COMPUTER CONTROLLED AIMING AND TAGGING SYSTEM

CONCEPT GENERATION

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PROBLEM STATEMENT

- **Real time analysis to test the ability and accuracy of C-CATS program**
- **Old Way:**
- Run dynamic cable testing with cameras and data sensors
- Hours of post processing to evaluate data
- Must start all over if the data is bad

- **Solution:**
- System with ability to see the accuracy immediately
- Real time mark on target to collect data
- Immediate feedback for good run/bad run

- **Project Goal:**
- Tagging system that can be statically tested for accuracy, repeatability, fire latency and safety

HIGH LEVEL SPECIFICATIONS

Specification	Value
Budget	$2000
Maximum Range	25 m
Azimuth Range	360 deg
Elevation Range	90 deg
Angular Velocity	≥ 360 deg/s
Resolution	≤ 1 deg/s
Maximum Weight	50 lb.
Power Source	Honda EU1000i Generator
Motors	Servos
Tagging System	Paintballs

PROJECT SUBSYSTEMS

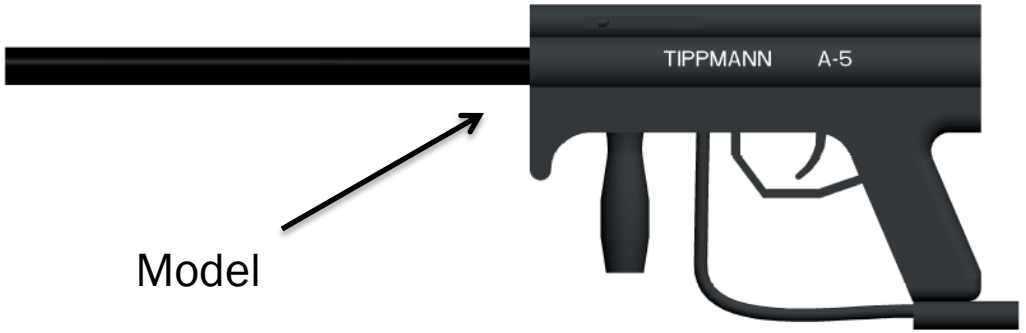
- Mechanism
- Tagging systems
- Motors
- Controllers
- Power system

MECHANISM

- Will incorporate a Double Gimbal assembly
- A gimbal is a pivoted support that allows the rotation of an object about a single axis.
- Double-Gimbal assembly will provide the mechanism with two degrees of freedom
  - Requires two motors

TAGGING SYSTEM

- Tippmann A-5
  - Rugged
  - Relatively Light ~ 3.11 lb
  - “E” Trigger
  - Cost Effective



TAGGING SYSTEM COMPONENTS

Q loader Hooper

•Spring loaded which prevents jamming.
•Can feed against gravity.
•Hose can be adjusted to fit many design specifications

Hammerhead Freedom Fighter Barrel

•Longer barrels for better accuracy and consistency
•Cost effective
•It is the barrels used in the design's specified gun

Nitrogen Pressure System

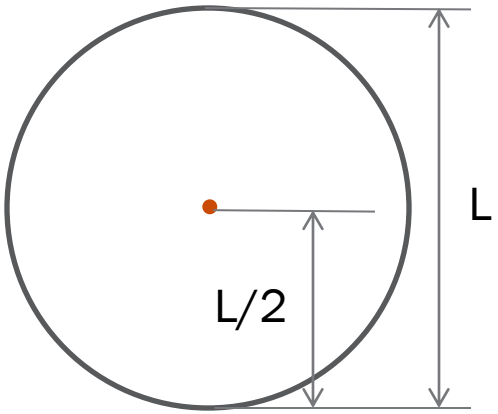
•Maintains stable pressure at different ambient temperatures
•Customer provides Nitrogen at testing facility

Paintballs (Evil versus Golf paintball)

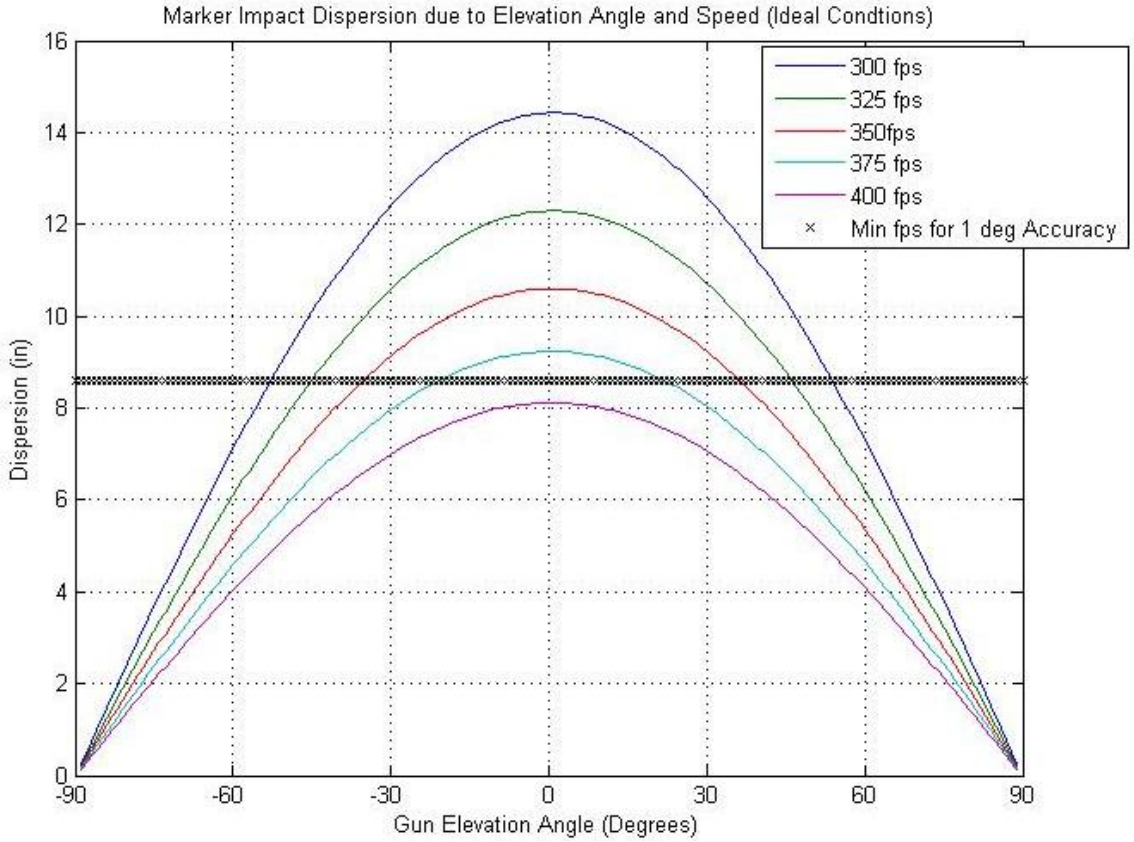
•Golf paintballs are more feasible since the marking can be measure easily
•Evil are more cost effective and are commonly used in standard paintball guns
•Testing is needed

DISPERSION

$$L = \frac{\theta}{2\pi} \cdot circumference$$



$$\frac{L}{2} = 8.59\ in.$$



MODEL

```
VOLUME =   6.4179570e+01   INCH^3
SURFACE AREA =   2.5125709e+02   INCH^2
DENSITY =   4.8500000e-02 POUND / INCH^3
MASS =   3.1127092e+00 POUND

CENTER OF GRAVITY with respect to _COMPLETE_MARKER coordinate frame:
X    Y    Z      1.9949758e-03 -1.0658488e+00  6.7722735e+00   INCH

INERTIA at CENTER OF GRAVITY with respect to _COMPLETE_MARKER coordinate frame:   (POUND * INCH^2)

INERTIA TENSOR:
Ixx Ixy Ixz   1.0180225e+02 -3.8512100e-03 -2.6614187e-02
Iyx Iyy Iyz -3.8512100e-03   9.0239872e+01 -9.0413392e+00
Izx Izy Izz -2.6614187e-02 -9.0413392e+00   1.2179945e+01
```

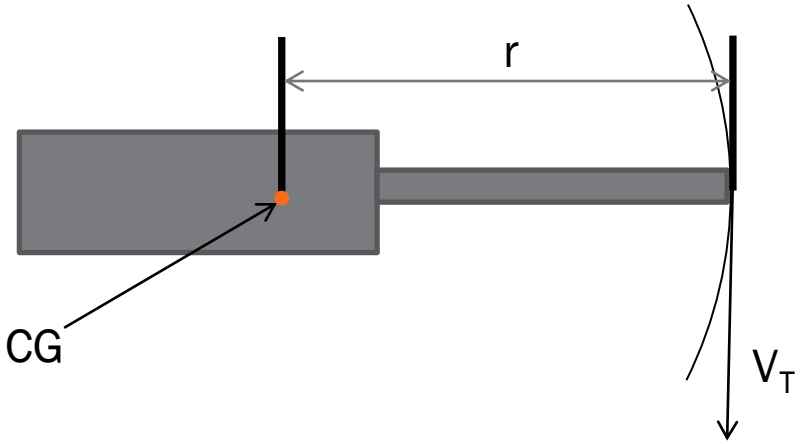
Mass = 3.11 lb

CG = 6.77 in

Ixx = 101.80 lbin^2

Tangential Velocity

- Minimum angular velocity ω = 360 deg/s
- Distance from CG of Marker to end of barrel r = 19 in



Tangential Velocity

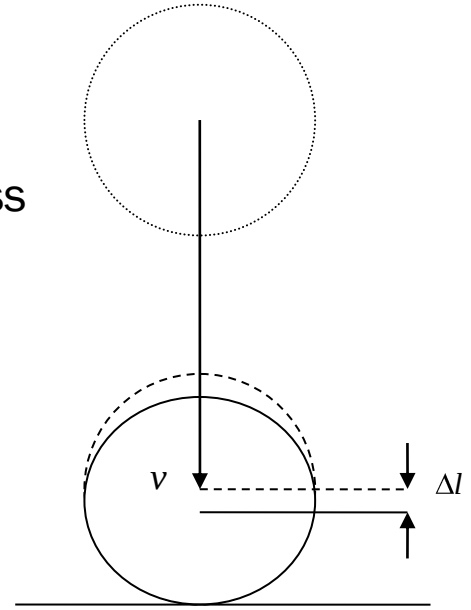
$$V_{Tavg} = \omega * r \qquad V_{Tavg} = 3.032\ m/s$$

ACCELERATION

• Maximum acceleration modeled as ball falling at tangential velocity with 2 inch travel of center mass

$$V_{Tavg} = 3.032\ m/s$$

$$a_{Tmax} = \frac{E_K}{m\Delta l} = \frac{\frac{1}{2}mv^2}{m\Delta l} = \frac{\frac{1}{2}v^2}{\Delta l} = 90.498 m/s^2$$



Angular Acceleration

$$\alpha_{max} = \frac{a_{Tmax}}{r} = 187.522 rad/s^2$$

REQUIRED TORQUE

• Torque = Moment of Inertia * Angular Velocity

$$\tau = I\alpha$$

• Moment of Inertia modeled in Pro/E. Maximum moment around x-axis

• Max Required Torque:

$$\tau_{\max} = I\alpha_{\max} = 5.587\,N \cdot m$$

DESIRED MOTOR CHARACTERISTICS

- High Torque for rapid change of direction
- Feedback capabilities
- Accurate positioning mechanism
- Reasonable cost

MOTORS

- Animatics Motors
- Dynamixel Motors
- Baldor Motors

SMART MOTORS

PRO

- Made by Animatics Coorporation
- High resolution motor
- Integrated motor, controller, amplifier, encoder and communications bus

CON

- Very Expensive

  upwards of $500
- Moderate Torque, Max approx. 5.4Nm

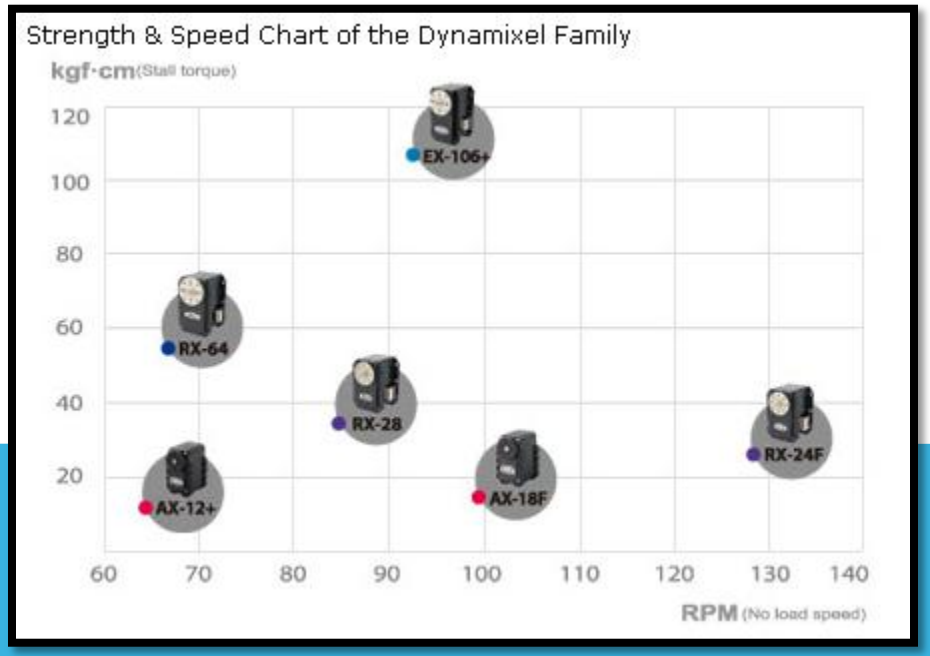
DYNAMIXEL MOTORS

PRO

- Reasonable cost ~$280
- Built in motor controller
- High torque, Max of 6.3 Nm
- Full line of brackets
- Excellent size

CON

- Moderate speed ~382 deg/s
- Decent resolution



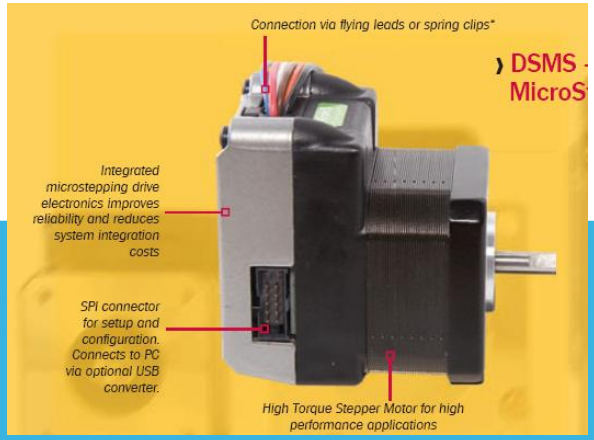
BALDOR MOTORS

PRO

- Built in Motor Controller
- Integrated stepper motor and micro stepping drive
- High Torque ~7.49 Nm

CON

- Unknown price
- Hard to find supplier
- No integrated feedback



RANKING CRITERIA

Rating:

1: Lowest Score

5: Highest Score

		Criteria			
		Cost	**Torque**	**Speed**	**Communication**
Ranking	**1**	>$400	< 2.99 Nm	<360º/s	No Feedback
	2	$300-$399	3 Nm – 3.99 Nm	360 º/s – 369.9º/s	Minimal Feedback
	3	$200-$299	4 NM – 4.99 Nm	370 º/s – 379.9 º/s	Additional Components Needed
	4	$100-$199	5 Nm – 5.99 Nm	380 º/s – 389.9 º/s	Multiple Ports Needed
	5	<$100	> 6 Nm	>390 º/s	Direct Connection

MOTOR DECISION MATRIX

Rating:
1: Lowest Score
5: Highest Score

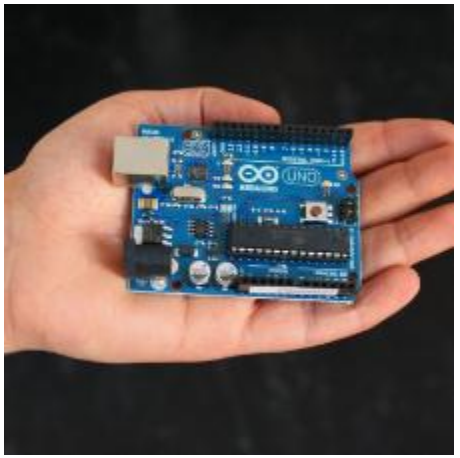
		Concepts					
		Smart Motors		Dynamixel		Baldor	
Specifications	Weight	Rating	Score	Rating	Score	Rating	Score
Cost	35%	1	0.35	3	1.05	1	0.35
Torque	25%	4	1	5	1.25	5	1.25
Speed	25%	3	0.75	4	0.75	3	0.75
Feedback	15%	4	0.6	5	0.75	1	0.15
Total	100%		2.7		3.8		2.5

DYNAMIXEL MOTOR

- Dynamixel Rx-64
- Torque: 64 kg-cm (6.276Nm)
- Speed: 0.157sec/60°
  (382 °/s)
- 18 V
- Resolution 0.29 deg

CONTROLLERS

- Arduino UNO
  - ATmega328 microcontroller (14 I/O pins)
  - 16 MHz clock speed.
  - 32 KB flash memory.
  - Slot included for XBEE wireless radio.



- ArbotiX RoboController
  - ATMEGA644p microcontroller (32 I/O pins)
  - 16 MHz clock speed
  - 64 KB flash memory.
  - 2 serial ports, 1 dedicated to Bioloid servo controller, the other to the XBEE wireless radio.
  - Dual 1A motor drivers, with combined motor/encoder header.
  - BioloidController library (open source) available for use with the Arduino IDE for the AX-12 servos.

RANKING CRITERIA

Rating:
1: Lowest Score
5: Highest Score

		Criteria					
		Clock Speed	**Wireless Capability**	**Micro-controller**	**Programming Environment**	**"Plug and Play" Capability**	**Ports**
Rank	**1**	<500 kHz	None	8 I/O pins	Assembly Language	Need to order additional parts	1
	2	501kHz – 999kHz	1 ft – 99 ft	16 I/O pins	N/A	N/A	2
	3	1 MHz – 4.99 MHz	100 ft – 199 ft	32 I/O pins	N/A	Some additional Programming needed to control motors	3
	4	5 MHz – 9.99 MHz	200 ft – 299 ft	64 I/O pins	Arduino IDE	N/A	4
	5	10+ MHz	300+ ft	128+ I/O pins	Labview	Ready to use	5+

MOTOR CONTROLLER DECISION MATRIX

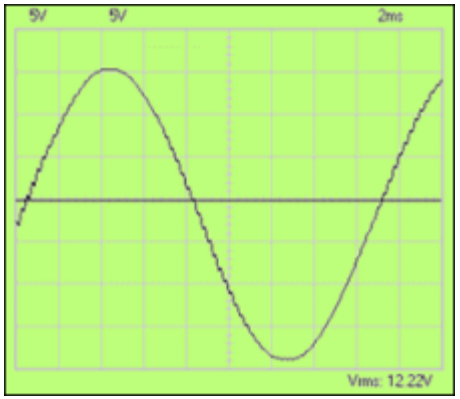
Rating:
1: Lowest Score
5: Highest Score

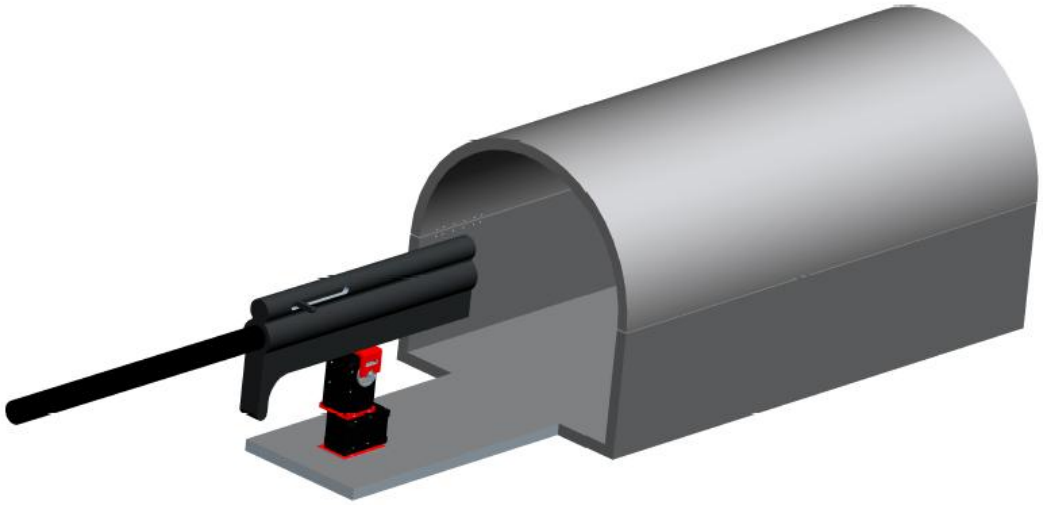
		Concepts			
		Arduino		ArbotiX Robocontroller	
Specifications	Weight	Rating	Score	Rating	Score
Clock Speed	0.125	5	0.625	5	0.625
Wireless Capability	0.050	5	0.250	5	0.250
Microcontroller Type	0.125	2	0.250	3	0.375
Programming Environment	0.125	5	0.625	4	0.500
“Plug and Play” Capability	0.400	3	1.200	5	2.000
Multiple ports included	0.050	1	0.050	3	0.150
Total	1.000		3.000		3.900

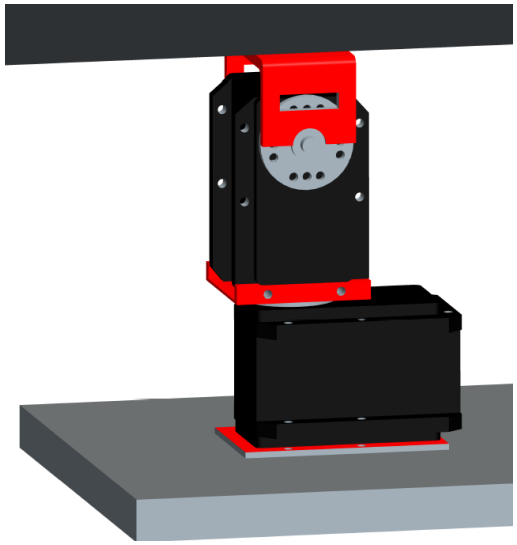
POWER SUPPLY

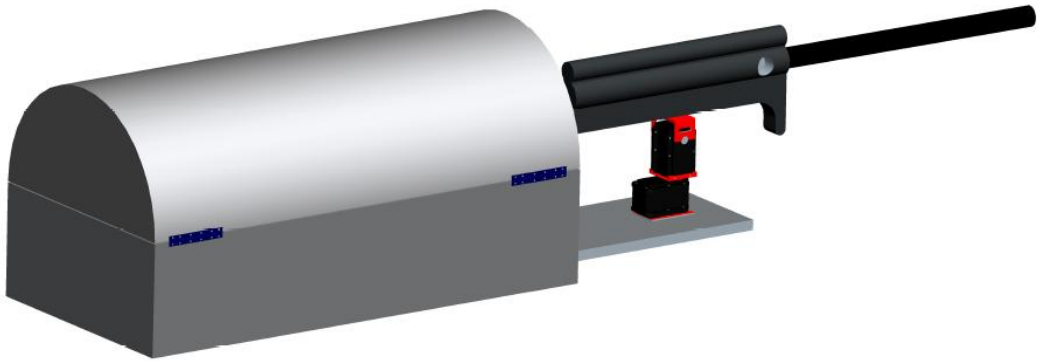
Power Generators

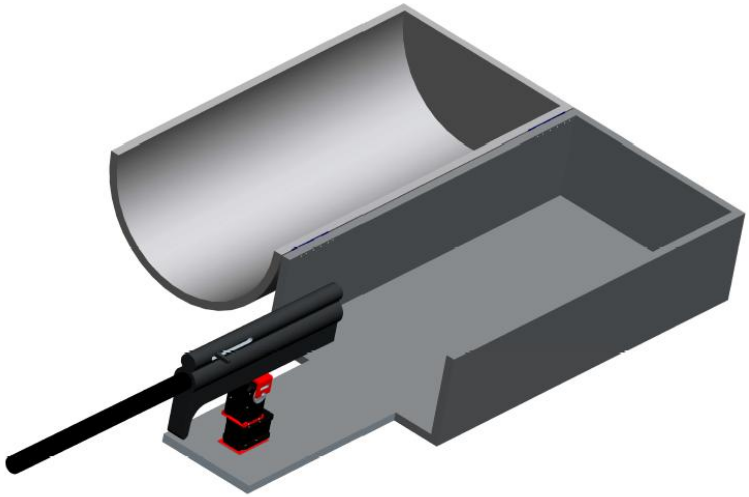
- Allows for testing to be done in an outside environment
- Customer prefers power generator
- Allow for multiple testing without any down time
- Uses existing inverter to allow for varying voltage output
- Operating time is 8+ hr





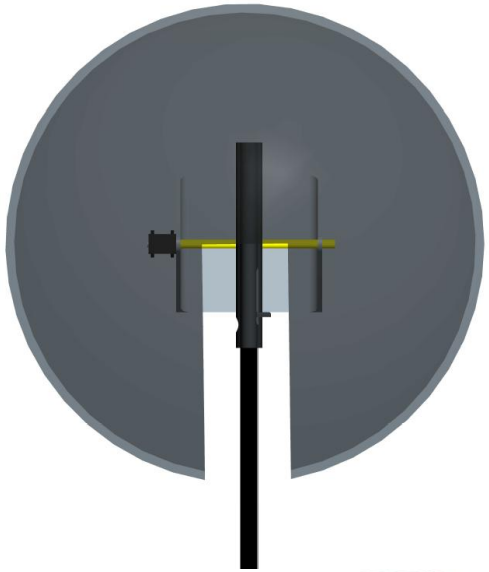


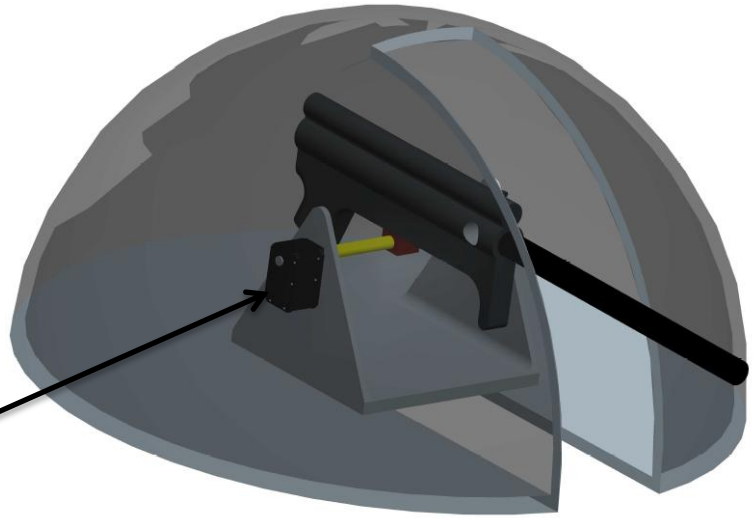


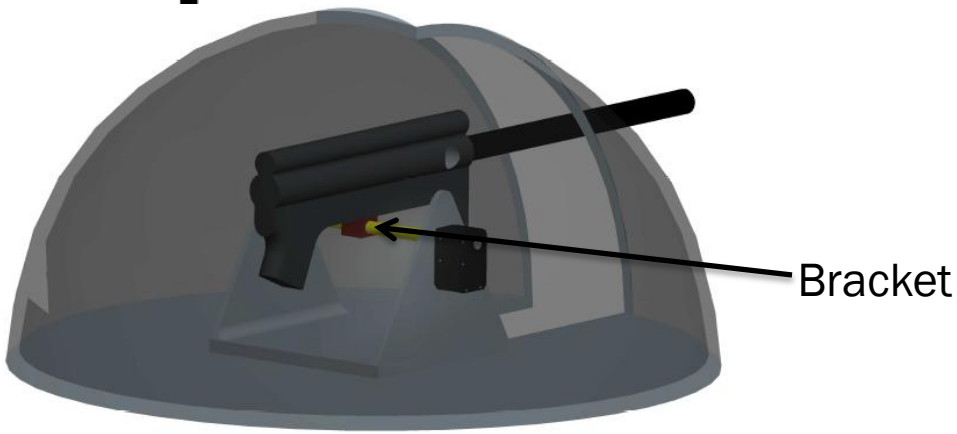


CONCEPT 1

- Houses all electronics and gear inside box
- Mounts gun on motors which is mounted on plate
- PROS:
  - All components are enclosed in box
  - Motors are moving gun directly
- CONS:
  - Wires and hoses could get tangled when operating and restrict movement







CONCEPT 2

- Houses all electronics and gear inside dome
- Mounts gun on bracket which is mounted on rod
- Uses motor to control gun elevation
- PROS:
  - Entire system is enclosed so electronics and hoses wont get tangled when spinning
- CONS:
  - Not streamlined and not easily attached to cable for future testing

FUTURE PLANS

- Discuss specifications and compare our findings with the Robotics and Paintball club
- Finalize Design (Dec)
- Have Go/No Go checkpoint with customer (Weekly conference call)
- Order parts as soon as possible

REFERENCES

http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4566030

http://www.rap4.com/rap4-golf-paintball-training-projectiles-a-258.html

http://www.qloader.com/a5.html

http://www.hammerheadpaintball.com/index.php?option=com_content&task=view&id=8&Itemid=8

http://www.trossenrobotics.com/c/robotis-dynamixel-robot-servos.aspx

QUESTIONS?