in both on and off of electronics safety to determine reliability. Test reliability of mechanical backup when the electronic system is turned off.

Results: The electrical safety is operational and powers off all electronics of the backpack when switched. The mechanical safety which is the inline ball valve was tested by triggering the cylinders when the valve was closed. The valve successfully blocked the flow of retardant.

6. Reaction time

- 6.1. The system shall spray the retardant within 10 seconds of detecting fire. The system should spray the retardant within 5 seconds of detecting fire.

Procedure: Time the amount of time it takes to turn the power on, flip the mechanical safety, activate the trigger for spraying the retardant, and for the retardant to be released.

Results: After a total of five tests the average reaction time was 6.83 seconds to react to the fire. This meets the specifications.

7. Size/Weight

- 7.1. The system shall weigh less than 45 lbs. The system should weigh less than 35 lbs.

Procedure: Weigh the entirety of the backpack (extinguishers included).

Results: The weight of the entire backpack with two extinguishers was a total of 28 pounds. The backpack without extinguishers is 12 pounds. This meets the specifications.

- 7.2. The system shall fit up to the 95th percentile height man and 5th percentile height man. The system should be adjustable to fit a 5th percentile woman.

Procedure: Measure the different strap sizes, adjustability of the straps, and strap lengths. Test also by having different sized people try the backpack on for comfortability.

Results: shoulder straps and hip straps have a minimum of 18" of adjustment allowing for fitting hips down to a size 28 and as large as a size 46. Test fit pack with 5 ft 2" man and 6ft 2" man (5th and 95th percentile man respectively), both found the pack comfortable.

8. User-Friendly

- 8.1. The apparatus shall be designed such that the user will not need to buy a specialized extinguisher tank.

Procedure: Try inserting various brands of 5lb extinguishers into the backpack and testing for successful uses.

Results: Various brands of 5lb extinguishers fit into the backpack. Currently working on testing if the retardant hose can be installed to different brands for the extinguisher to be successfully used. The user was easily able to install the extinguishers with five minutes.

- 8.2. The apparatus shall have at least three user interface elements, with an option to add on two additional user interface elements.

Procedure: The apparatus currently has a power on/off switch, a toggle switch to change between fire extinguishers, and an actuation trigger for

spraying the retardant. There simply needs to be a test to verify that each interface will perform its designed tasks.

Results: All of the above-mentioned user interfaces work as intended.

9. Cost Effective

- 9.1. The system shall have a prototype cost of \$350 or less. The system should have a prototype cost of less than \$200.

Procedure: Add up all the expenses for the group as a whole. Determine if it is less than \$350.

Results: The project prototype cost is \$232.29 excluding labor. This meets the design spec but is unfortunately slightly higher than the preferred goal of \$200.

Summary of Results:

ID	Description	Results	Meets Specification?
1.1	Weight Distribution	-	-
1.2	Each fire extinguisher shall have 3 points of contact	Each Extinguisher is held by 3 points	Yes
2.1	Retardant Deployment Success Rate		-
2.2	Battery life	The battery life exceeds specs and is calculated at 30 Hours	Yes
3.1	Number of mounts for fire extinguisher	Built into the backpack are two locations for the fire extinguishers	Yes
4.1	Toggle Time between fire extinguishers	Average of 2.1 Seconds to change between cylinders. This is slow due to the human speed.	Yes
4.2	Display for life left in	Sprays retardant for 20	-

	each fire extinguisher	seconds; code still in progress	
5.1	Included Safeties	Functional electrical and mechanical safeties that restrict the flow of retardant.	Yes
6.1	Reaction Time	The average reaction time to be able to react to the fire was 6.83 Seconds.	Yes
7.1	Weight of Product	The weight exceeded expectations by only weighing 28 pounds with two full cylinders.	Yes
7.2	Size of Product	-	-
8.1	Option for Multiple Extinguisher Brands	Different brands fit into the backpack.	Yes
8.2	Number of user interface elements	There are three functional user interfaces	Yes
9.1	Cost of Materials	The cost specification was reached with a parts cost of \$232.29.	Yes

6. Final Prototype Pictures



7. Accounting of Resources

a. Labor Hours

Name	Hours	Hourly Rate	Total
Quinton Cline	99	\$20	\$1980
Keith Spitzer	117	\$20	\$2340
Zach Anderson	89	\$20	\$1780
Khaled Ahmed Khaled	83	\$20	\$1660
Suliman Buzakouk	73	\$20	\$1460

Total: \$9220

b. Bill of Materials

Part	Manufacturer	Description	Source	Quantity	Price (\$)	Subtotal(\$)
12mm Waterproof Momentary Push Button Switches	Awpeye	Push button switch that will be used for trigger	Amazon	1	0.73	0.73
PCB Screw Terminals	Electronics Salon	Used to secure wires onto the Arduino headers.	Amazon	3	0.57	1.69
I2c Display	Sunfounder	The main user interfaces display	Amazon	1	9.99	9.99
Tamiya Connectors	VRC Hobbies	Used to make power connectors to interface with the battery.	Amazon	2	0.45	0.90
3000 mAH NiMH Batteries	Powerextra	The system battery that supplies power.	Amazon	1	13.50	13.50
60Kg Servomotor	Annimos	The servo that is used to actuate the push on the extinguisher handles.	Amazon	1	48.99	48.99
Arduino Uno	Arduino	Used to control the backpack electronics.	Amazon	1	16.50	16.50
18 Gauge Speaker Wire 4 Conductor	Monoprice	Connects the battery and servo in the backpack to the remote handle.	Amazon	6	0.29	1.74
3/8 inch Fuel Gas Line	NBR	Tubing that attaches from cylinder to nozzle near users hand.	Amazon	6ft	1.89/ft	11.34
Hose Clamps	selizo	Used to clamp down the hose.	Amazon	7	0.25	1.75
Scuba Tank Straps	Scuba Choice	Holds cylinders in place on the backpack.	Amazon	4	16.97	67.88

Cargo Backpack Frame	Stansport	Contains all the sub systems.	Amazon	1	68.49	68.49
PET Expandable Braided Sleeving	Flexo	Wrap cables leading to the handle	Amazon	7ft	0.91/ft	6.41
Black Pro Series Tough PLA	Matterhackers	Filament for 3D printed parts.	Amazon	0.33kg	52/kg	17.16
6 inch Multipurpose Cable Tie	TR Industrial	Cable Handle Management	Amazon	4	\$0.09	0.36
3/4 " Galvanized Tube Strap	Oatey	Hold servo backplate and secure hose	Home depot	4	0.25	1.00
3/8" Brass Barb Ball Valve	OCSParts	Manual Mechanical Safety	Amazon	1	6.99	6.99
3/8" Brass Tee Hose Splicer Fitting	Dixon	Extinguisher Hose splicer	Amazon	1	6.70	6.70
#8 1" Wood Screw	Grip-Rite	Servo Motor cover plate mounting screw	Home Depot	8	0.07	0.56
#3 1/2" Sheet Metal Screw	Everbilt	Screws to mount servo motor and tube straps	Home Depot	5	0.19	0.95
Black Electrical Tape	Soundoriginal	Fasten mechanical pull covering	Amazon	1/2	1.10	0.55
1/16" Cold Rolled Steel Sheet	Hillman	Extinguisher Bracket Material	Lowe's	1/8	35.48	4.44
1/8" Cold Rolled Steel Sheet 12"x12"	Onlinemetals.com	Bracket material for servo motor mount cover plate	Onlinemetals	1/4	4.13	1.03
3/32" 1x19 SS Wire Rope	Alps	Mechanical emergency pull wire	West Marine	8	0.51	4.08
1/8" Snap On Cable Covers	Davis Instruments	Mechanical pull wire cover	West Marine	2	1.49	2.98
3/32" copper oval Sleeves	West Marine	Crimps for mechanical pull loops	West Marine	4	0.45	1.79

5/32" SS Thimble	West Marine	Mechanical pull loop reinforcement	West Marine	2	0.65	1.30
1/2" Cotter Ring	Ronstan	Servo arm connection to mechanical emergency pull wire	West Marine	2	0.49	.98

Total: \$232.29

Drafting:

