Aaron Hoyt EE.

Daniel Agudelo CpE.

Rachel Gremillion CpE.

Rafael Ramirez CpE.

Nerf-Battlebot

Red Team

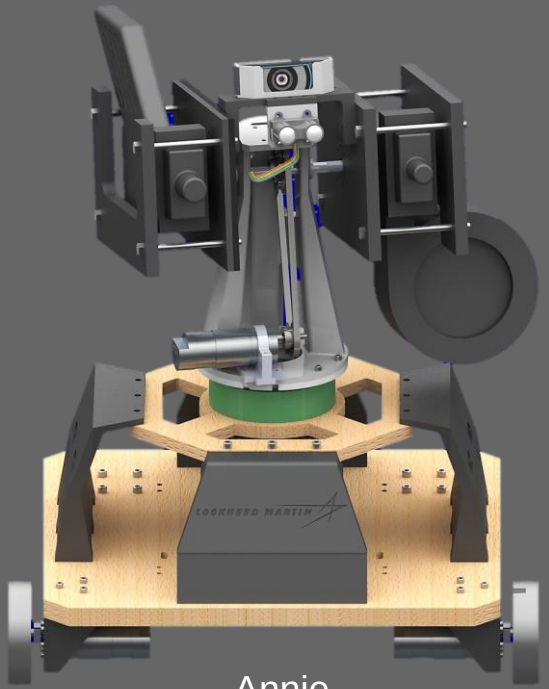
Group 9

Motivation

Lockheed Martin sponsorship

Collaborate with other engineering disciplines

High quality components



Annie

Goals and Objectives

- Design a modular system
- Provide robot with powerful and precise, but also efficient movement
- Processing onboard
- Utilize two sensor modalities

Customer Requirements

Dimensions and Mobility

3 ft. x 3 ft. x 3 ft. (L x W x H)

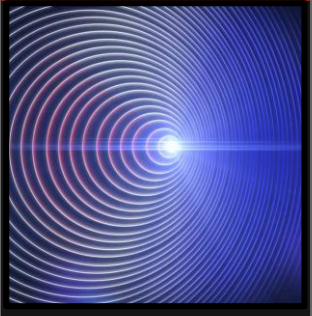
Must be able to traverse battlefield

Budget

Prototyping budget of $2K

Maximum as-demonstrated cost of $1K

Sensor



Use at minimum one sensor

Weapon System

Must acquire and fire at selected targets
Max ammo store: 50 rounds per gun

Target Detection

Video highlight overlay on detected targets

Wireless connection

Engineering Requirements

Power

Be able to last two 10 minute rounds

Movement Speed

Be able to obtain a minimum speed of 1.0 ft/s

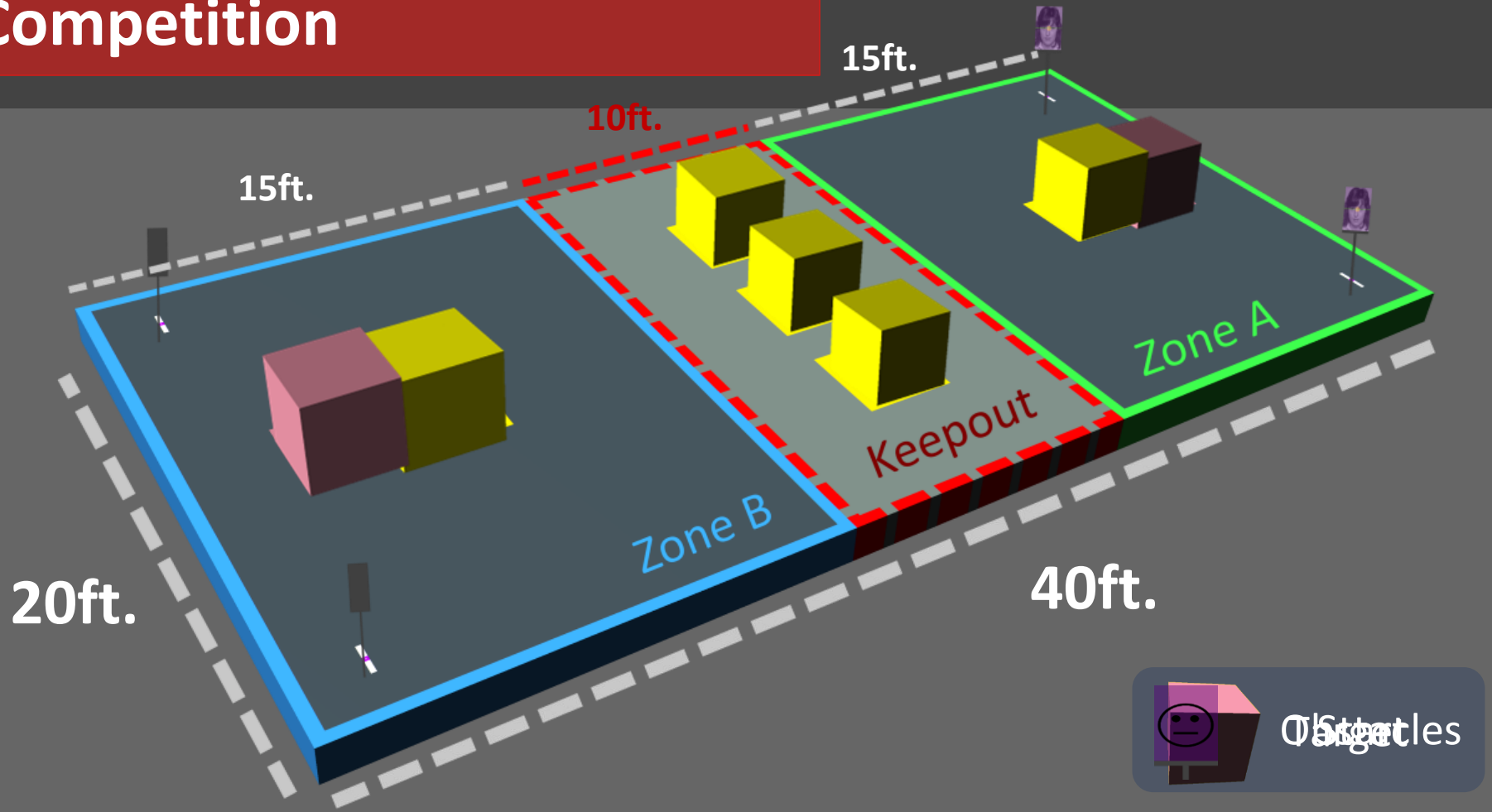
Targeting

Detect and hit 2ft. x 2ft. targets from max range of 40 ft.

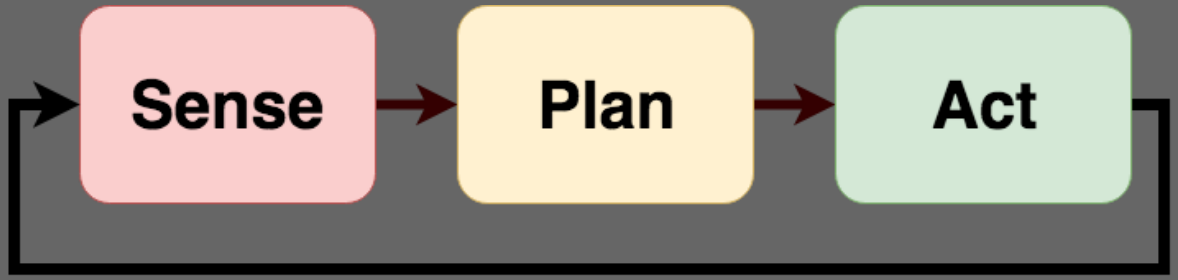
Processing time

Be able to detect and fire upon target within a 3 second time frame

Competition



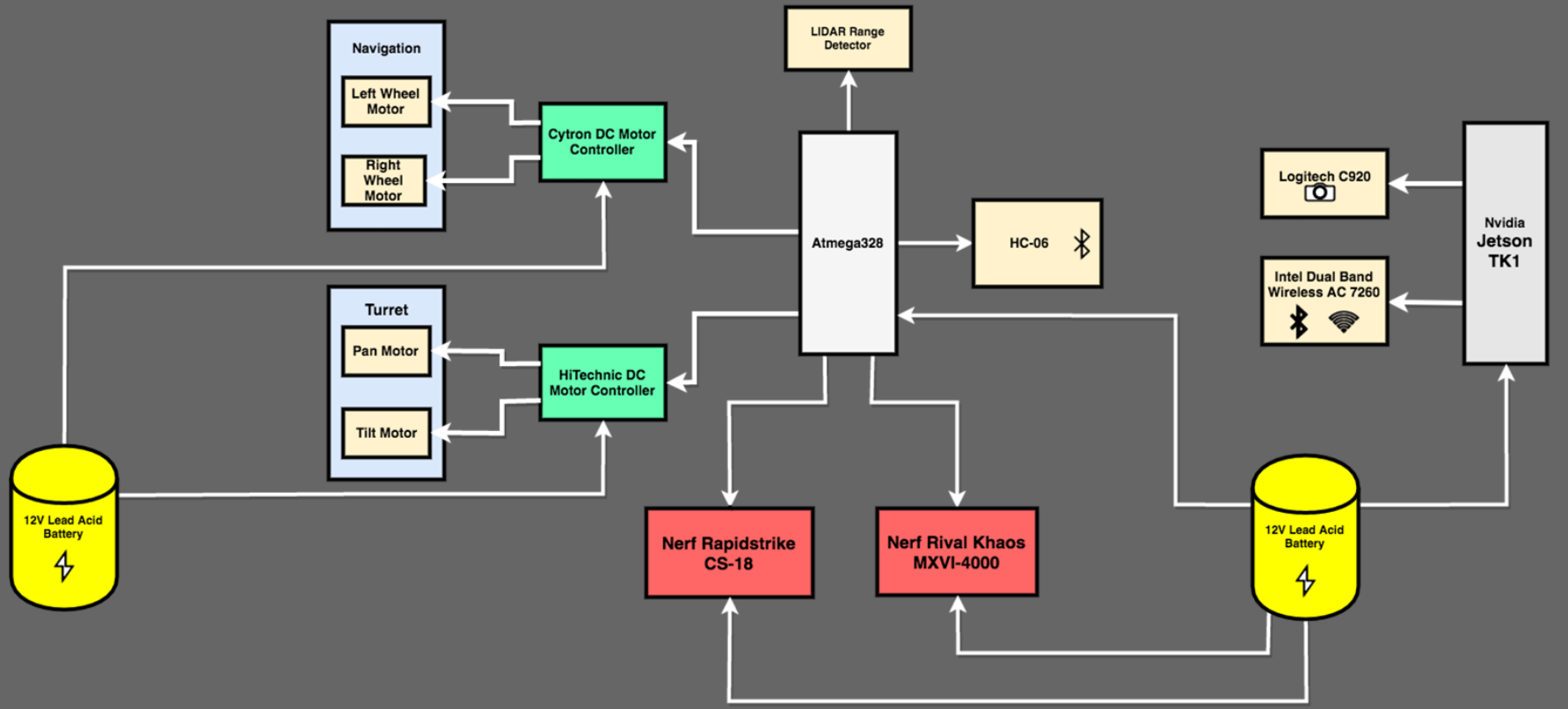
Robot Architecture



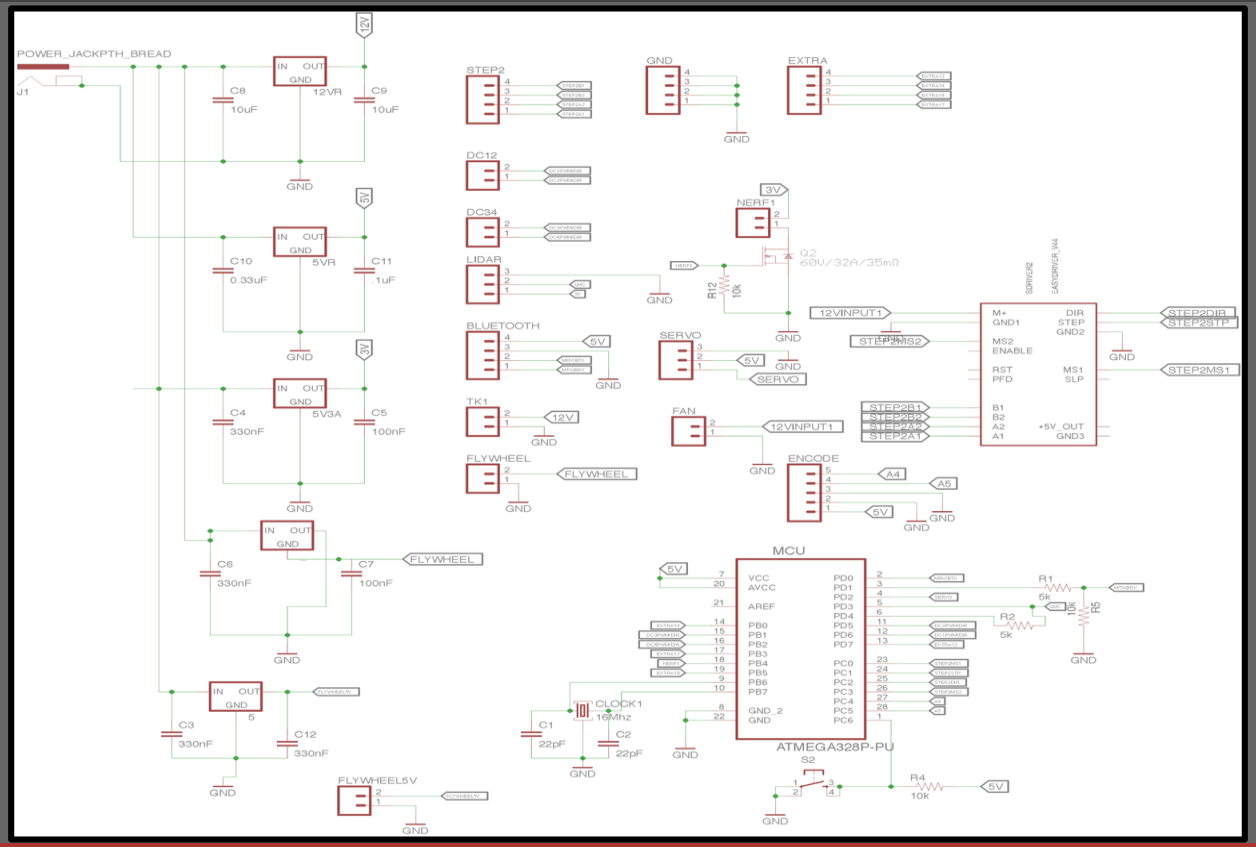
Deliberative paradigm

- Find all targets
- Distinguish target type
- Fire upon appropriate targets

Final Design

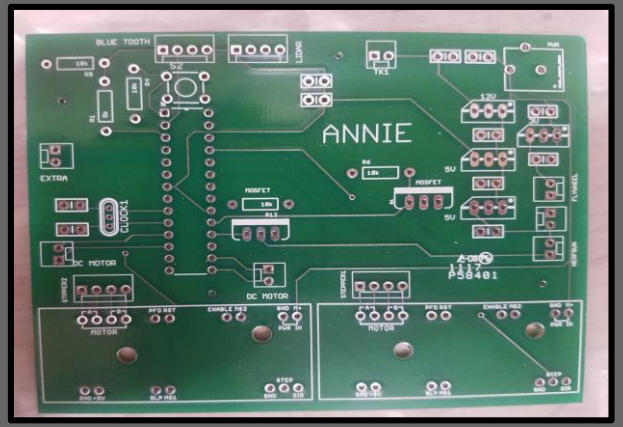


PCB Schematic

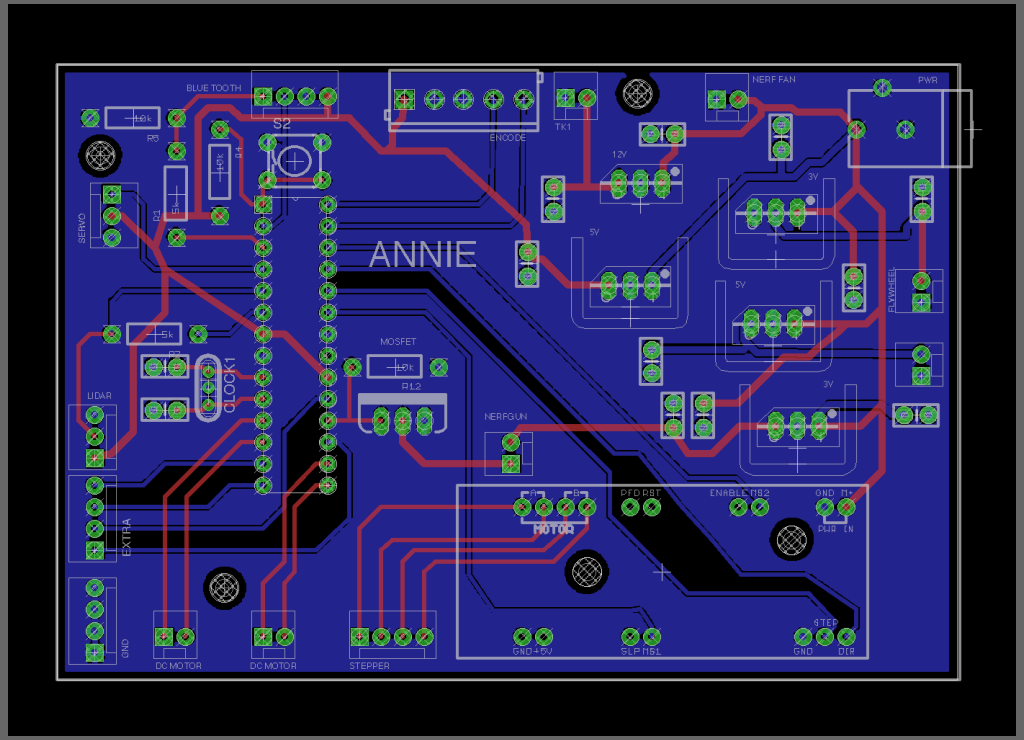


PCB Design and Assembly

- Power ports for various systems
- ATMega328p MCU
- Bluetooth
- Lidar Connection
- Encoder input
- Nerf Blaster MOSFET switching



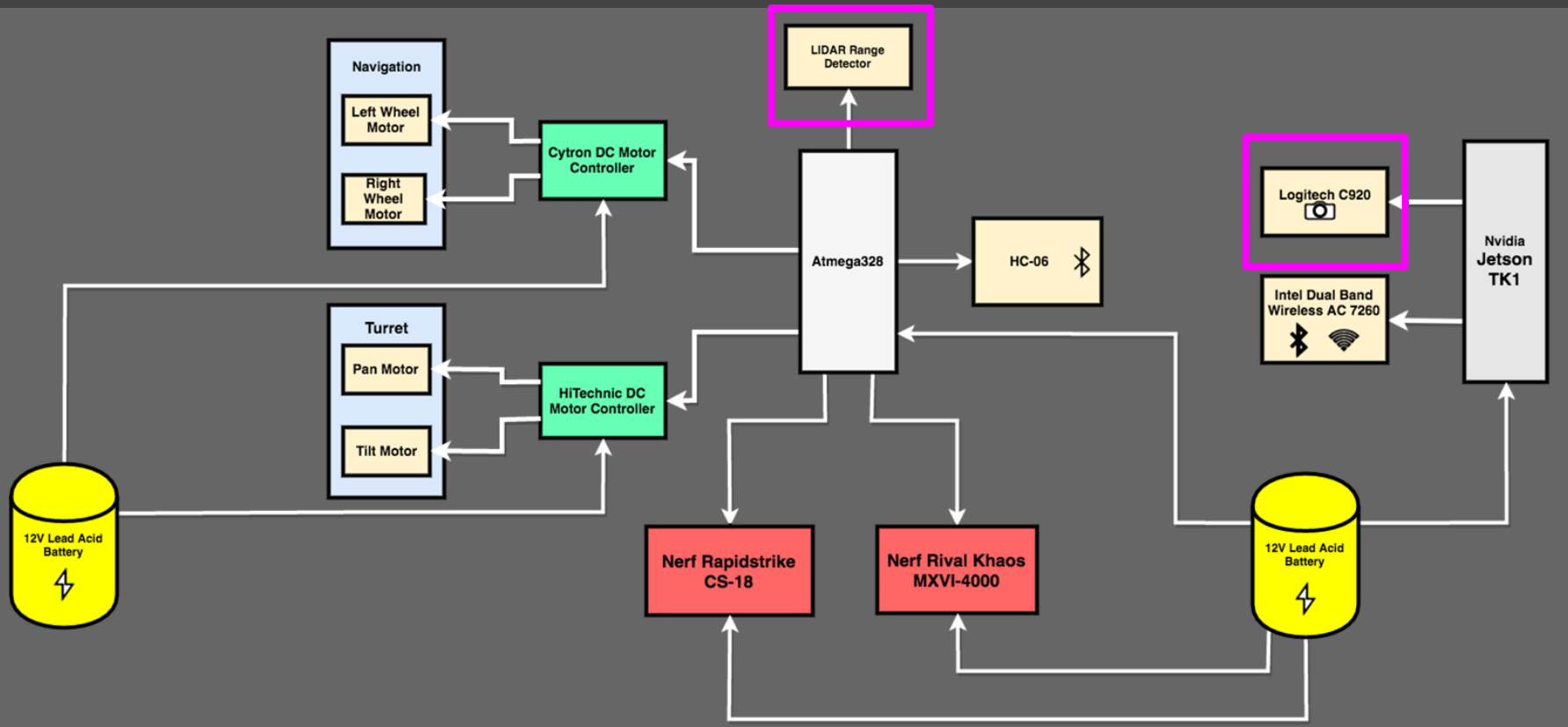
PCB before Assembly



Board Layout in EagleCAD

Hardware Selection

Sensors


LIDAR Range Detector
Navigation
Left Wheel Motor
Right Wheel Motor
Cytron DC Motor Controller
Atmega328
HC-06
Logitech C920
Nvidia Jetson TK1
Intel Dual Band Wireless AC 7260
Turret
Pan Motor
Tilt Motor
HiTechnic DC Motor Controller
12V Lead Acid Battery
Nerf Rapidstrike CS-18
Nerf Rival Khaos MXVI-4000
12V Lead Acid Battery

Camera Selection

Logitech C920 Webcam

- $52.49
- 1080p
- 6 ft USB
- 7 x 4.8 x 9.2 cm
- 70 x 43 FOV

Raspberry Pi Camera Module v2

- $25.00
- 1080p
- Ribbon Cable
- 2.5 x 2.4 x 0.9 cm
- 62 x 48 FOV

Pixy CMUcam5

- $67.00
- 800p
- Multiple plugins
- 5.3 x 5 x 3.6 cm
- 75 x 47 FOV

Logitech C920 Webcam

- Video compression
- 1080p Video Recording
- 6 ft. USB cable

Make	Angle of View	Resolution	Frame Rate	Price ($USD)
Logitech HD Pro Webcam C920	70 x 43	1920 x 1080	30	$58

Rangefinder Selection

LIDAR-Lite v3

- $149.99
- 131 ft
- +/- 2.5 cm
- 2 x 4.8 x 4 cm

TeraRanger Duo

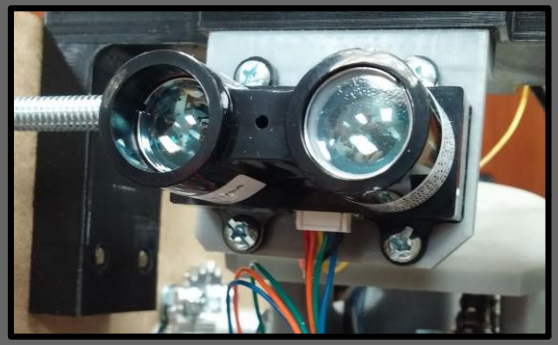
- $207.20
- 46 ft
- +/- 2 cm
- 5.3 x 4.4 x 2.5 cm

LeddarTech Leddar One

- $115.00
- 49 ft
- +/- 5 cm
- 2” in diameter

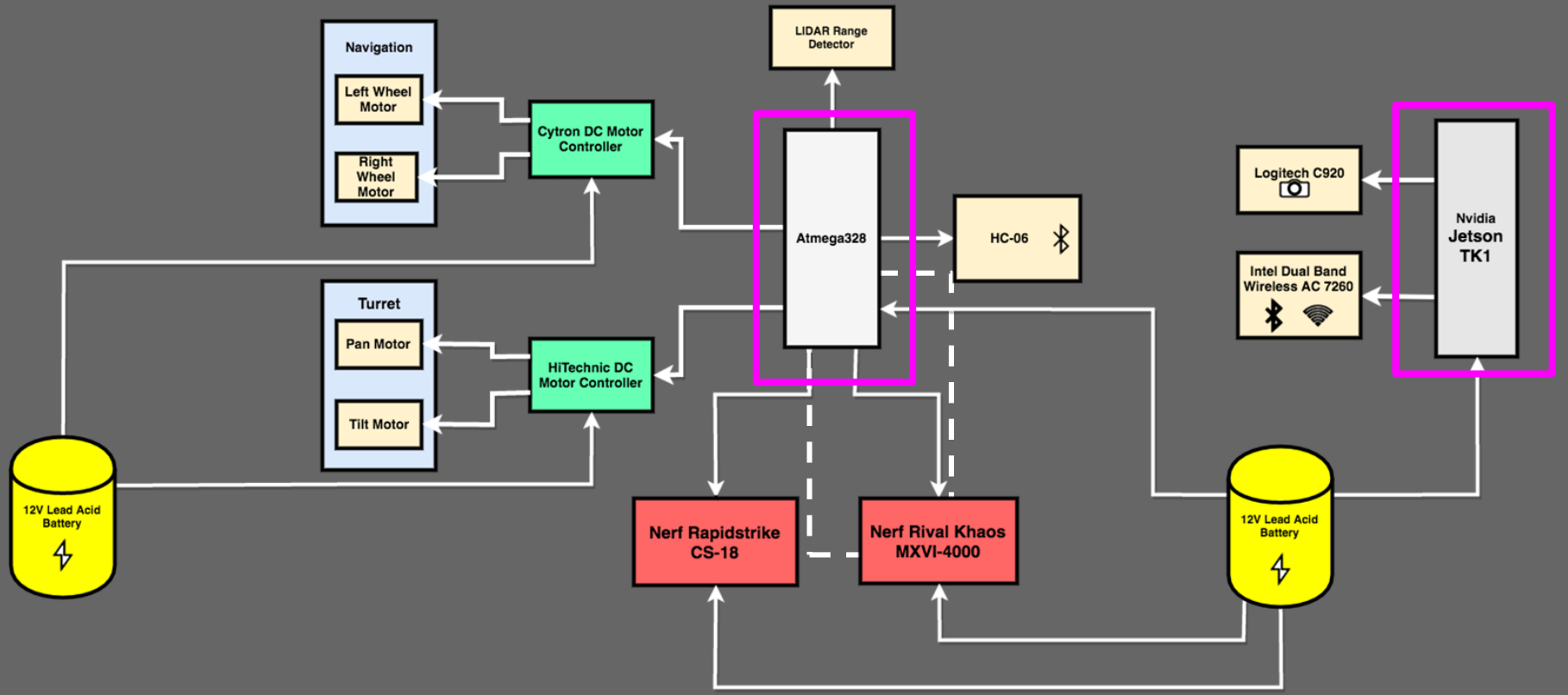
Lidar-Lite 3 Rangefinder

- Longest Range
- Accuracy
- Affordable



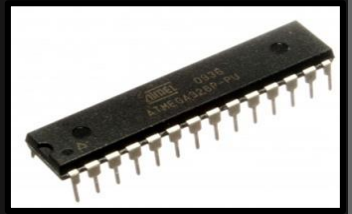
Make	Size	Max Range	Accuracy	Price ($USD)
LIDAR-Lite 3 Laser Rangefinder	2 ⨯ 4.8 x 4 cm	131.23 ft	+/- 2.5 cm	$149.99

Processing Units



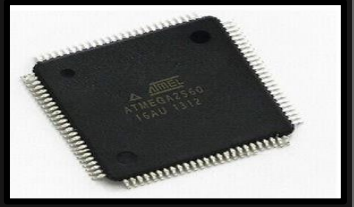
Microcontroller Selection

ATmega 328p



- 8-bit AVR RISC
- 32KB Flash
- 1.8 - 5V Operating
- 1-UART, 1-I2C, 2-SPI
- 28 pins, 14 digital, 6 analog

ATmega 2560



- 8-bit AVR RISC
- 256KB Flash
- 4.5 - 5.5V Operating
- 2-UART, 3-SPI, 1-I2C
- 64 pins, 54 digital, 10 analog

MSP430F169

- 16-bit
- 60KB Flash
- 1.8 -3.6V Operating
- 2-UART, 1-I2C
- 48 GPIO

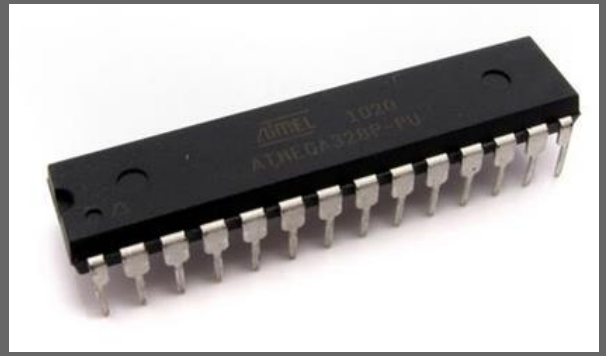
ATMega328P

Purpose

- Main control unit
- Used to control motors
- Digitally triggering Nerf-Blasters

Specifications

- Receiving input from sensors
- 14 Digital I/O pins
  - 6 PWM pins
- 6 Analog input pins
- Operating Voltage: 5V
- Input Voltage: 6-20V



ATmega328p

ARDUINO

Initial Complications

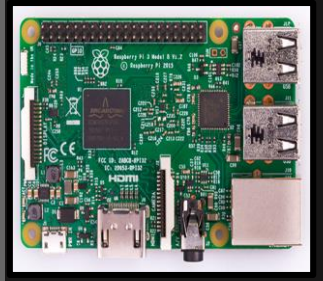
- Device overload
  - Insufficient pin availability
    - Reduce functionality to reduce pin count
  - Potential processing delay
    - Sending commands to multiple devices simultaneously
- Dual ATmega328p
  - Split performance load
  - Increase complexity via device communication

Microprocessor Selection

NVIDIA Jetson TK1

- $129
- 2.3 GHz
- Quad Core
- OpenCV
- 2GB RAM

Rasberry Pi 3 Model B



- $35.69
- 1.2GHz
- Quad Core
- Grade Level Processing

NVIDIA Jetson TX1

- $300
- 256-core Maxwell
- Quad Core
- OpenCV
- 4GB DDR4

Jetson TK1

Purpose

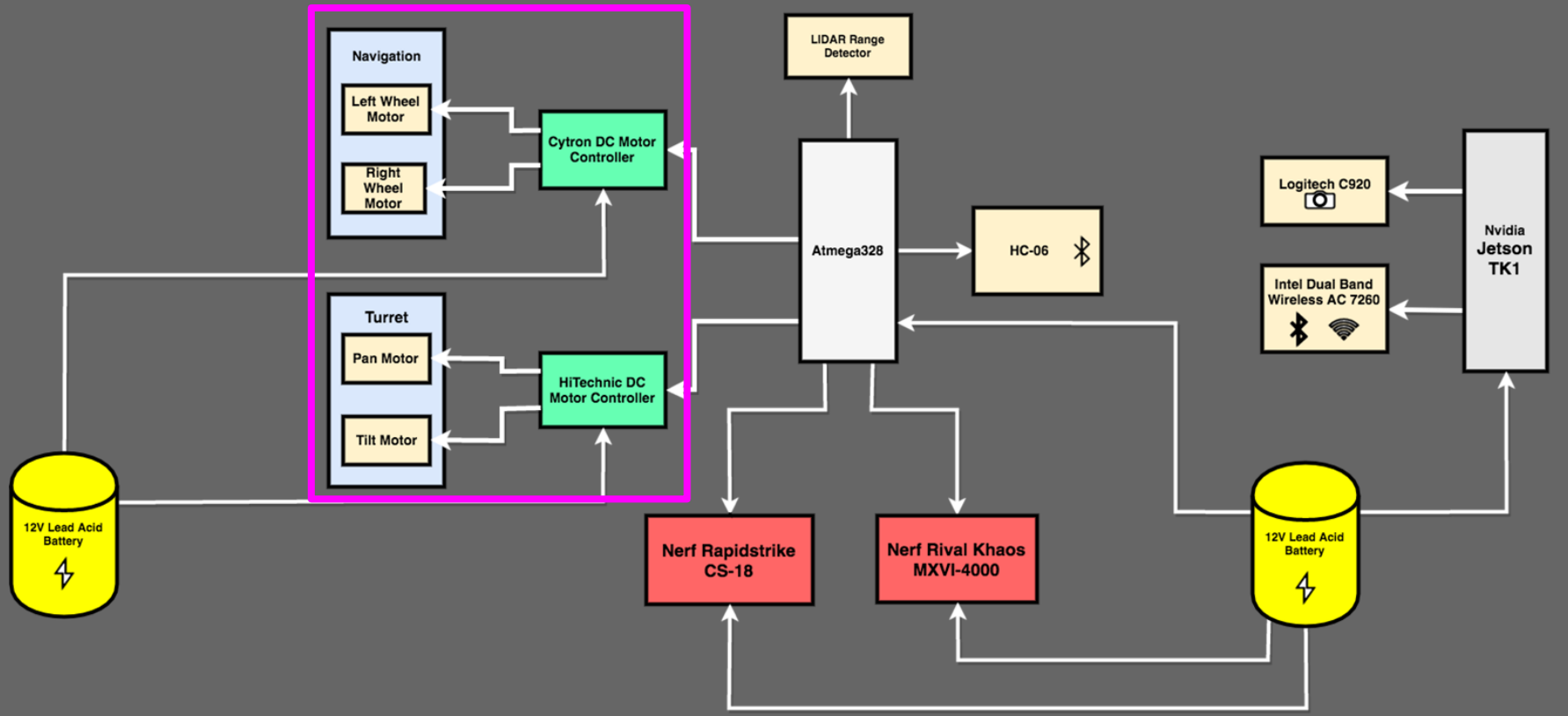
- Run automated targeting algorithms and image processing
- Input and output relay from and to microcontroller
- Wireless communication to controller for manual navigation

Specifications

- 2.3 GHz 4 plus 1 CPU
- 2GB RAM
- GPU optimized for OpenCV
  - 192 CUDA Cores

NVIDIA Jetson TK1

Motors and Drivers

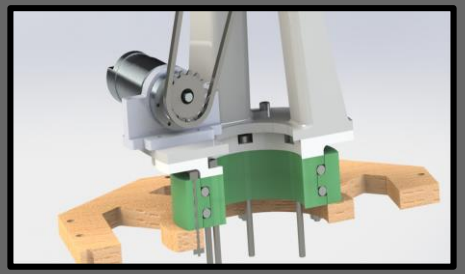


Motor Selection

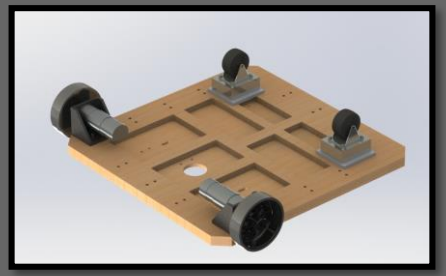
DC Motors

- Battlebot manual navigation
- Pan/Tilt of Turret System
- Maximum velocity of 3.3ft/s using four motors
- Equipped with Encoders
- Operating at 12V, 1.3A

NeveRest 40 Gearmotor



Turret Location



Drivetrain Location

Initial Motor Selection

Stepper Motors/Drivers

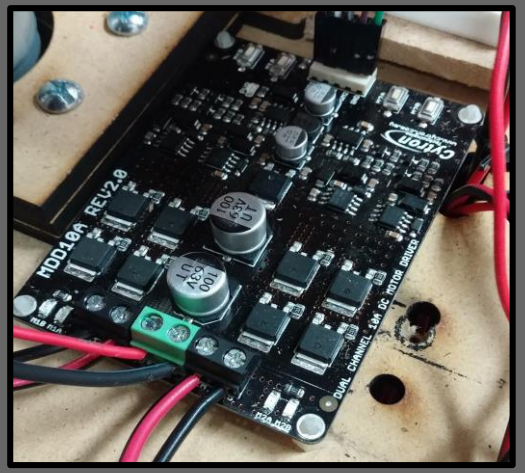
- Utilizing A3967SLB Chip
- .9 degrees per step
- Two logic inputs allow for full, half, quarter, and eighth step
- Did not provide enough current to rotate optical mount

Stepper Motor and Driver

Motor Drivers

HiTechnic DC Motor Controller

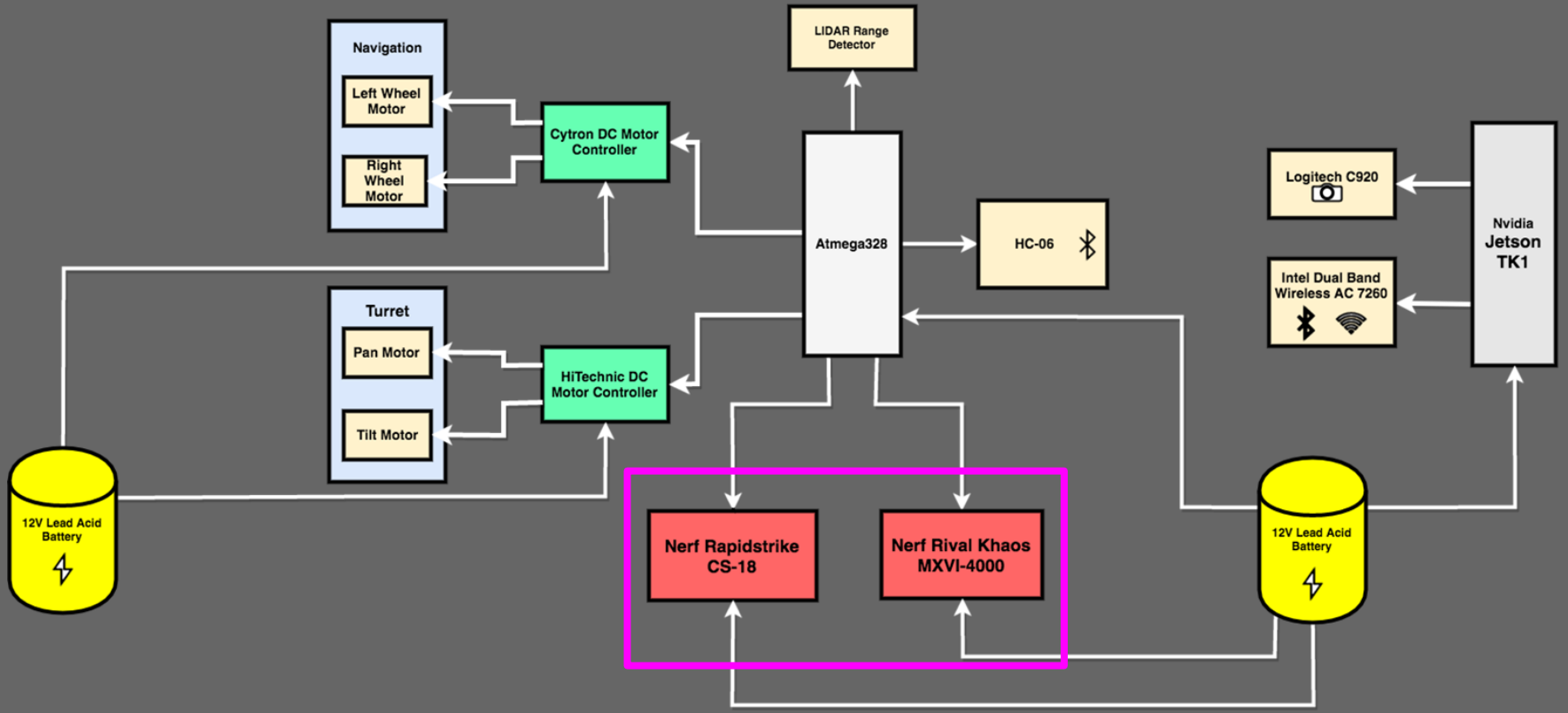
- Equipped with Encoders
- Supplies up to 4A with 9-15V input
- Provides I2C Communication



Cytron DC Motor Driver

- 10A 5-25V Dual Channel Controller
- DC Motors: 12V, 1.17A
- Bi-directional control

NERF-Blasters



NERF-Blasters Selection

Name	Ammo Type	0-Angle Range	Velocity	Price
Rival Zeus MXV-1200 Battle Gun	Ball	65-75 feet	100 feet/second	$39.99
Rival Khaos MXVI-4000	Ball	65-75 feet	100 feet/second	$62.99
N-Strike Elite Rampage	Dart	50 feet	50 feet/second	$31.99
Rapidstrike CS-18	Dart	55 feet	75 feet/second	$39.99

Rapidstrike CS-18

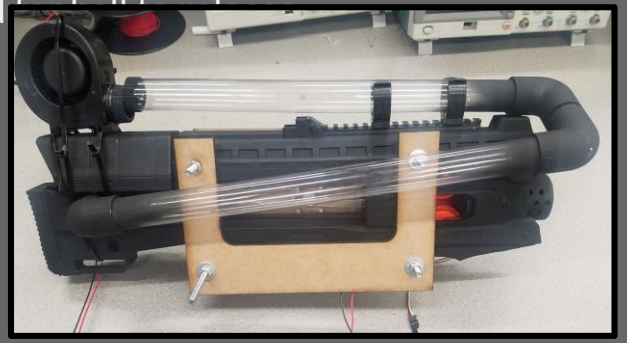
Rival Khaos MXVI-4000

Initial Nerf Blaster Selection

Rival Zeus MXV-1200

- 50 Nerf Balls with Custom Feeder
- Operated via ATMega328P using Fan and Servo Motor
- Fan required high voltage to feed ammo
- Special latch needed from barrel

Inside the Rival Zeus MXV-1200



Modification of Rival Zeus MXV-1200

NERF-Blasters Integration

Rapidstrike CS-18

Power: 6V, 1.5A

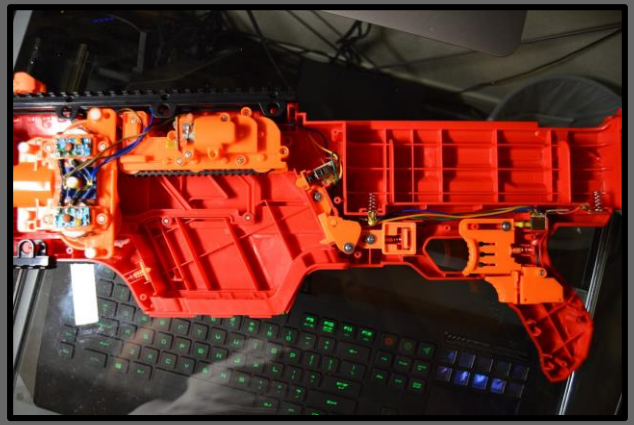
Utilizes two motor systems

Rapidstrike CS-18

Rival Khaos MXVI-4000

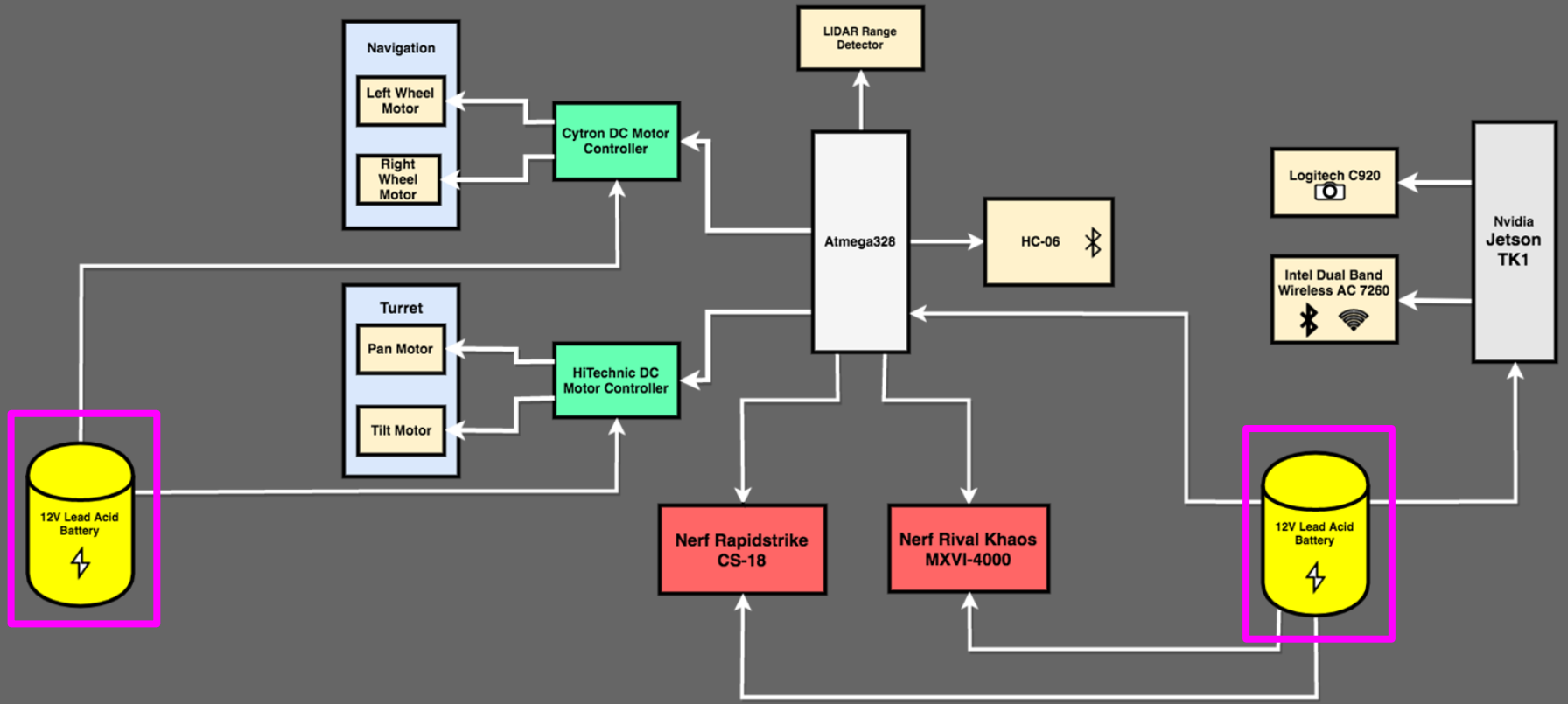
Power: 9V, 1.5A

Utilizes two motor systems



Rival Khaos MXVI-4000 Battle Gun

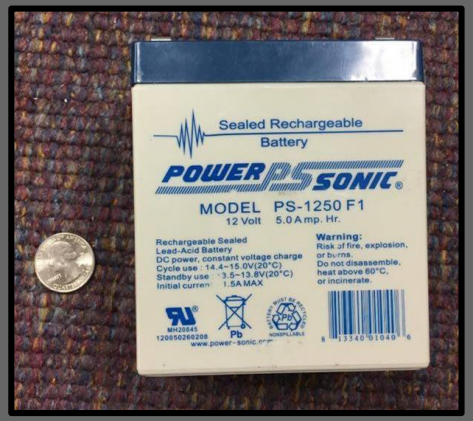
Power


Navigation
Left Wheel Motor
Right Wheel Motor
Cytron DC Motor Controller
LIDAR Range Detector
Atmega328
HC-06
Logitech C920
Nvidia Jetson TK1
Intel Dual Band Wireless AC 7260
Turret
Pan Motor
Tilt Motor
HiTechnic DC Motor Controller
12V Lead Acid Battery
Nerf Rapidstrike CS-18
Nerf Rival Khaos MXVI-4000
12V Lead Acid Battery

Power Consumption

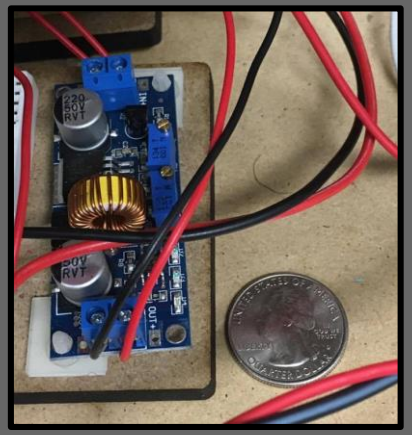
Component	Quantity	Voltage(V)	Total Current(mA)	Mostly On/Off	Power(W)
Microcontroller	1	5	46.5	ON	0.23
DC Motor	4	12	4800	OFF	57.60
Nerf-Blaster (Darts)	1	6	1500	OFF	9.00
Nerf-Blaster (Ball)	1	9	1500	OFF	13.50
Jetson TK1	1	12	2500	ON	30.00
LIDAR Lite	1	5	130	OFF	0.65
				Total Power	110.98

Power Selection



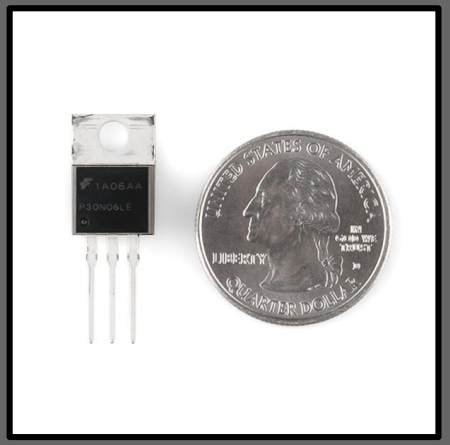
Sealed Lead Acid Battery

- Two power systems
- 12V, 5 aH
- 15 minute run time per charge



Drok DC-DC Step Down Variable Regulator

- Provides constant voltage and current
- Short circuit protection



N-Channel MOSFET

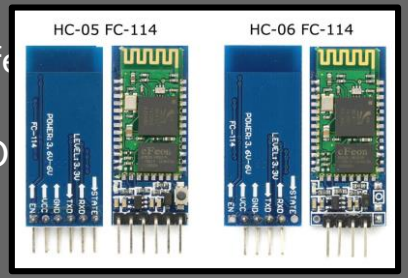
- Low voltage on-switching
- Supports circuits up to 60V and 30A

Communication Hardware

Onboard Processing

HC-06

- Bluetooth v2.0
- Full Duplex
- Frequency: 2.4 GHz
- Transfe
- rial O



Bluetooth Module HC-06

Remote Workstation

Intel Dual Band Wireless

- WiFi, Bluetooth
- PCIe
- Remote Control
- U d

Intel Dual Band Wireless-AC 7260

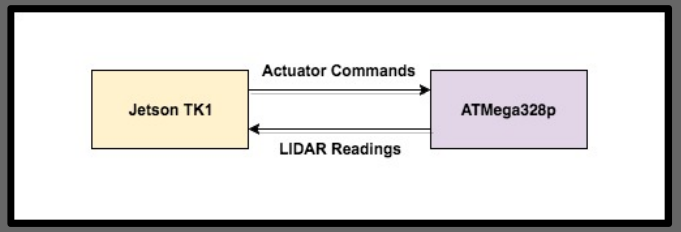
Serial Communication

Purpose

- Send actuator commands from Single Board Computer to MCU
- Send LIDAR readings from MCU to Single Board Computer for processing

Software

- POSIX Terminal Serial Interface
- Arduino Serial



Serial Port Configuration
Asynchronous Serial
Baud rate: 115200
Character Size: 8 bits
Parity: 0 bits
Stop: 0 bits
Non-Canonical Mode

Software Involvement

Deliverables

- Manual Navigation
- Turret Control
- LIDAR Sensor Readings
- Nerf Blaster Triggering

Assistance

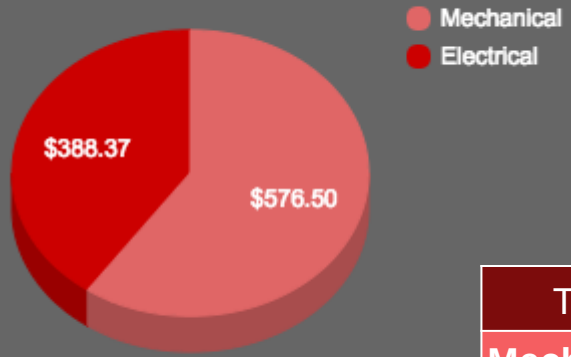
- Integration

Administration

Work Distribution

	PCB Design	Motor Control	Sensors	Firing System	Communication	Software
Aaron H.	✗	✗		✗		
Daniel A.			✗		✗	✗
Rachel G.	✗	✗				✗
Rafael R.			✗		✗	✗

Division of Budget



AS IS	Total
Mechanical	$576.50
Electrical	$388.37
Budget Remaining	$35.13

TESTING	Total
Mechanical	$365.16
Electrical	$576.50
Budget Remaining	$225.99

TOTAL	Total
AS IS	$964.87
TESTING	$774.01
Budget Remaining	$261.12

See Appendix

Issues

Issues

- Balancing $1000 on demonstrated cost
- Optimizing output pins on microcontrollers
- Only two DC Motors for Manual Navigation
- DC Motors with Encoders
- Rival Zeus MXV-1200
- Integrating Cross-Discipline

Acknowledgements

Red Team would like to give a special thanks to the University of Central Florida College of Engineering and Computer Science as well as Lockheed Martin Missiles and Fire Control Orlando for collaborating, funding, and setting up this senior design competition.

We would also like to thank the individuals listed below for their time and consultation services in assisting in our preliminary design and helping to assure our continual improvement:

Helmuth Bauer
Timbrel Carson
Brandon Slack
Steve Yenisch
Ray Boettger
Ray Gardner
Tom Vito
Don Harper

In addition to our consultants, we would like to recognize our individual sponsors and advisors for their guidance on this project:

Kenny Chen
Dr. Mark Heinrich
Dr. Mark Steiner
Jonathan Tucker
Dr. Jihua Gou
Dr. Lei Wei

Regards,
Red Team

Questions?

Appendix

Subsystem	Part	Short Description	Ttl Qty	Used Qty	Unit Cost	Ttl Cost	Used Cost	Specific To	Final Design
	6061 T6 Aluminum Pipe	Piping attachment	1	1.00	$5.38	$5.38	$5.38	Mechanical	No
	Nubs (Wheel Cap)	Hub cap	4	2.00	$5.50	$22.00	$11.00	Mechanical	Yes
	Hubbed Sprocket (A 6C 7-25B15)	Attached to motor for elevation	1	1.00	$11.72	$11.72	$11.72	Mechanical	Yes
	Steel Roller Chain	Piece will connect to sprockets for elevation	2	1.00	$4.00	$8.00	$4.00	Mechanical	Yes
	Sprocket (A 6C 7-25026)	Attached to turret skewer for elevation	1	1.00	$6.40	$6.40	$6.40	Mechanical	No
	Angular-Contact Ball Bearing	Bearing to allow turret rotation	1	1.00	$58.68	$58.68	$58.68	Mechanical	No
Navigation	Wheels	4 inch wheels (6mm bore)	2	2.00	$5.50	$11.00	$11.00	Mechanical	Yes
	Spur Gear	Drive	1	1.00	$0.00	$0.00	$0.00	Mechanical	Maybe
	Spur Gear (hubbed)	Rush Gears TA3240; attached to motor for rotation	1	1.00	$0.00	$0.00	$0.00	Mechanical	Maybe
	Material cost TBD		1	1.00		$0.00	$0.00	Mechanical	Maybe
Firing	Nerf Rival Zeus MXV-1200 Blaster (Red)		1	1.00	$40.00	$40.00	$40.00	Mechanical	No
Firing	Nerf N-Strike Elite Rapidstrike CS-18		1	1.00	$39.99	$39.99	$39.99	Mechanical	Yes
Motors	NeveRest 60 Gearmotor (am-3103a)		1	1.00	$28.00	$28.00	$28.00	Mechanical	Yes
Motors	NeveRest 40 Gearmotor (am-2964a)		3	3.00	$28.00	$84.00	$84.00	Mechanical	Yes
Motors	3V 1.7A 68oz-in Stepper Motor	Turret elevation and rotation	2	0.00	$16.95	$33.90	$0.00	Mechanical	Yes
Firing	Ammo attachement Dart	Purchased second hand	1	1.00	$15.00	$15.00	$15.00	Mechanical	Yes
Motors	Futaba S3004 Standard Servo Motor		1	1.00	$12.49	$12.49	$12.49	Mechanical	No
Blaster Insulation	Big Gap Filler Insulating Foam Sealant Quick Stop Straw	To help glue blasters fixed	2	0.00	$5.25	$10.50	$0.00	Mechanical	No
Caster Wheels			2	2.00	$6.27	$12.54	$12.54	Mechanical	No
Blaster	Nerf Rival Zeus	Second just in case	1	1.00	$46.85	$46.85	$46.85	Mechanical	No
Bearing Balls			1	1.00	$4.75	$4.75	$4.75	Mechanical	Yes
Ammo (Darts)	200pcs 7.2cm Refill Bullet		1	0.25	$13.99	$13.99	$3.50	Mechanical	No
Blaster	Rapid Strike		1	1.00	$49.99	$49.99	$49.99	Mechanical	No
Blower	Blower for ball ammo		1	1.00	$4.95	$4.95	$4.95	Mechanical	No
Ball Ammo Tubing	Length Plastic Tubing		3	1.50	$2.28	$6.84	$3.42	Mechanical	No
Ball Ammo Tubing	Right degree attachment		4	4.00	$1.98	$7.92	$7.92	Mechanical	No
Nylon Unthreaded Spacers			1	0.06	$9.85	$9.85	$0.59	Mechanical	Yes
L-Bracket	Simpson Strong-Tie 12-Gauge Angle		2	2.00	$3.27	$6.54	$6.54	Mechanical	No
Wood for plate and base	Medium Density Fiber wood		3	2.00	$7.42	$22.26	$14.84	Mechanical	Yes
Caster Wheels	2 in. Swivel Non-Marking Rubber Caster		2	2.00	$4.37	$8.74	$8.74	Mechanical	Yes
Processing	NVIDIA Jetson TK1	Processor for computer vision algorithms	1	1.00	$129.00 [1]	$129.00	$129.00	Electrical	Yes
Power	Powersonic PS-1250 F1 Replacement Battery 12V 5 AH	Power	3	1.00	$17.32	$51.96	$17.32	Electrical	Yes
Sensors	Logitech C920 HD Pro Webcam		1	1.00	$52.49 [2]	$52.49	$52.49	Electrical	Yes

AS IS	Total
Mechanical	$576.50
Electrical	$388.37

TESTING	Total
Mechanical	$365.16
Electrical	$408.85

ALL BUDGET	Total
As Is	$964.87
Testing	$774.01

Appendix

Subsystem	Part	Short Description	Ttl Qty	Used Qty	Unit Cost	Ttl Cost	Used Cost	Specific To	Final Design
Misc.	Elegoo Upgraded Electronics Fun Kit w/ Power Supply Module, Jumper Wire, Precision Potentiometer, 830 tie-points Breadboard for Arduino, Raspberry Pi, STM32	Bundled up wires and connections	1	1.00	$16.86 [3]	$16.86	$16.86	Electrical	No
Processing	3-pack NEW Atmega328p-pu Chip w/ Arduino UNO Bootloader		1	0.33	$13.48 [4]	$13.48	$4.49	Electrical	Yes
Power	STMicroelectronics 5V 1.5A Positive Voltage Regulator L7805CV in Antistatic Foam		1	1.00	$5.45 [5]	$5.45	$5.45	Electrical	No
Misc.	AmazonBasics USB 2.0 Cable - A-Male to B-Male - 6 Feet (1.8 Meters)	Used to connect arduino to computer	1	1.00	$4.99	$4.99	$4.99	Electrical	No
Processing	Raspberry Pi 3 Model B Motherboard		1	1.00	35.99	$35.99	$35.99	Electrical	No
Processing	PCB	Created by Electrical team as requirement for class	1	1.00	16.06	$16.06	$16.06	Electrical	Yes
Misc.	ZJchao 9V 1A Power Adapter for Arduino (2-Flat-Pin Plug / 100CM Cable)	Additional voltage supply to arduino in the case that a device will not power with the built in 5V	1	1.00	$5.59	$5.59	$5.59	Electrical	No
Misc.	SanDisk Ultra 32GB microSDHC UHS-I Card with Adapter, Grey/Red, Standard Packaging (SDSQUNC-032G-GN6MA)		1	1.00	9.95	$9.95	$9.95	Electrical	No
Power	DE-SW050 Fixed 5V switching regulator		1	1.00	$15.00	$15.00	$15.00	Electrical	No
Motor Control	10A Dual Channel Bi-directional DC Motor Driver		2	1.00	$23.49	$46.98	$23.49	Electrical	Yes
Sensors	LIDAR-Lite 3 Laser Range Finder	Used to detect target distance	1	1.00	$112.49 [6]	$112.49	$112.49	Electrical	Yes
Motor Control	EasyDriver- Stepper Motor Driver		1	0.00	$13.46 [7]	$13.46	$0.00	Electrical	No
Communication	SparkFun USB to Serial Breakout - FT232RL		1	1.00	$13.46 [8]	$13.46	$13.46	Electrical	No
Power	Crystal 16MHz		3	3.00	$0.86 [9]	$2.58	$2.58	Electrical	No
Power	TIP31C Transistor		5	5.00	$1.06	$5.30	$5.30	Electrical	No
Power	DC Barrel Plug to 2-Pin Terminal Block Adapter		1	1.00	$1.95	$1.95	$1.95	Electrical	Yes
Power	Voltage Regulator - 12V		5	5.00	$1.50	$7.50	$7.50	Electrical	No
TK1	Replacement TK1		1	1.00	$200.00	$200.00	$200.00	Electrical	No
Turret mount	Hubs		3	3.00	4.99	$14.97	$14.97	Mechanical	No
Turret mount	Aluminum hub sprockets		3	3.00	4.79	$14.37	$14.37	Mechanical	Yes
Turret mount	Aluminum rod		1	1.00	3.08	$3.08	$3.08	Mechanical	Yes
Base plate organization	Female Thread Standoffs		4	4.00	3.49	$13.96	$13.96	Mechanical	Yes
Bolts, Nuts, and L-brackets	Average		1	1.00	60.00	$60.00	$60.00	Mechanical	Yes
Encoder Cables		Connects to gear motor to gear driver with encoder	2	2.00	5.00	$10.00	$10.00	Mechanical	Yes
Gear Motor Bracket			1	1.00	6.99	$6.99	$6.99	Mechanical	Yes
Stepper Motor Brackets		-	1	1.00	8.94	$8.94	$8.94	Mechanical	No
Gear Motor Driver with Encoder		Connects to Elevation and Rotation Motor for location assist	1	1.00	75.00	$75.00	$75.00	Mechanical	Yes
Sprockets	Sprockets connect to skewer hubs for rotation		1	3.00	3.70	$3.70	$11.10	Mechanical	Yes

Appendix

Subsystem	Part	Short Description	Ttl Qty	Used Qty	Unit Cost	Ttl Cost	Used Cost	Specific To	Final Design
Blaster	Nerf Rival Chaos	Comes with Ammo and cartridge	1	1.00	70.00	$70.00	$70.00	**Mechanical**	Yes
Material Cost	For all materials Additively manufactured	This estimate was gathered by taking the volume and mass of each part in solidworks and calculating it with relation to the cost of ABS Plastic material	1	1.00	50.00	$50.00	$50.00	**Mechanical**	Yes
Adhesive Standoffs	To hold hardware upright and off base plate		1	1.00	8.00	$8.00	$8.00	**Mechanical**	Yes
Skewer Rod Final Purchase			1	1.00	2.37	$2.37	$2.37	**Mechanical**	Yes
Delrin Plastic	Used approximately 1 ft^2 of material on parts		1	1.00	18.00	$18.00	$18.00	**Mechanical**	Yes
Voltage regulator	Drok Step down constant current and voltage regulator		3	3.00	9.56	$28.68	$28.68	**Electrical**	Yes
Static Proof Cloth	Used to protect electronis		1	0.30	8.00	$8.00	$2.40	**Electrical**	Yes