Battlebot

Sponsored by Lockheed Martin: Applied Research

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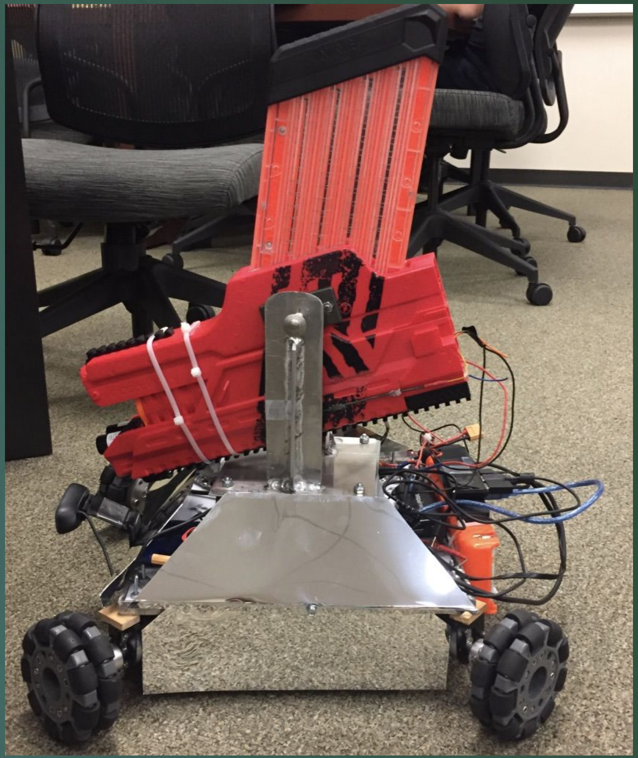
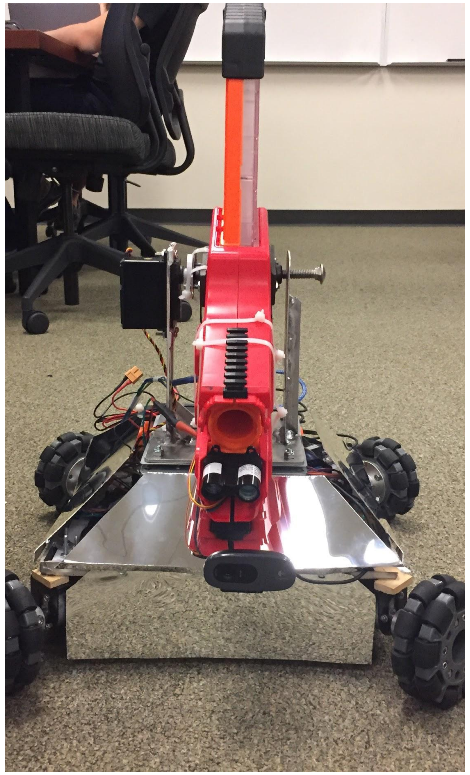


UCF Faculty, Advisors, and Industry Experts

RAY GARDNER (TECHNICAL CONSULTANT) ◆ MARK STEINER (MAE DIRECTOR OF ENGINEERING DESIGN)
KURT STRESSAU (MAE SENIOR DESIGN COORDINATOR) ◆ LEI WEI (ECE SENIOR DESIGN COORDINATOR)
MARK HEINRICH (CS SENIOR DESIGN COORDINATOR) ◆ JIHAN GOU (ME FACULTY ADVISOR)

Battlebot Final Design

- Modular
- Responsive
- Accurate Target Discrimination



Green Team Battlebot

EE/CpE: Statement of Work

- Design, build, test, and deliver an autonomous fire control system
  - Autonomously detect, track, and fire at an object of a selected color
- Compete in NERF Battlebot competition
  - Comprised of several 10-minute rounds

Work Distribution

Mechanical		Computer Science		Computer & Electrical	
Name	Responsibilities	Name	Responsibilities	Name	Responsibilities
Tyler Coughlin	• Drivetrain	**Daniel Healy**	• Prioritization • Object Detection • RF Control • User-Application • Hardware Integration	**Clayton Cuteri**	• System Communication • Sensor Detection
Austin Moore	• Turret			**Corey Nelson**	• Fire Control Board • Electrical Integration
Jared Weber	• Frame	**Nick Ho Lung**	• Facial Detection • Movement Detection	**Kyle Nelson**	• Electrical Integration • Fire Control Board
Corbin Rowe	• Skirt • Power	**Sayeed Tahseen**	• Video Feed • Background Subtraction	**Alexander Perez**	• Planning • Team Logistics • Blob Detection • System Integration
Nathan Herald	• NERF Weapon				

Group 2: Goals and Motivation

The project goals:

- Cost-effective
- 100% in compliance with Lockheed's required specifications

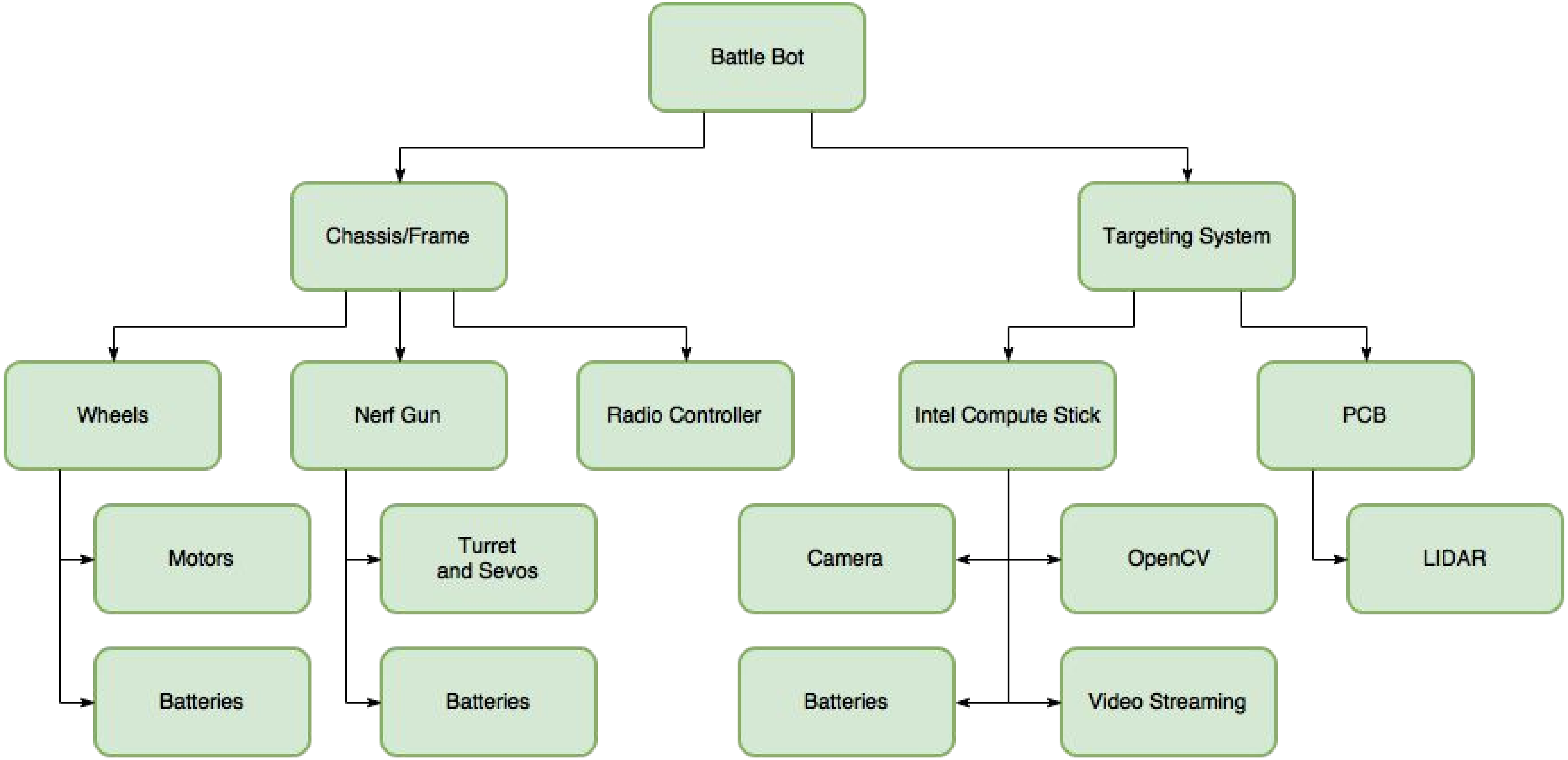
The cumulative motivation:

- Experience coordinating with multiple engineering disciplines
- Working together with Lockheed Martin Applied Research

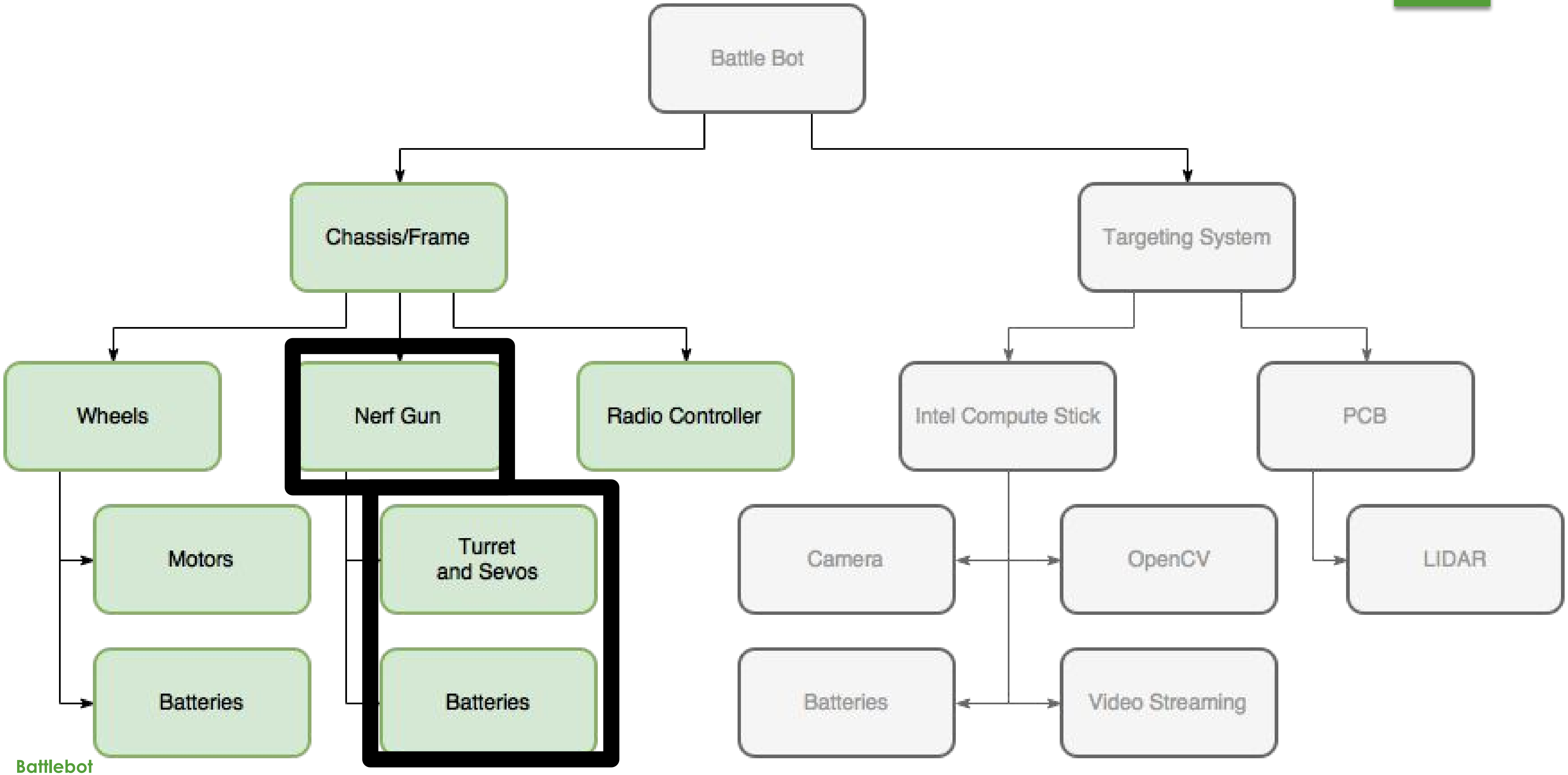
Engineering Requirements

- Color Detection of 16" x 16" target
  - Accurate within 8 inches of centroid
- Sufficient battery life for Lockheed Battlebot Competition
  - At least 10 minutes
- Compact PCB
  - Less than $100mm^2$ to fit on robot
- Dual Sensor Integration
  - Camera
  - Accurate Range Measurement within 40 feet

Battlebot Subassemblies



Battlebot Subassemblies: Chassis/Frame

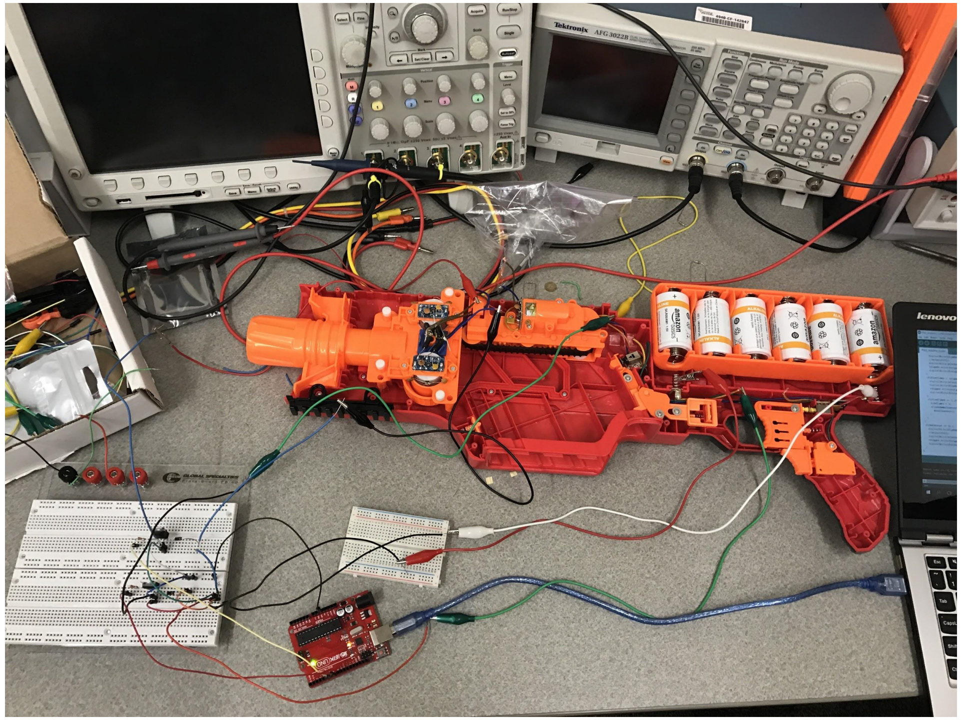


Weapon Choice: NERF RIVAL KHAOS

- Stock 40 round magazine
- Electric Trigger to integrate with PCB
- Highest FPS rating of NERF Rival line

Nerf Gun: Fall/Spring Analysis

- Gun disassembled for internal component analysis
  - Physical switches removed
  - Wired to PCB
  - Battery relocated and gun size reduced
- Issues
  - Length
  - Thermistor



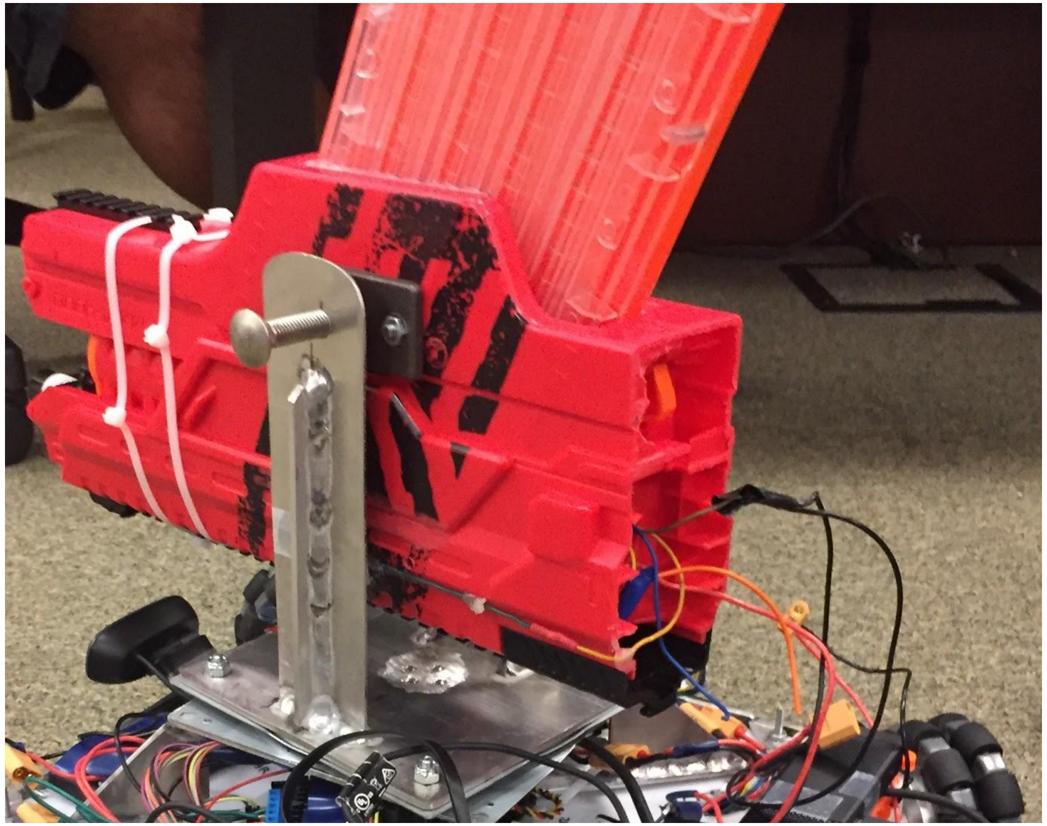
Servo Part Analysis

COMPONENT	HS-805BB	HS-645MG
Bearing Type	Dual Ball Bearing	Dual Ball Bearing
Speed (4.8V)	0.19sec/60°	0.24/sec/60°
Speed (6.0V)	0.14sec/60°	0.20sec/60°
Torque (4.8V)	19.8 kg/cm	7.7 kg/cm
Torque (6.0V)	24.7 kg/cm	9.6 kg/cm
Size	2.59 x 1.18 x 2.26 in	1.59 x 0.77 x 1.48 in
Price	$38.99	$49.99

One of two chosen servos

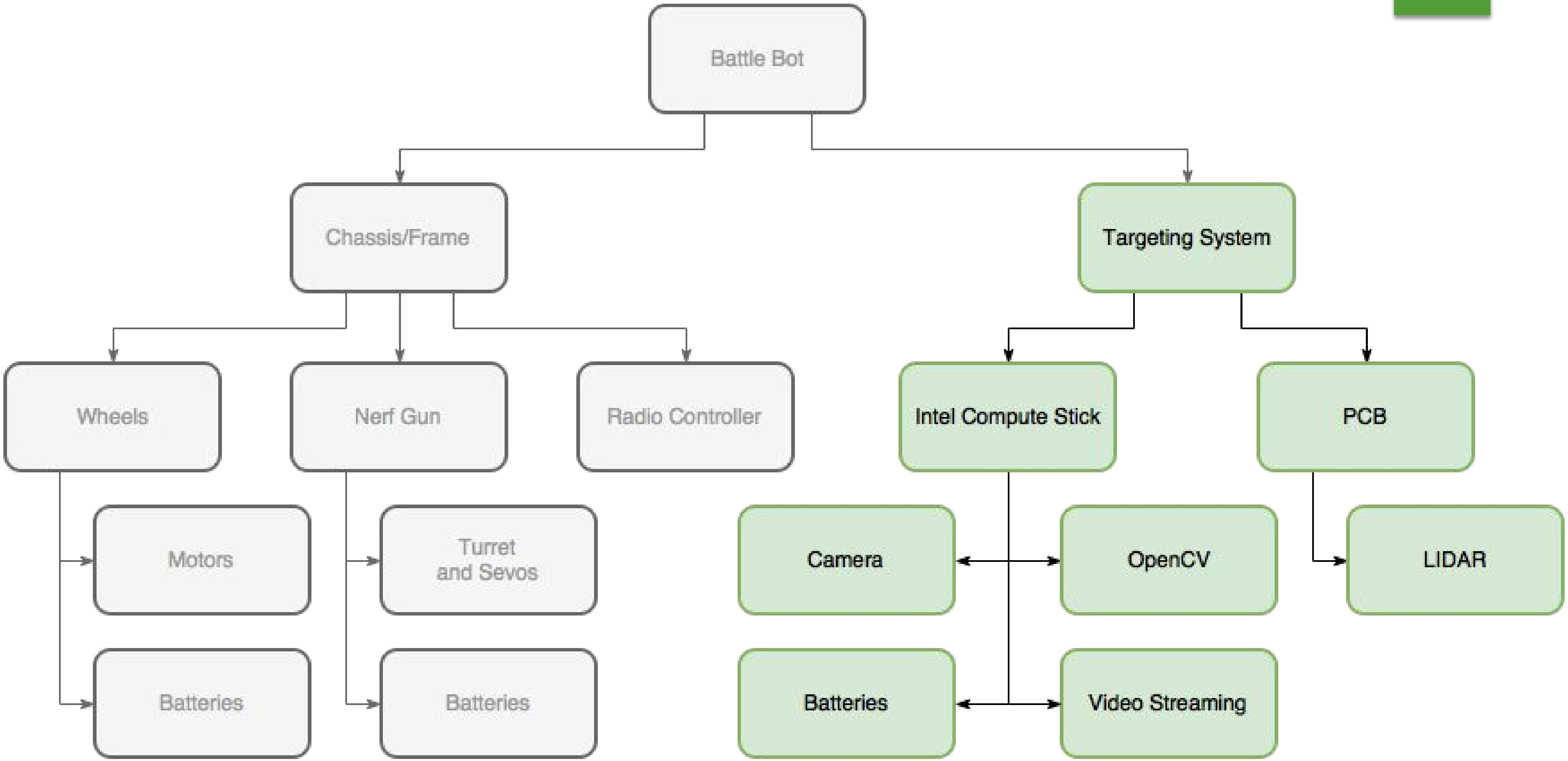
Turret System

- Pan and Tilt system for 2 degrees of motion
  - Metal Gear Pan Servo
  - Giant-scale Tilt Servo



NERF Pan & Tilt system as designed by the M.E. team

Battlebot Subassemblies: Targeting System



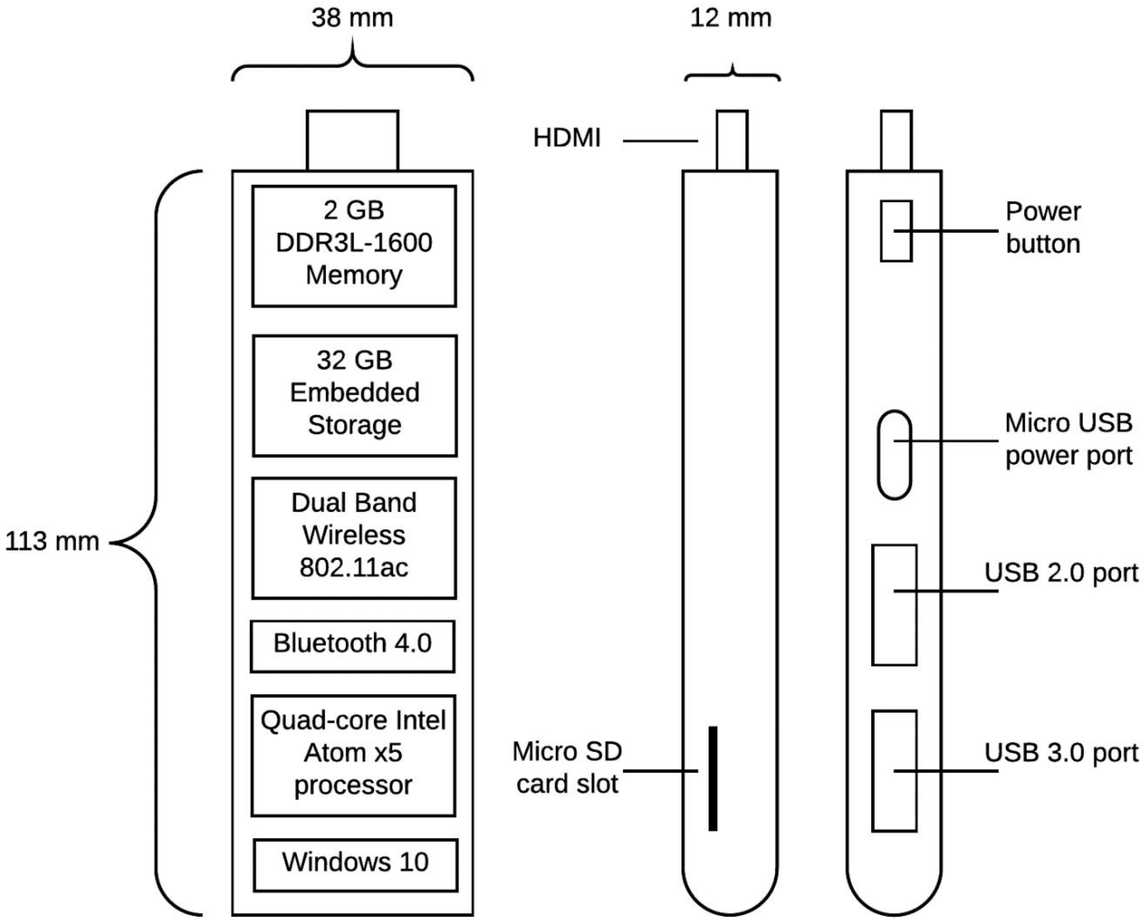
Intel Stick Advantages

- Twice the memory
- Provides Internal Flash Storage
- Over 3X faster CPU

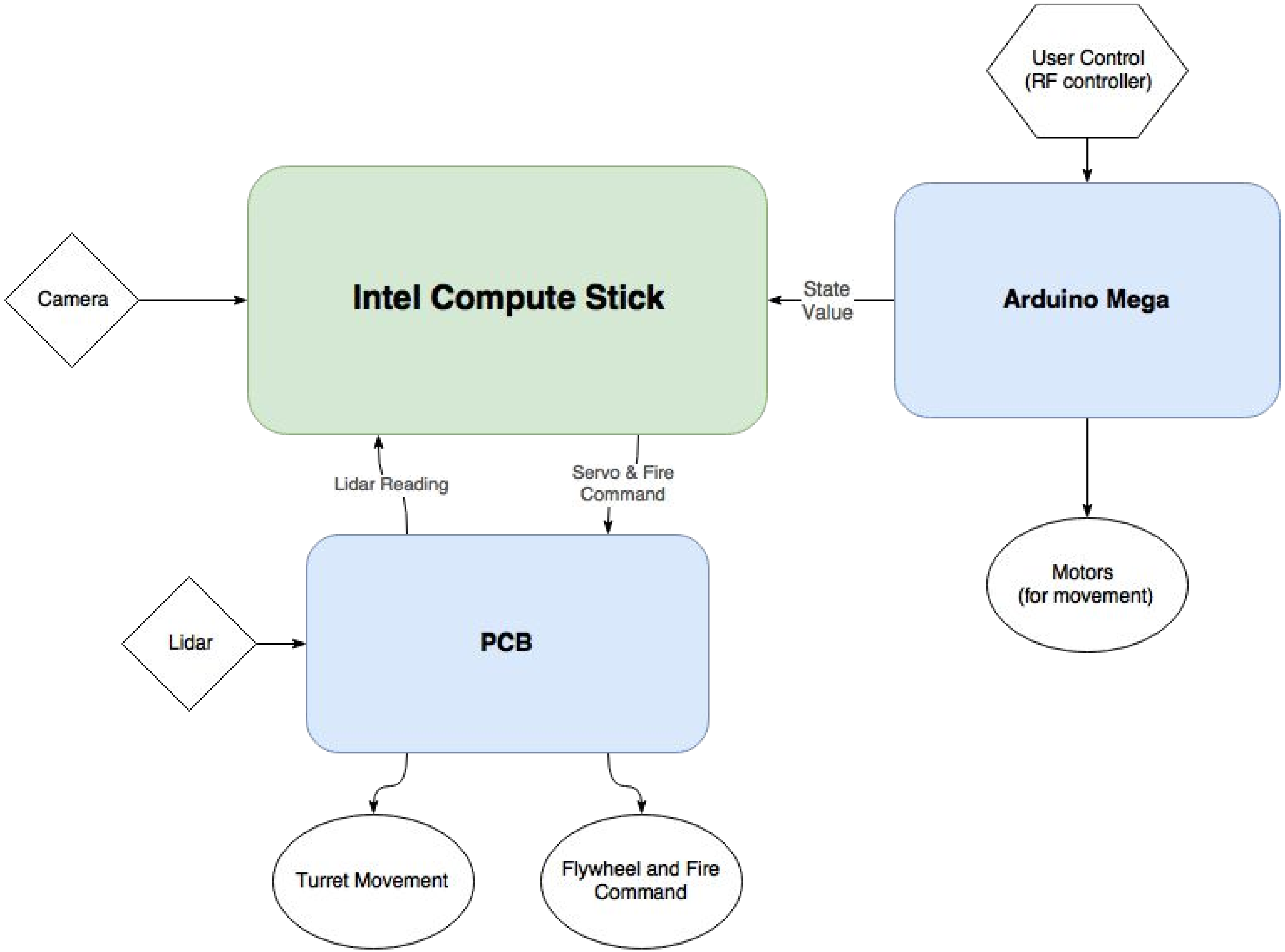
	Intel Stick	Raspberry Pi 3
Clock Speed	1.44 GHz	1.2 GHz
Memory	2 GB	1 GB
Internal Storage	32 GB	N/A
USB Ports	2	4
Power Consumption	10 Watts	4 Watts
Average CPU Benchmark	1697	482
OS	Windows	Raspbian
Dimensions:	113 x 38 x 12 mm	3.4 x 2.3 x 0.8 in
Cost	$130.00	$35

Intel Compute Stick: Algorithm Processing

- Full Windows 10 computer in palm-sized package
- 2 GB of RAM
- Internal Flash Storage
- Expandable Storage
- USB to PCB & Camera
- Fast CPU

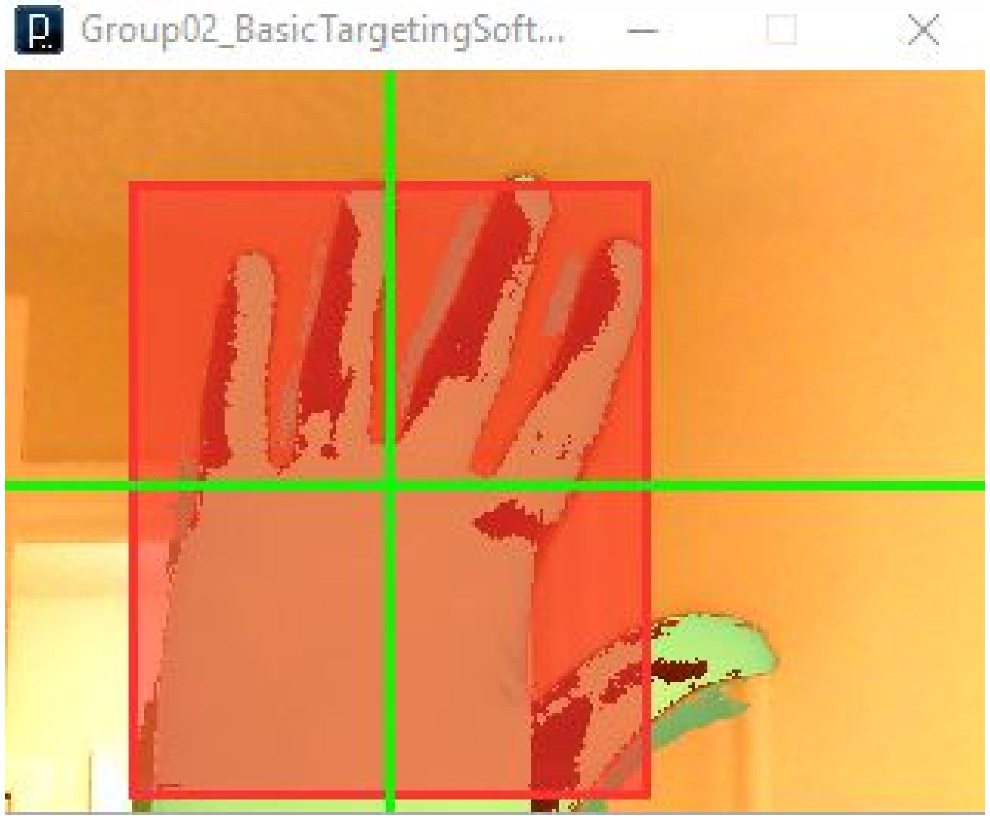


Autonomous Targeting System: Overview



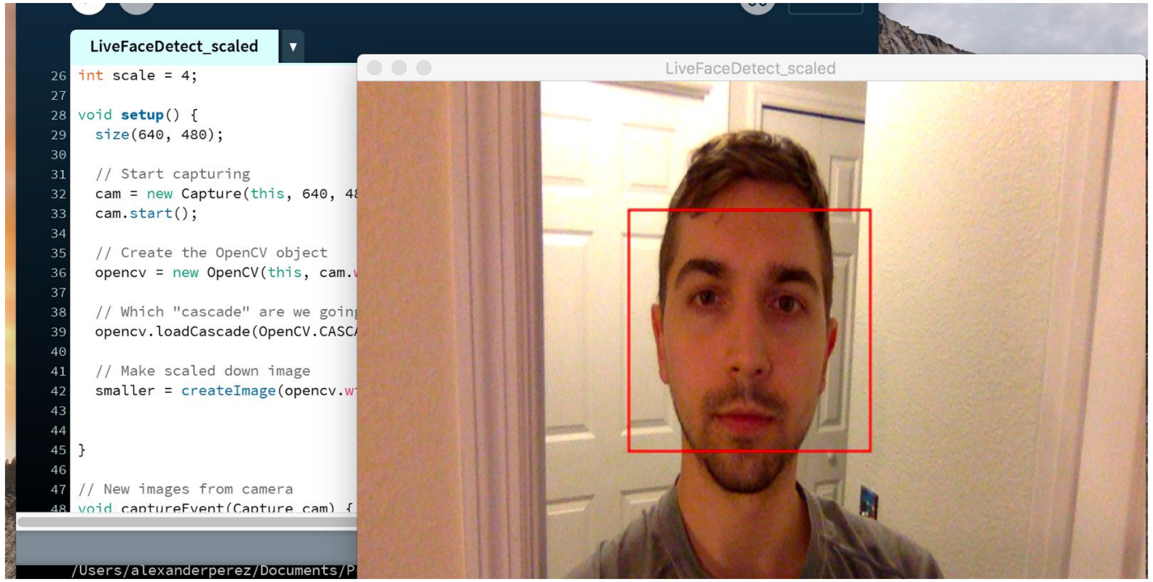
OpenCV Blob Detection

- Open-source computer vision tool
- Useful for detecting colors and movement



Example using Blob Detection to track motion

"Processing"



Example of using imported library to detect faces

- Processing is an object-oriented environment
  - Supports Computer Vision libraries
  - Provides means of implementing:
    - 1) Graphical User Interface
    - 2) Video stream
    - 3) Communication with hardware

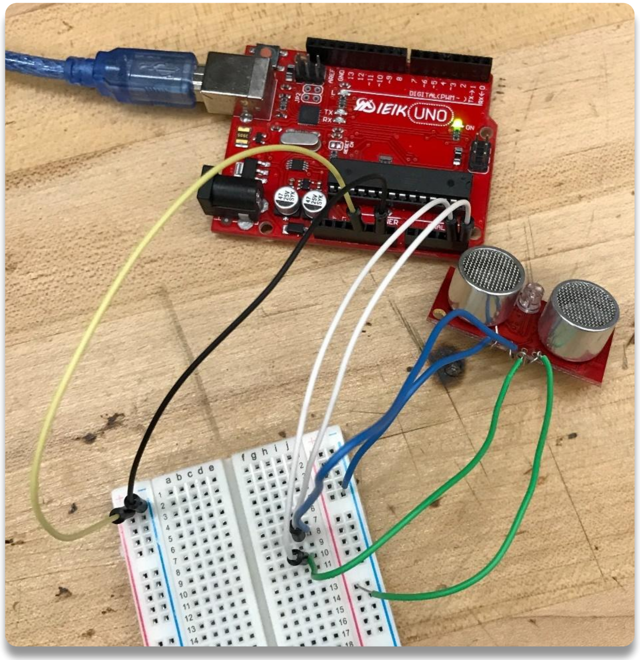
Logitech Camera Analysis: C270 vs C615

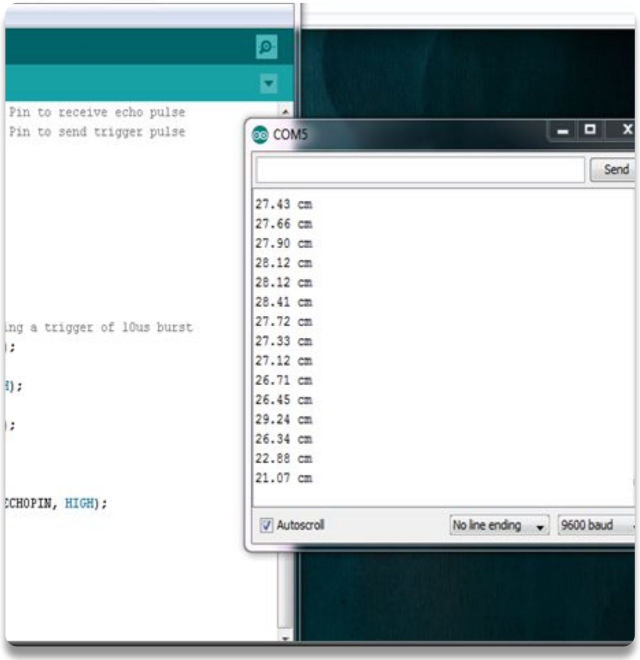
	Logitech C270 ($20)	Logitech C615 ($40)
Photo Quality	3 Megapixels	8 Megapixels
Field of View (FOV)	60°	74°
Optical Resolution (True)	1280 x 960 1.2 MP	True = 2MP, Interpolated = 8MP
Video Capture (16:9 W)	720p	1080p
Frame Rate (max)	30fps @ 640x480	30fps @ 640x480
Focus Type	Fixed Focus	Auto Focus

- Logitech C270 was selected: More affordable and less demanding on the computer due to lower resolution

Ultrasonic Sensor: Fall Analysis

- The sensor was tested to verify functionality
- Results revealed greater difficulty with long range detection than specified in the product documentation





Solution: LIDAR Range Sensor Upgrade

Features	LIDAR Lite V3	SRF08 Ultrasonic
Range	0 – 40 meters	3cm – 6m
Power	5V	5V
Current	130ma	20ma
Optimal Range	>5 meters, <45 meters	6m
Cost	$150	$50

- LIDAR Lite V3 was selected due to increased range

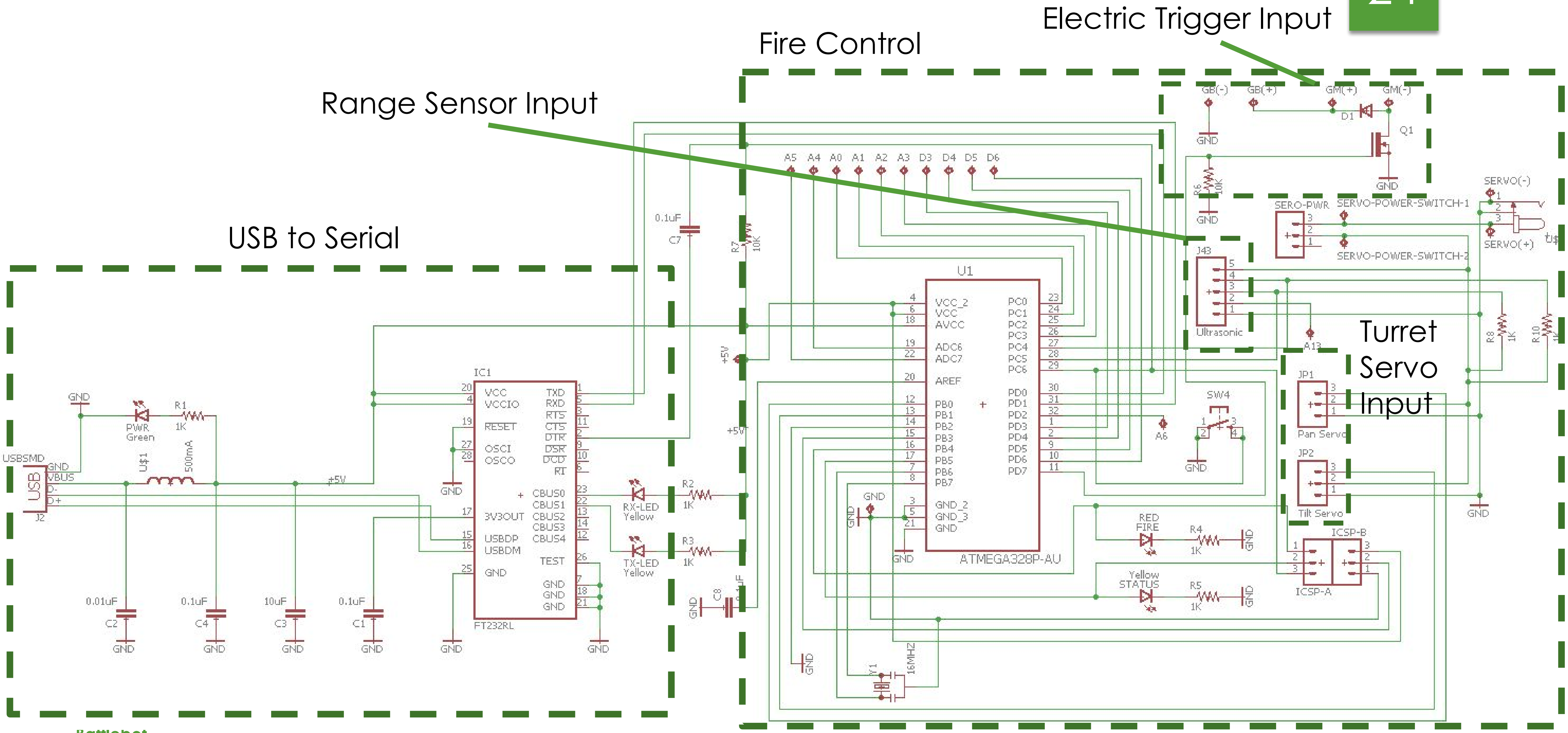
Targeting System Battery Technologies

- Rechargeable Lithium Ion Battery
  - 6700 mah
  - Powers the Intel Stick
- 6V Battery Holder
  - Provides 6V of power to peripherals

ATmega328/P Microcontroller

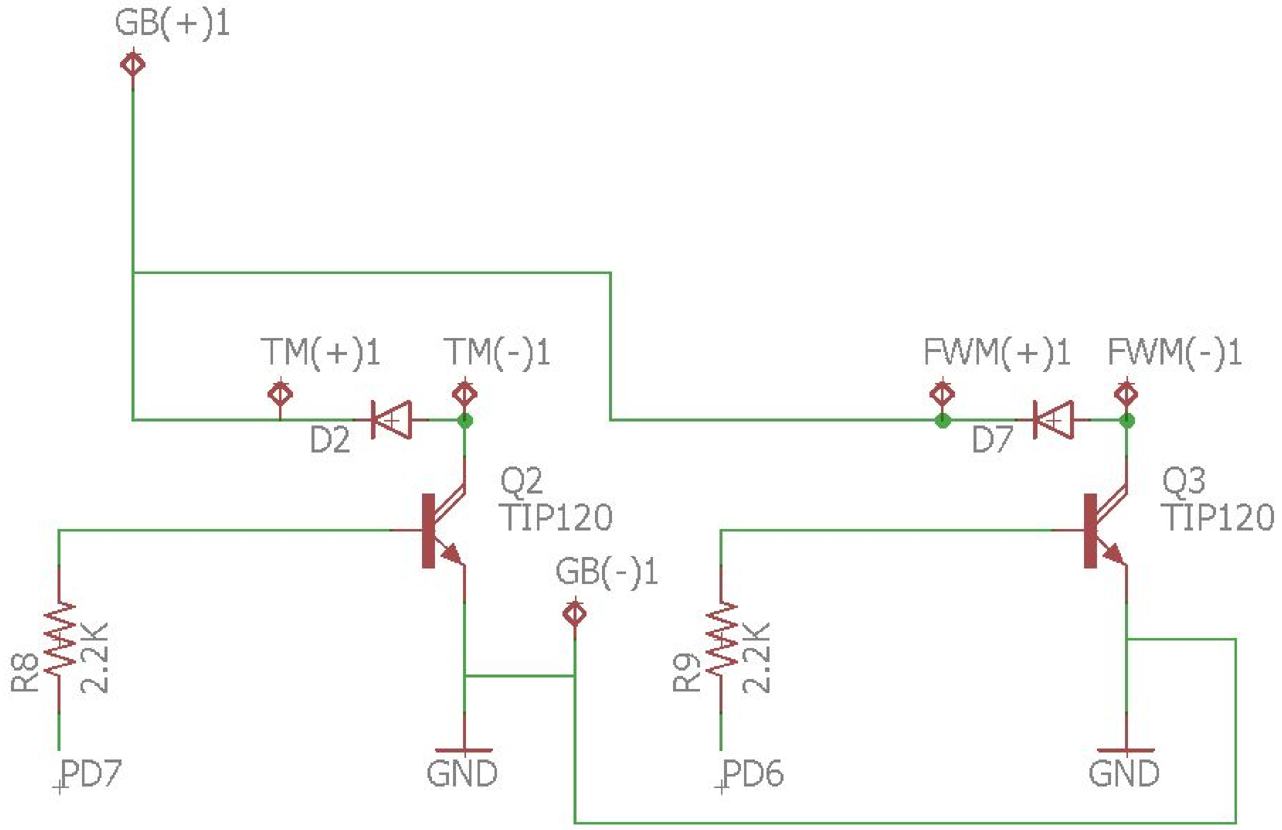
- 32K Flash Storage
- 23 GPIO pins
- Low cost development
  - Arduino Uno (IEIK) $10

Custom Targeting Schematic



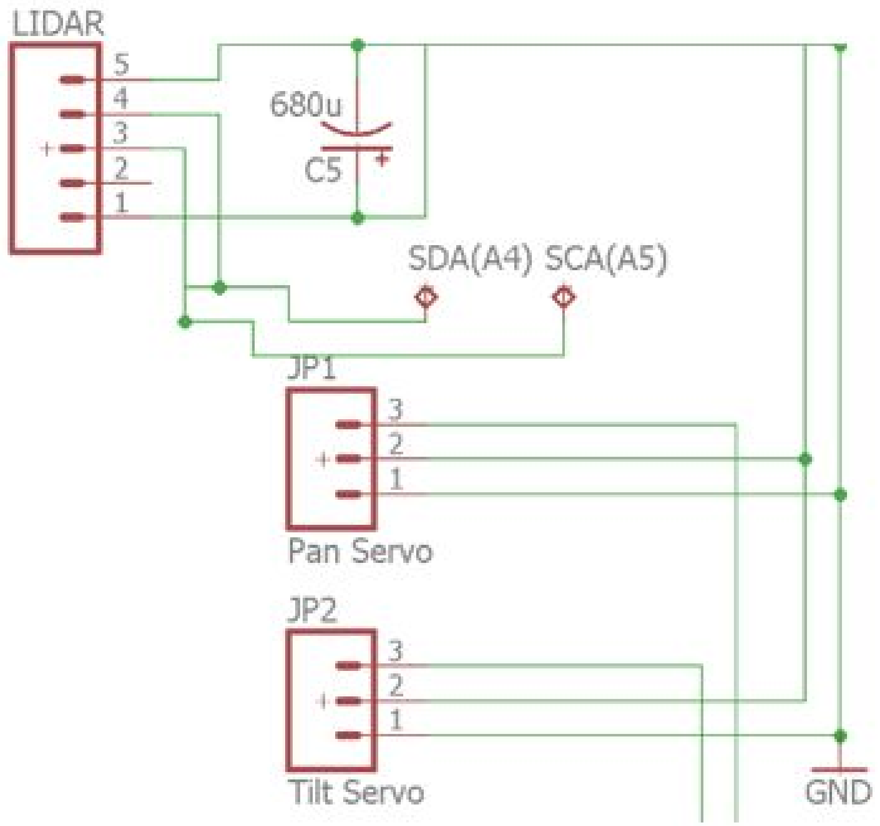
Flywheel and Trigger Motor Control

- Two transistors individually control the NERF flywheel and trigger motor



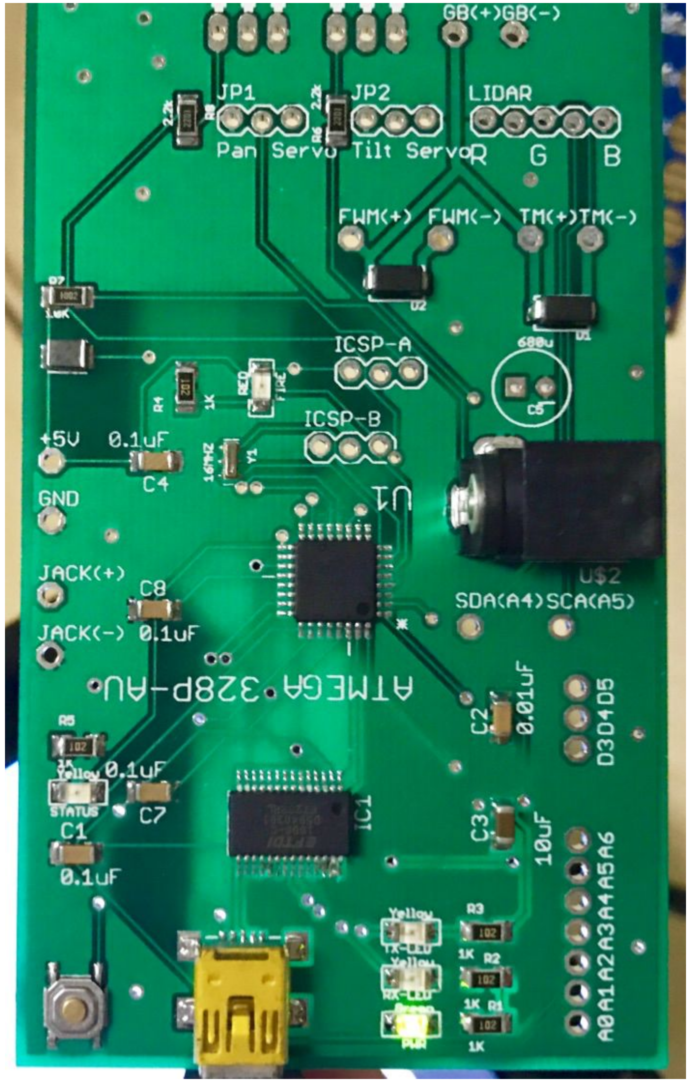
Servo and Sensor Control

- The data outputs of the *pan servo*, *tilt servo*, and *range sensor* are connected to various inputs of the microcontroller
- The microcontroller sends and receives data from these peripherals

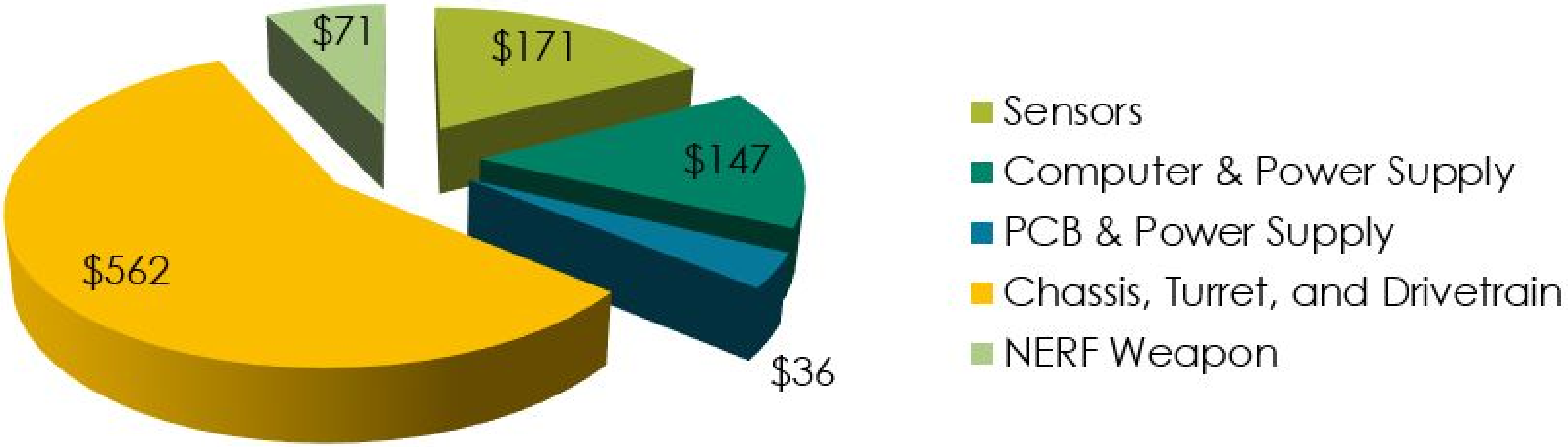


Custom PCB Design

- Two layers
  - Surface mounted components
- Measures approximately 6" x 4"
  - Smaller size to reduce cost
- $2 per board from PCBway
  - Additional component costs
- Issue
  - Design flaws

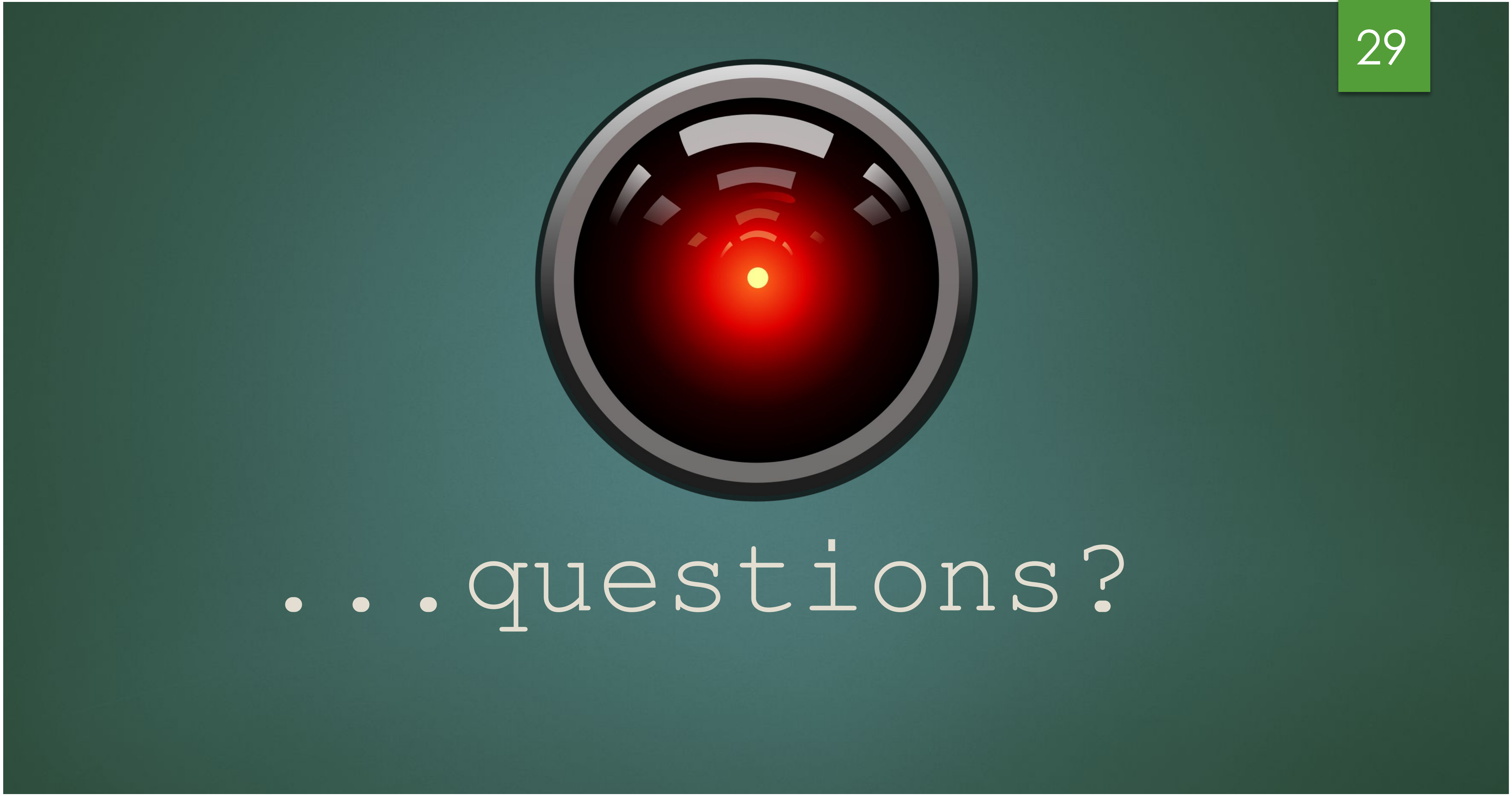


Budget & Finance



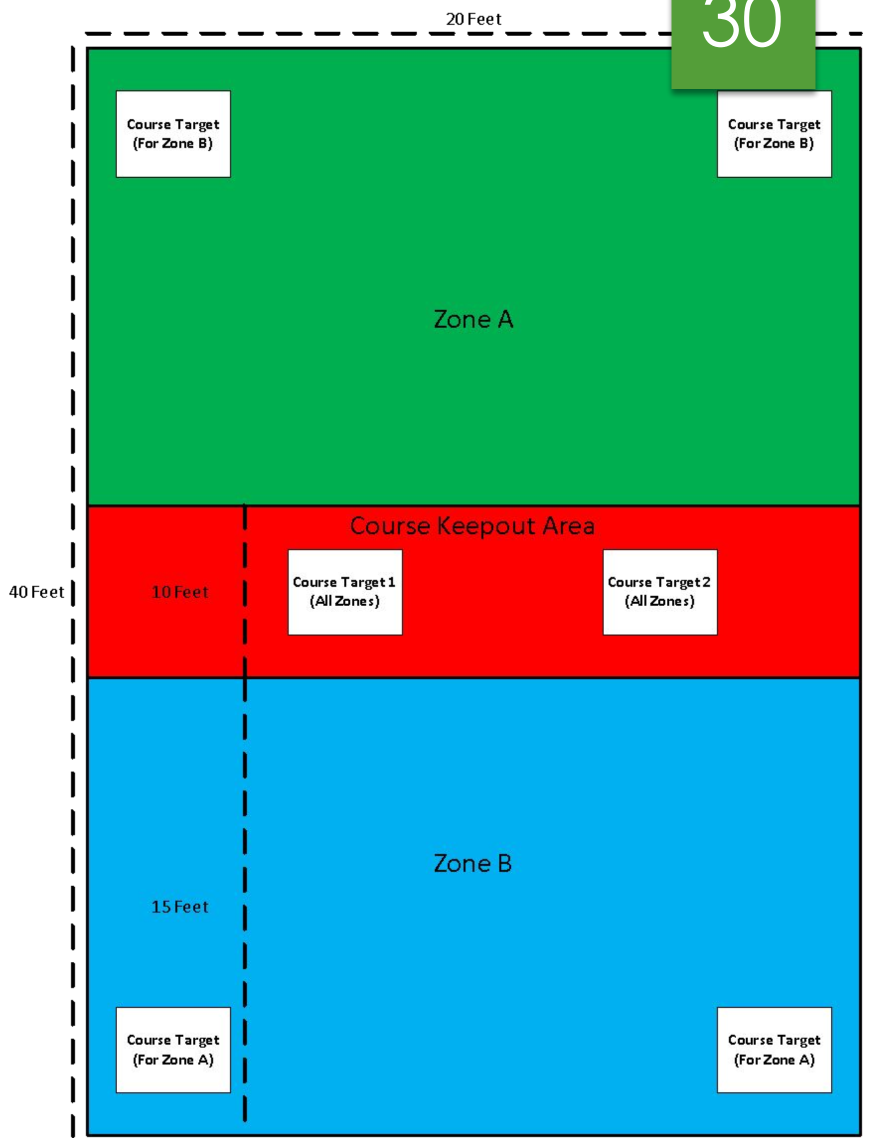
EE/CpE Total: $505

Total: $987

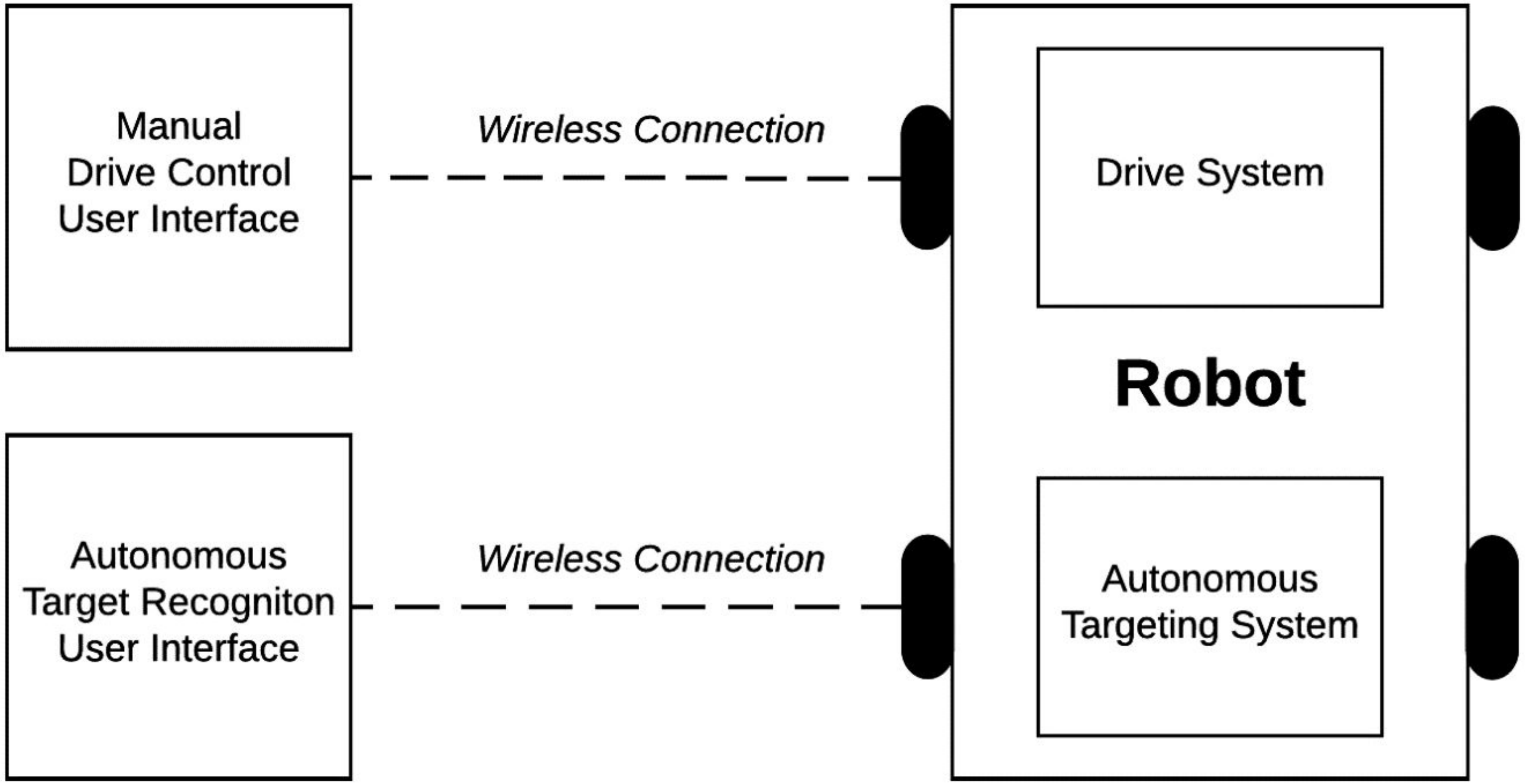

...questions?

Course Description

- 40 ft. x 20 ft.
- 2 primary zones
- 1 keep-out area (10 ft. x 20 ft.)
- 2 course obstacles
- Multiple stationary course targets



Project Top-Level Overview



Lockheed Robot Requirements

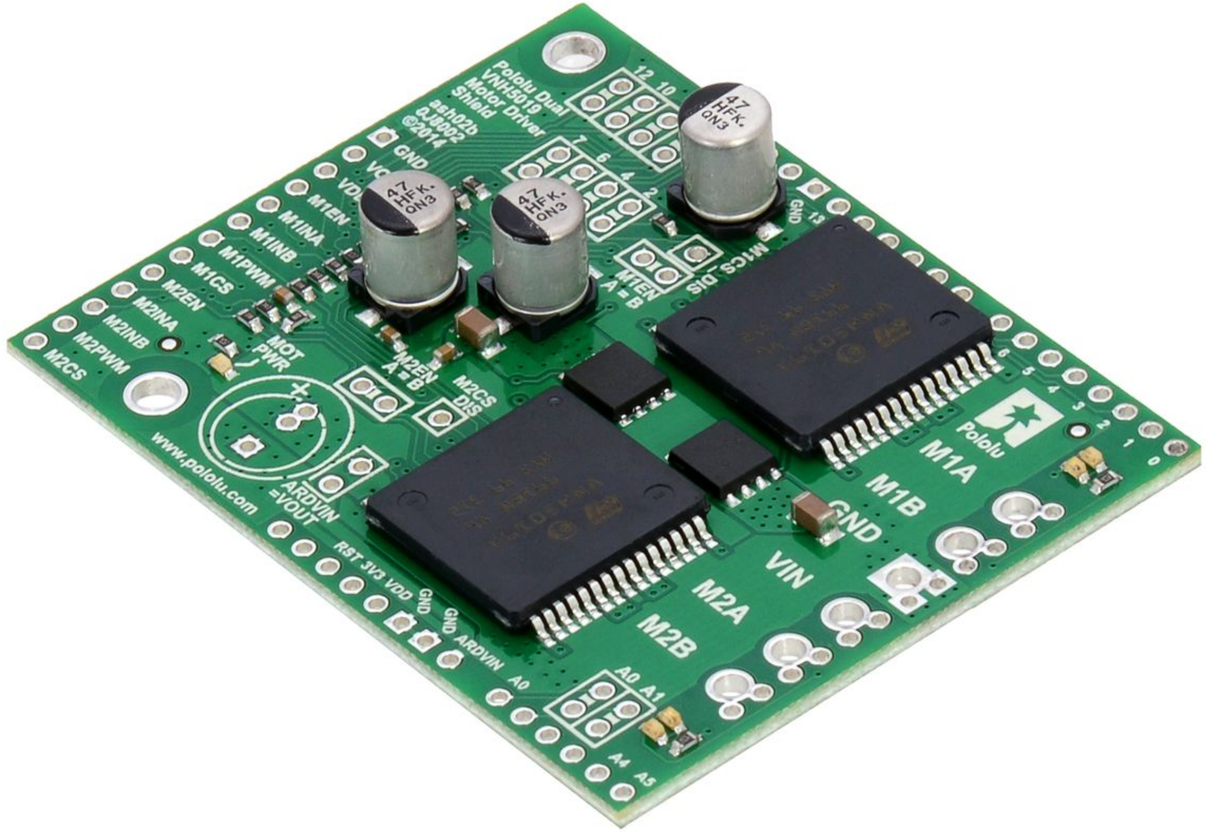
- **Physical Platform**
  - Maximum size of 3ft. x 3ft. x3ft.
- **Budget**
  - Maximum budget of $2k
  - Maximum as-demonstrated cost of $1k
- **Sensors**
  - Minimally use 1 sensor modality
- **Weapon Systems Allowed on Robot**
  - 1 NERF Ball and/or Dart Gun
  - Maximum of 50 shots per weapon
- **Target Detection Automation**
  - Provide video overlays that highlight detected targets
  - Provide wireless video feed

Radio Control

- GoolRC FS-T6 2.4ghz Digital Proportional 6 Channel RC Transmitter and Receiver
- Comes with receiver that wires into Arduino

Motor Driver

- Pololu Dual VNH5019
- 2 Channels
- 12 amps continuous output current per channel



Drivetrain Battery

- 12 volts
- 9 amp-hours
- Provides sufficient power for competition
    - At least 10 minutes when motors are pulling the maximum 5 amps
- 5.6 pounds