COLLEGE OF ENGINEERING AND COMPUTER SCIENCE

Aaron Hoyt	EE.
Daniel Agudelo	CpE.
Rachel Gremillion	CpE.
Rafael Ramirez	CpE.

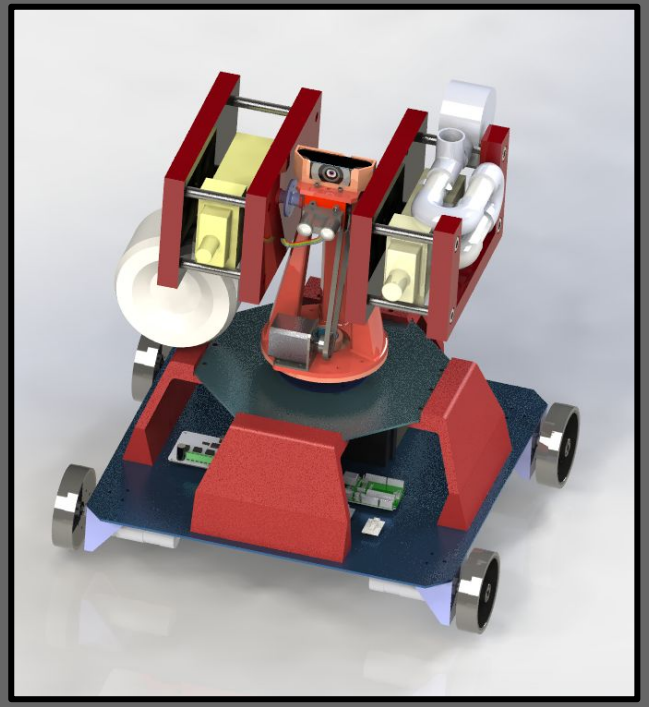
Nerf-Battlebot

Red Team

Group 9

Motivation

- Lockheed Martin mentorship
- Collaborate with other engineering disciplines
- High quality components



Annie

Goals and Objectives

- Design a modular system
- Provide robot with powerful as well as precise movement
- Onboard processing
- Combine two sensor modalities

Customer Requirements

Dimensions and Mobility

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

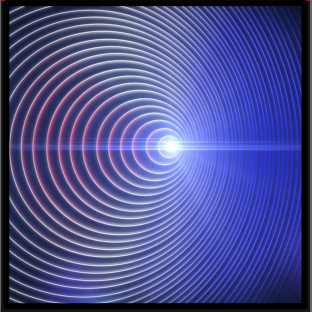
Must be able to traverse battlefield

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

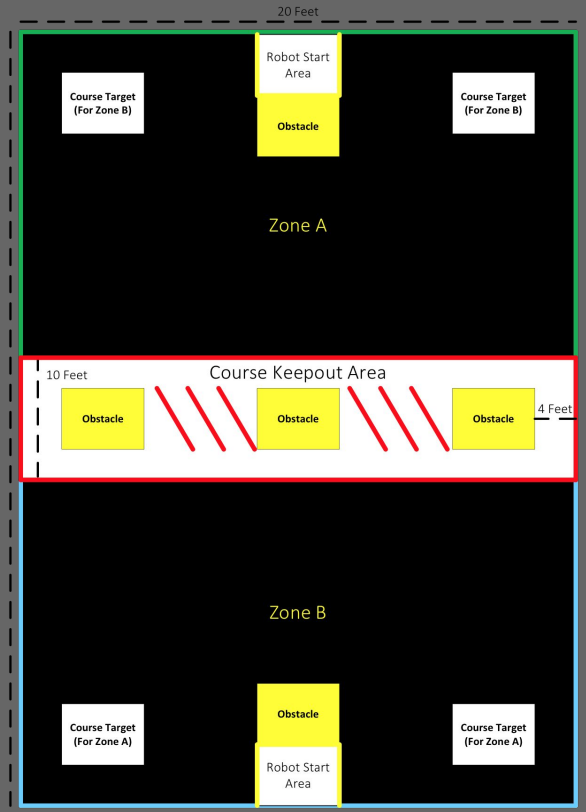
Aiming Accuracy

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



Arena

- 40ft. by 20ft.
- Two Zones
  - 15ft. by 20ft.
- Course Keepout Area
  - In the middle
  - 10ft. by 20ft.

Rounds

- One-to-one robot battle
- 10 minutes
- Three rounds
  - Red vs. Green
  - Red vs. Blue
  - Green vs. Blue

Point System

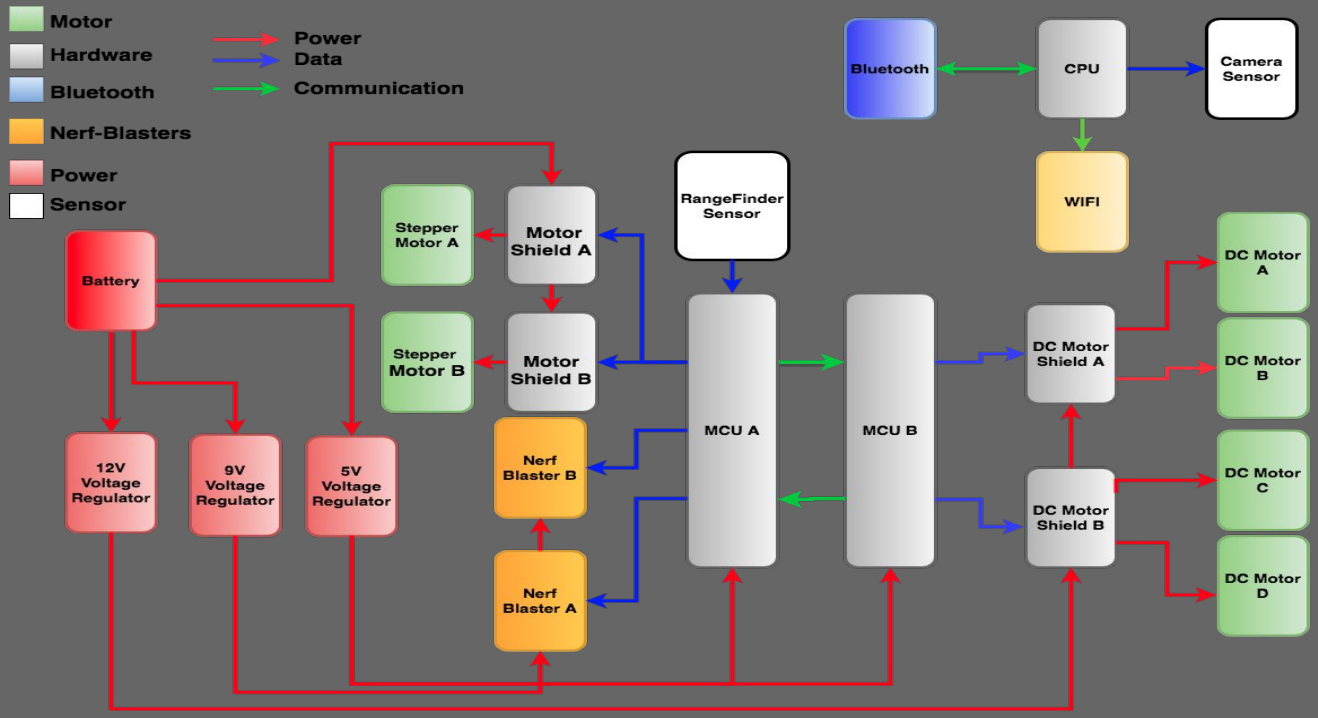
- Enemy Bot Nerf Ball (2)
- Enemy Bot Nerf Dart (4)
- Enemy Medic (8)
- Course Target [Max 2] (2)
- Entering Restricted Area (-5)

Robot Architecture

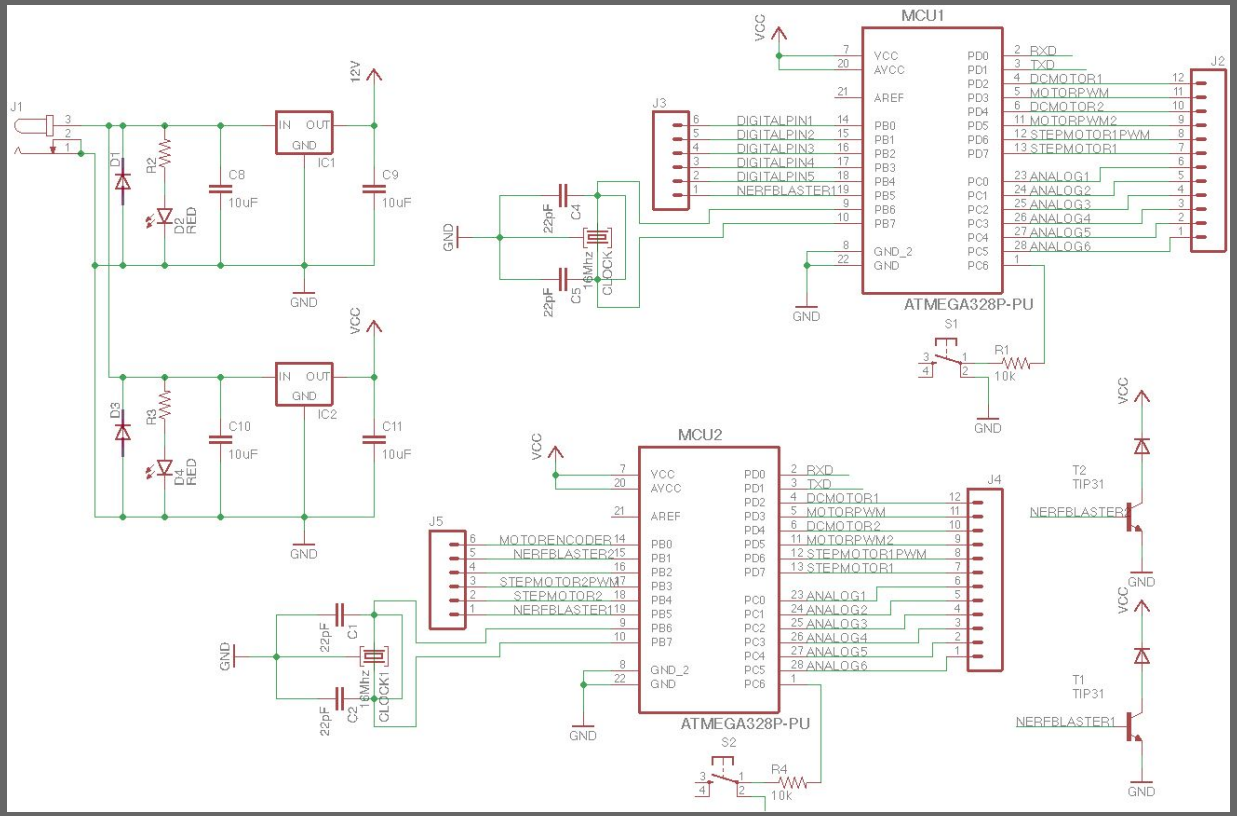
Deliberative paradigm

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

Block Diagram

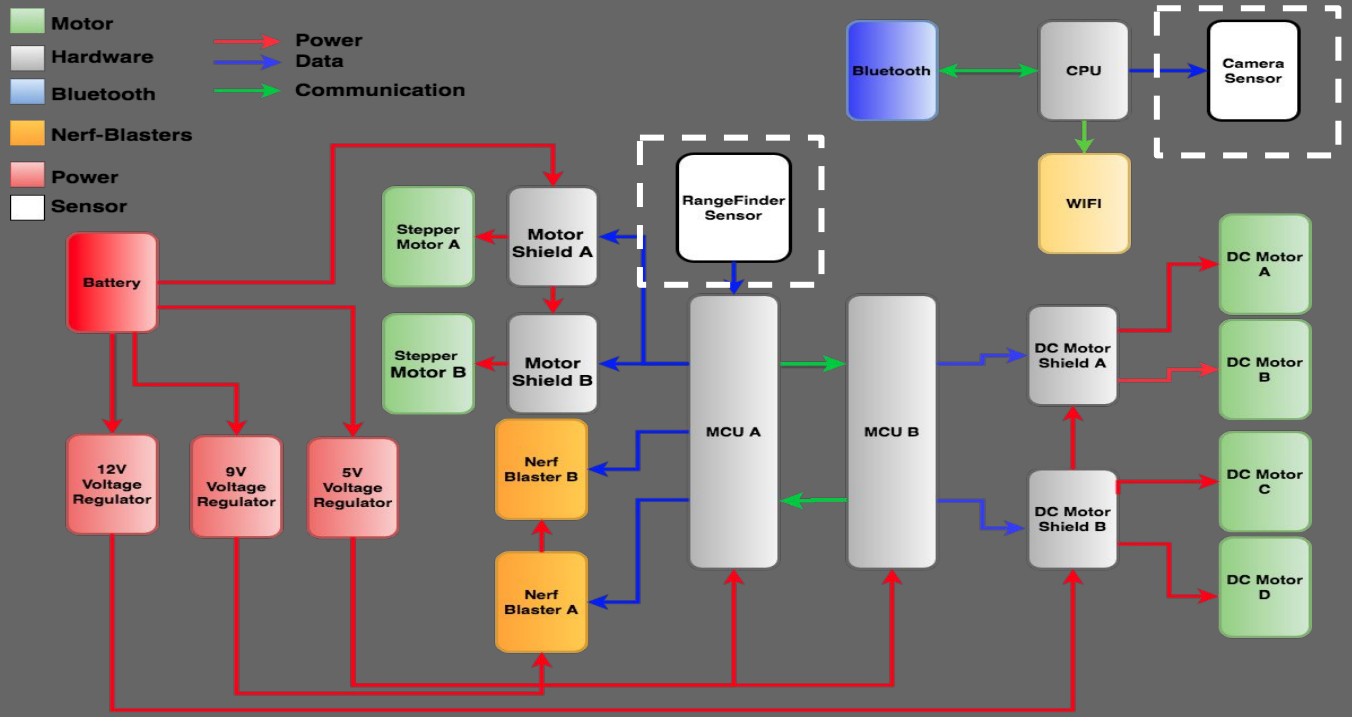


PCB Schematic



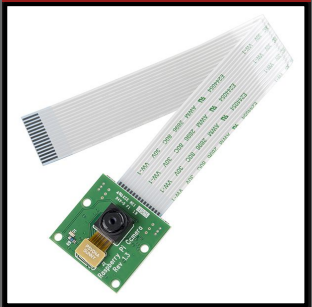
Hardware Selection

Sensors


Motor
Hardware
Bluetooth
Nerf-Blasters
Power
Sensor
Power
Data
Communication
Bluetooth
CPU
Camera Sensor
WIFI
RangeFinder Sensor
Stepper Motor A
Motor Shield A
Battery
Stepper Motor B
Motor Shield B
MCU A
MCU B
DC Motor Shield A
DC Motor A
DC Motor B
12V Voltage Regulator
9V Voltage Regulator
5V Voltage Regulator
Nerf Blaster B
Nerf Blaster A
DC Motor Shield B
DC Motor C
DC Motor D

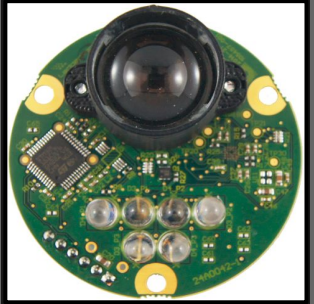
Logitech C920 Webcam

- Built-in H.264 video compression
  - Low video transfer bit rates
- Plug and play via USB
  - Included USB cable reaches top of robot from base

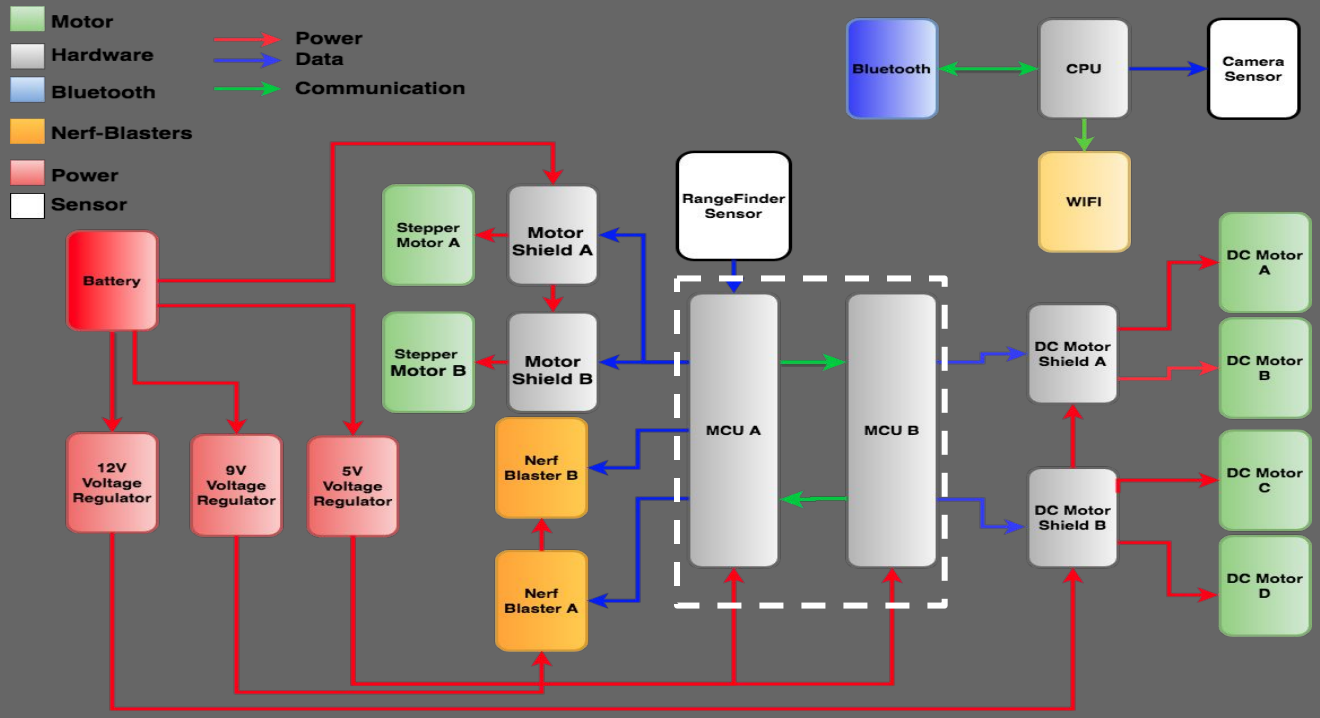
Logitech C920 Webcam	Raspberry Pi Camera Module v2	Pixy CMUcam5
		
• $52.49	• $25.00	• $67.00
• 1080p	• 1080p	• 800p
• 6 ft USB	• Ribbon Cable	• Multiple plugins
• 7 x 4.8 x 9.2 cm	• 2.5 x 2.4 x 0.9 cm	• 5.3 x 5 x 3.6 cm
• 70 x 43 FOV	• 62 x 48 FOV	• 75 x 47 FOV

LIDAR-Lite Rangefinder

- Affordable
  - Best performance over cost
- Longest distance detection
- Comparable accuracy
- Small form factor

LIDAR-Lite v3	TeraRanger Duo	LeddarTech Leddar One
		
• $149.99	• $207.20	• $115.00
• 131 ft	• 46 ft	• 49 ft
• +/- 2.5 cm	• +/- 2 cm	• +/- 5 cm
• 2 x 4.8 x 4 cm	• 5.3 x 4.4 x 2.5 cm	• 2” in diameter

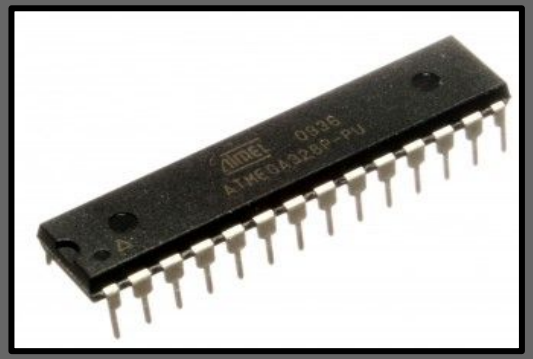
Microcontrollers



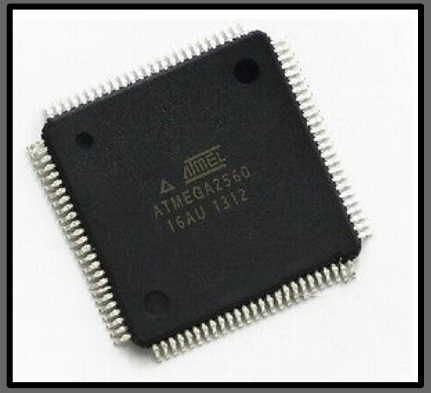
Microcontrollers

ATmega328p-pu

- 20 input/output pins
  - 14 digital (6 of which are PWM)
  - 6 analog (can be used as digital pins)
- 5V operating voltage
- 6-20V input voltage allowed



ATmega328p-pu



ATmega2560

ATmega2560

- 70 input/output pins
  - 54 digital (14 of which are PWM)
  - 16 analog (can be used as digital pins)
- 5V operating voltage
- 6-20V input voltage allowed

Microcontroller 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

Image Processing

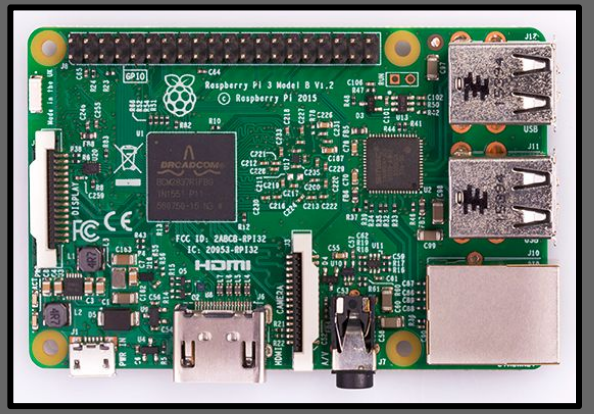
NVIDIA Jetson Tegra K1 (TK1)

- $129 with student discount (Original $192)
- 2.3 GHz Quad Core
- GPU optimized for OpenCV
- 2GB RAM

NVIDIA Jetson TK1

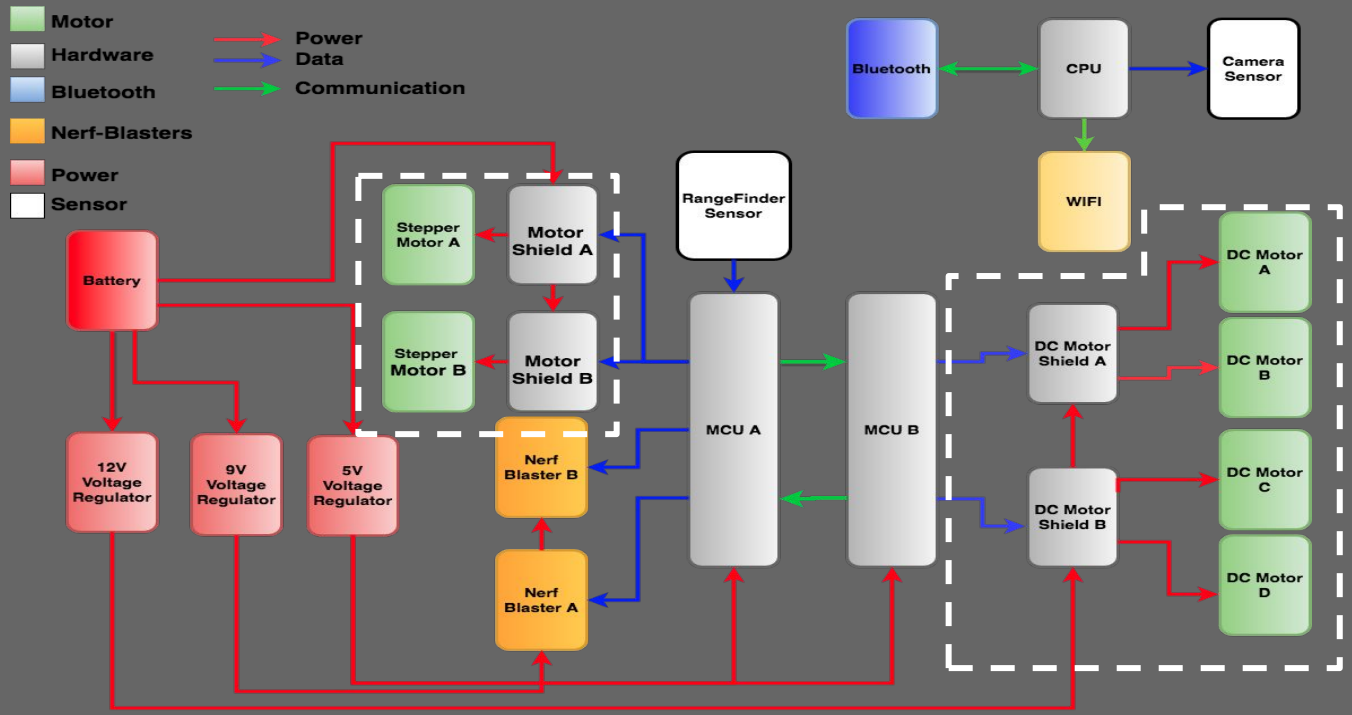
Raspberry Pi 3 Model B

- $35.69
- 1.2GHz Quad-Core
- 1GB RAM
- Introductory grade level of processing



Raspberry Pi 3 Model B

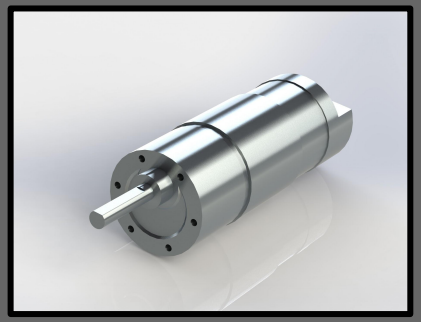
Motors and Drivers



Motor Selection

DC Motor

- Will be used for Battlebot manual navigation
- Maximum velocity of 3.3ft/s using four motors
- Equipped with Encoders
- Operating at 12V, 1.3A



NeveRest 40 Gearmotor

Stepper Motor

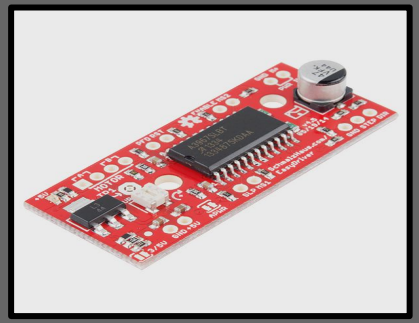
- Will be used for pan/tilt of the turret
- 68 oz-in to supply enough force to adjust Nerf Blasters
- 0.9 step angle for precise accuracy
- Operating at 3.06V, 1.7A

Hybrid Stepper Motor

Stepper Motor Driver

EasyDriver Stepper Motor

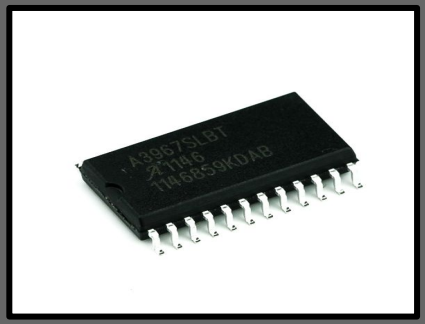
- 6V to 30V supply voltage
- Any voltage of stepper motor
- Current control from 150mA/phase to 700mA/phase



EasyDriver Stepper Motor

A3967SLB chip

- Step, Direction, MS1, and MS2 Input Pins
- Two logic inputs allow for full, half, quarter, and eighth step
- Compatible with bipolar motors

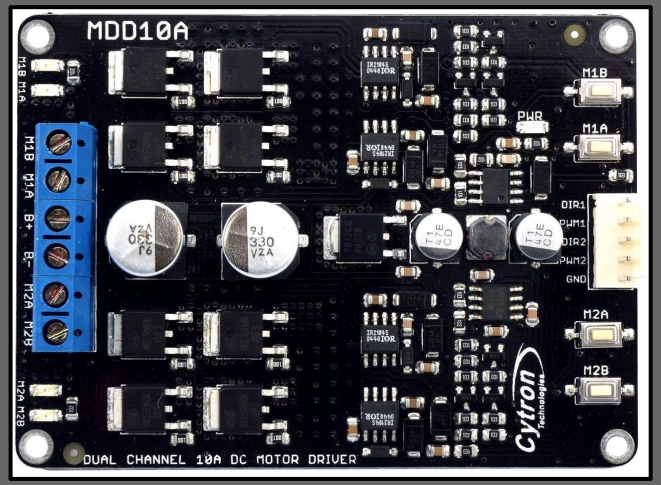


A3967SLB

DC Motor Driver

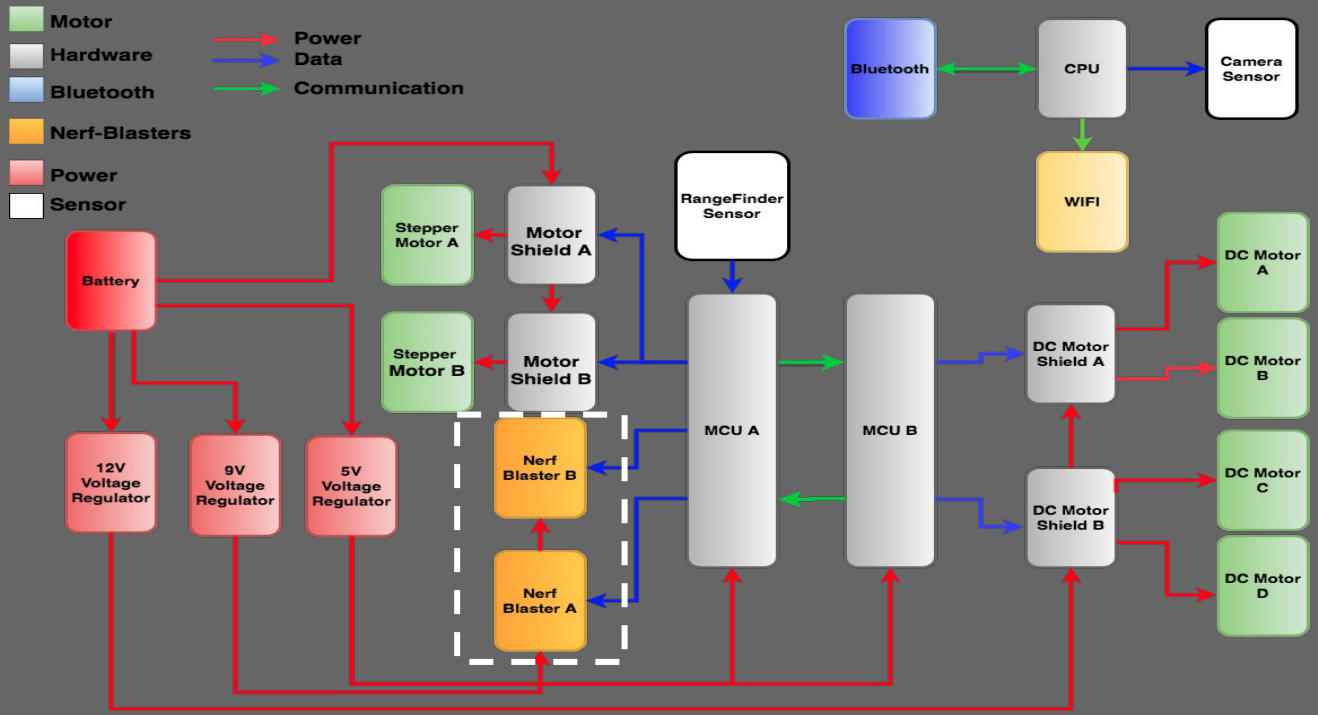
Dual Channel DC Motor Driver

- Drives two DC motors
- Bi-directional control
  - PWM1, PWM2, DIR1, DIR2
- 5V to 25V motor voltage
- Maximum 10A continuous
- PWM frequency up to 20 KHz for speed control



Dual Channel DC Motor Driver

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
N-Strike Vulcan EBF-25	Dart	25-35 feet	49 feet/second	$44.99
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 Zeus MXV-1200 Battle Gun

NERF-Blasters Integration

Rapidstrike CS-18

- Power: 6V, 1.2A
- Utilizes two motor systems

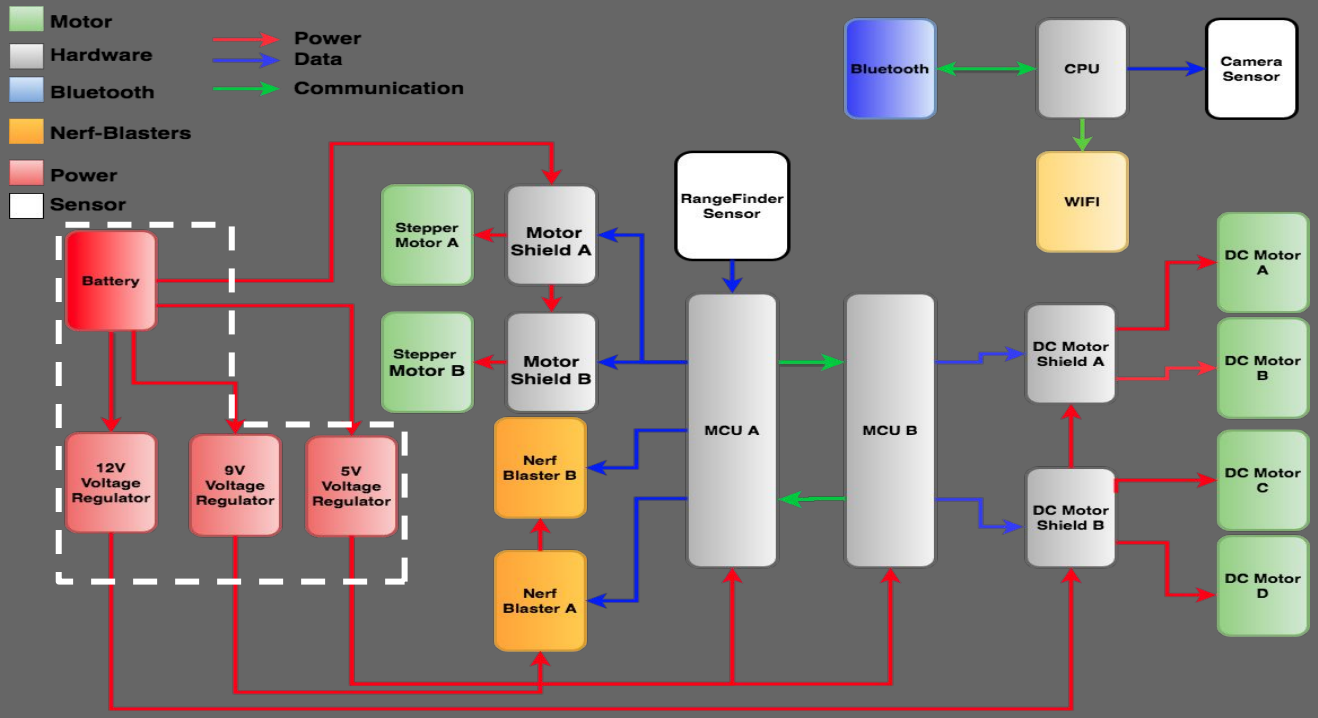
Rapidstrike CS-18

Rival Zeus MXV-1200

- Power: 9V, 1A
- One motor system and mechanical latch

Rival Zeus MXV-1200 Battle Gun

Power


Motor
Hardware
Bluetooth
Nerf-Blasters
Power
Sensor
Power
Data
Communication
Bluetooth
CPU
Camera Sensor
WIFI
RangeFinder Sensor
Stepper Motor A
Motor Shield A
Stepper Motor B
Motor Shield B
Battery
12V Voltage Regulator
9V Voltage Regulator
5V Voltage Regulator
Nerf Blaster B
Nerf Blaster A
MCU A
MCU B
DC Motor Shield A
DC Motor Shield B
DC Motor A
DC Motor B
DC Motor C
DC Motor D

Power Consumption

Component	Quantity	Voltage(V)	Total Current(mA)	Mostly On/Off	Power(W)
Microcontroller	2	5	46.5	ON	0.46
DC Motor	4	12	4800	OFF	57.60
Stepper	2	3	3400	OFF	10.20
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	121.41

Battery Selection

Sealed Lead Acid Battery

- 12V, 5 aH
- 15 minute run time
- Supplies high current
- Low cost: $15

Communication

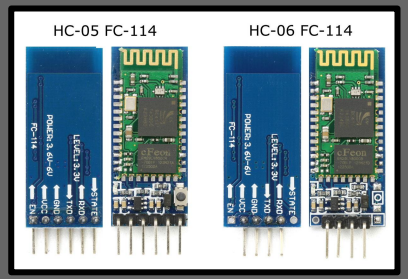
Onboard Processing

Bluetooth

- One module per MCU
- HC-05 Master/Slave
- HC-06 Slave

I2C

- CPU- Master
- MCU- Slave



Bluetooth Modules HC-05, HC-06

Remote Workstation

Intel Dual Band Wireless

- WiFi, Bluetooth
- PCIe
- Remote Control
- Upstream video feed

Intel Dual Band Wireless-AC 7260

Software Involvement

Deliverables

- DC Motor, Stepper Motor, LIDAR-Lite, and Nerf Blaster control algorithms for use by CS team
  - i.e. sending speed, direction, distance outputs to motors and retrieving target range data from sensors

Assistance

- Provide help to CS team on computer vision algorithms
- Testing functionality

Administration

Work Distribution

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

Design Budget

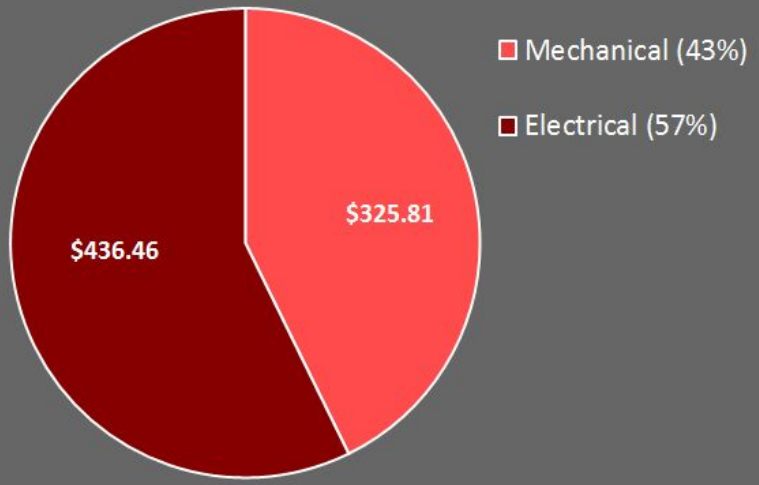
Component Name	Qty	Unit Cost	Cost
NVIDIA Jetson TK1	1	$129.00	$129.00
LIDAR-Lite v3	1	$112.49	$112.49
Logitech C920 Webcam	1	$52.49	$52.49
10A Dual Channel Bi-Directional DC Motor Driver	2	$23.49	$46.98
ATmega328p-pu (3-pack)	1	$13.48	$13.48
Powersonic PS-1250 F1 12V	1	$17.32	$17.32
Voltage Regulator L7805CV 5V 1.5 A	1	$5.45	$5.45

Component Name	Qty	Unit Cost	Cost
Voltage Regulator 5V 1A	1	$15.00	$15.00
16 MHz Crystal	3	$0.86	$2.58
SparkFun EasyDriver Stepper Motor Driver	2	$13.46	$26.92
DC Barrel Plug to 2-Pin Terminal Block Adapter	1	$1.95	$1.95
TIP31C Transistor	5	$1.06	$5.30
Voltage Regulator 12V	5	$1.50	$7.50
		Total	$436.46

Testing Budget

Component Name	Qty	Unit Cost	Cost
USB 2.0 A-male to B-male	1	$4.99	$4.99
Elecgoo Upgraded Electronics Fun Kit	1	$16.86	$16.86
ZJchao 9V 1A Power Adapter for Arduino	1	$5.59	$5.59
Arduino Uno R3 Microcontroller A000066	1	$16.06	$16.06
Sparkfun USB to Serial Breakout Board	1	$13.46	$13.46
		Total	$56.96

Division of Budget



	Total
Mechanical	$325.81
Electrical	$436.46
Budget Used	$762.27
Budget Remaining	$237.73

Issues and Future Plans

Issues

- Balancing $1000 on demonstrated cost
- Optimizing output pins on microcontrollers
- Drop two DC Motors

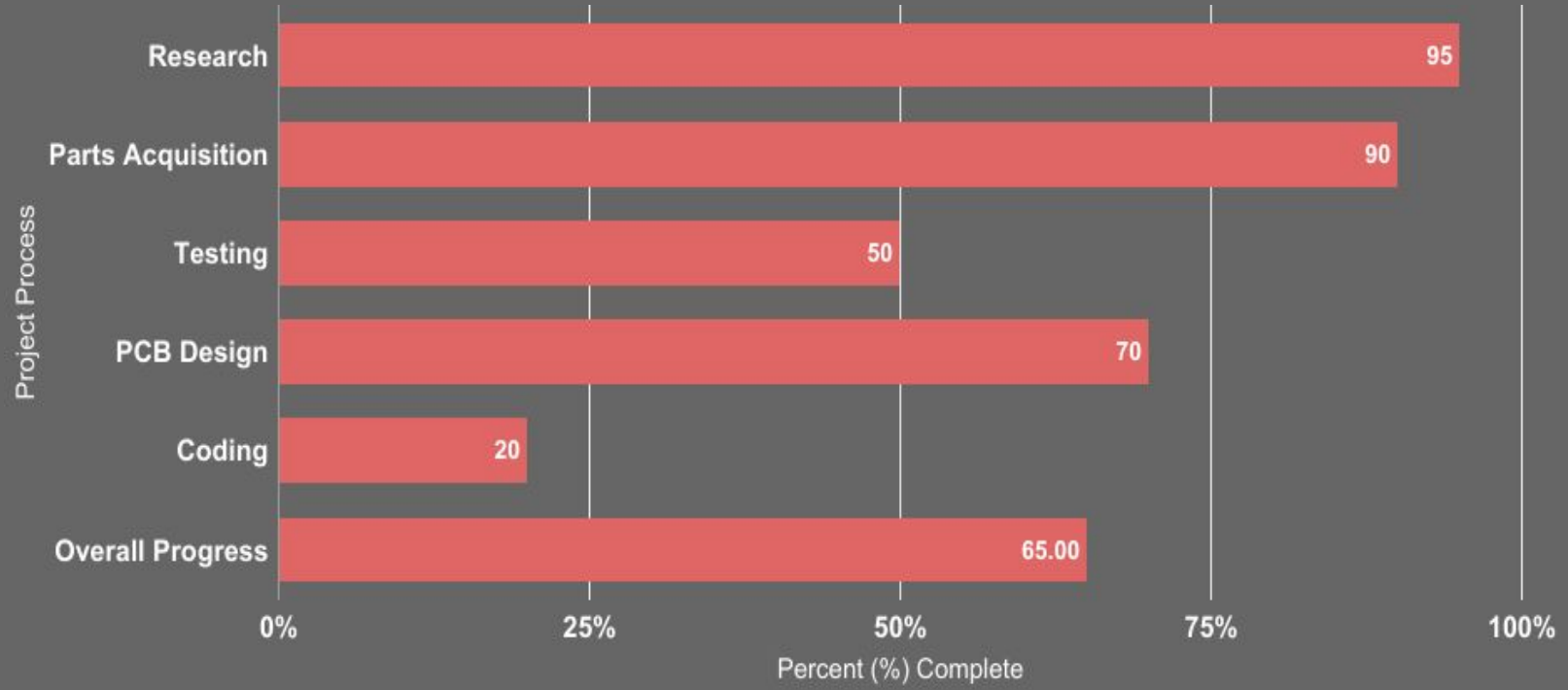
Backup Plan

- Provide own chassis and backup programming

Future Plans

- Triggering Nerf-blasters
- Finalize PCB design

Progress


Research
Parts Acquisition
Testing
PCB Design
Coding
Overall Progress
95
90
50
70
20
65.00
Project Process
0%
25%
50%
75%
100%
Percent (%) Complete

Questions?