

Computer Controlled Aiming and Tagging System (C-CATS)

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Background

- Real time analysis to test the ability and accuracy of fuze sensor program
- Current Setup:
 - Run dynamic cable testing with cameras and data sensors
 - Hours of post processing to evaluate data
 - Cannot immediately determine good/bad test

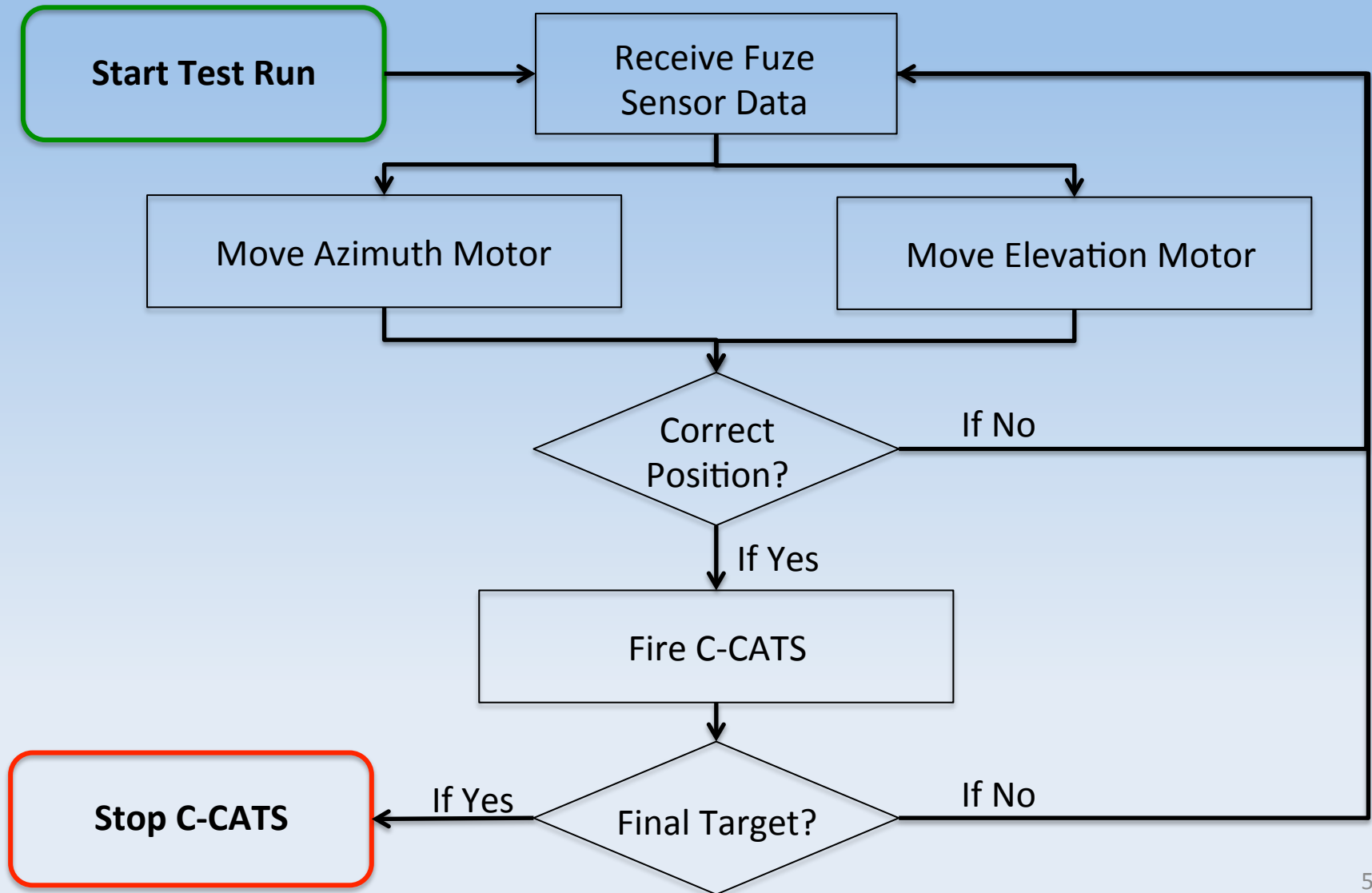
Problem Statement

- 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

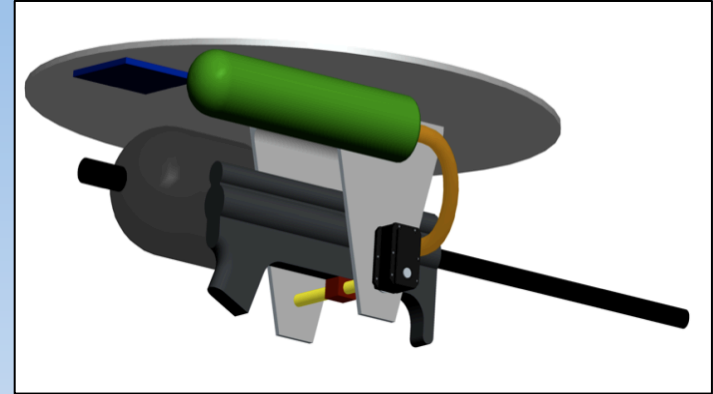
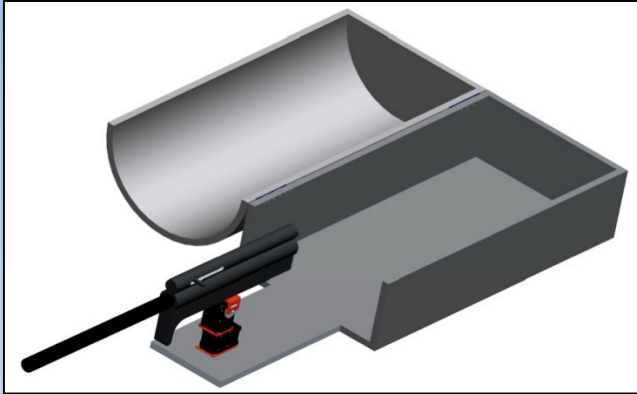
High Level Specifications

Specification	Value
Maximum Range	82 ft.
Azimuth Range	360 deg
Elevation Range	90 deg
Angular Velocity	≥ 360 deg/s
Resolution	≤ 1 deg/s
Maximum Weight	50 lbs.
Power Source	Standard Wall Plug
Motors	Servos
Tagging System	Paintballs
Budget	\$2000

Functional Diagram



Design Concepts



- Low torque on motors
- Constricts wiring when moving
- Weighs approximately 50 lbs.

- Average weight (~30 lbs.)
- All components move together
- Large azimuth motor torque (57.4 ft-lbf)

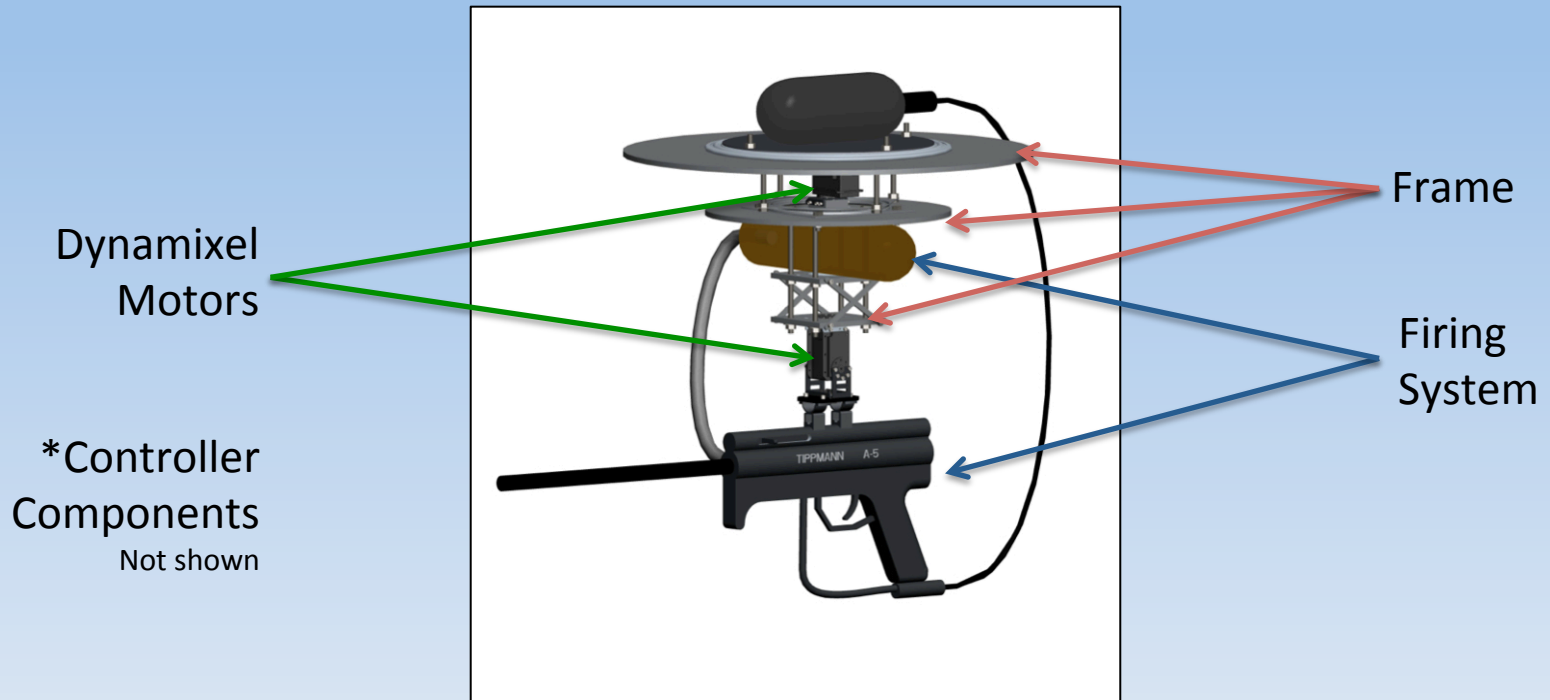
Design Decision Matrix

		Concepts			
		Concept 1		Concept 2	
Specifications	Weight	Rating	Score	Rating	Score
System Weight	30.0%	2	0.60	4	1.20
Elevation Torque	25.0%	4	1.00	4	1.00
Azimuth Torque	25.0%	4	1.00	1	0.25
Area for Components	20.0%	2	0.40	3	0.60
Total	100.0%		3.00		3.05

Optimization

- Both scored very close in decision matrix
- Both exhibit significant cons
- Best from concept 1:
 - Best setup for motor torque values
- Best from concept 2:
 - Most maneuverability
 - Maximum space for component mounts

Final Design



Final Design Properties:	
Discs	Aluminum 6061
Elevation Torque	3.65 ft-lbf
Azimuth Torque	7.53 ft-lbf
System Weight	30 lbs.

Motors

Motors

- Two different Dynamixel servo motors will be integrated into our system.
 - RX-64
 - Responsible for elevation position.
 - EX-106+
 - Responsible for azimuth position.
- Both will be linked in series by a daisy chain bridge from the Arbotix controller to power and control.



Motors

Dynamixel RX-64

- Torque: 64 kg-cm
(4.63 ft-lbf)
- Speed: 0.157sec/60°
(382 °/s)
- 18 V
- Resolution 0.29 deg
- 300 deg operating angle



<http://www.trossenrobotics.com/dynamixel-rx-64-robot-actuator.aspx>

Motors

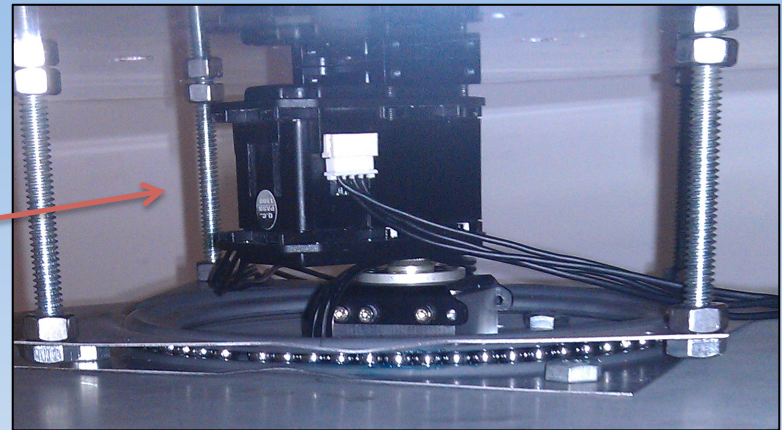
Dynamixel EX-106+

- Torque: 106 kg-cm
(7.67 ft-lbf)
- Speed: 0.143sec/60°
(420 °/s)
- 18 V
- Resolution 0.06 deg
- 251 deg operating angle



<http://www.trossenrobotics.com/dynamixel-ex-106-robot-actuator.aspx>

Motors



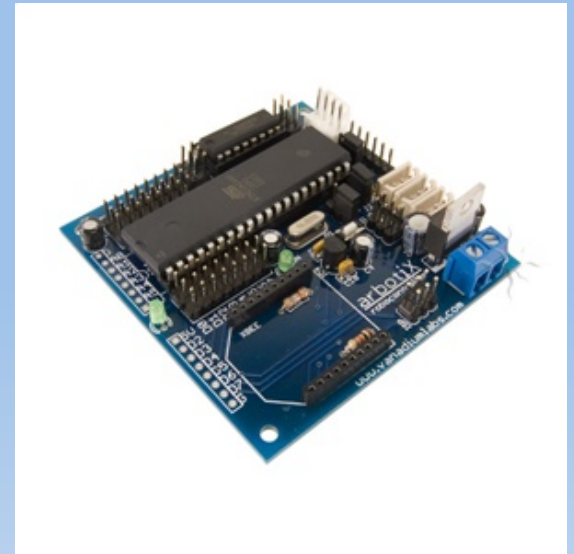
Motor Issues

- EX-106+ motors run on a different baud rate
 - Does not allow RX and EX motors to run in same chain
 - Need to reprogram EX baud rate
 - Did not have necessary equipment
- Run both azimuth and elevation on RX-64
 - Azimuth speed was not compromised
 - Not as much torque

Controller & Components

Controller

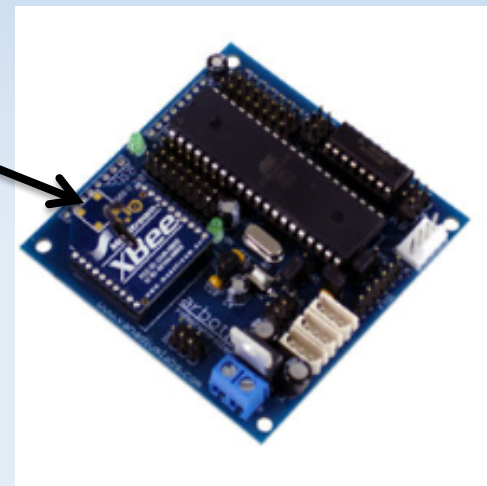
- ArbotiX RoboController
 - ATMEGA644p microcontroller.
 - 16 MHz clock speed for accuracy.
 - 2 serial ports
 - 1 dedicated to Bioloid servo controller
 - the other to the XBEE wireless radio.
 - BioloidController library (open source)
 - Available for use with the Arduino IDE for Dynamixel motors.



<http://www.trossenrobotics.com/p/arbotix-robot-controller.aspx>

Xbee Wireless Radio

- An Xbee 1 mW radio transmitter will be used to remotely communicate to our system.
- The user will be able to input commands from a distance of 100 meters.
- The XBee transmitter will be mounted on the USB module and connected to a laptop via USB cable and the receiver will be placed on the motor controller.



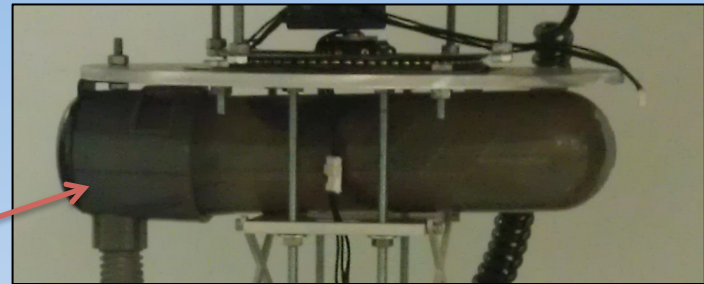
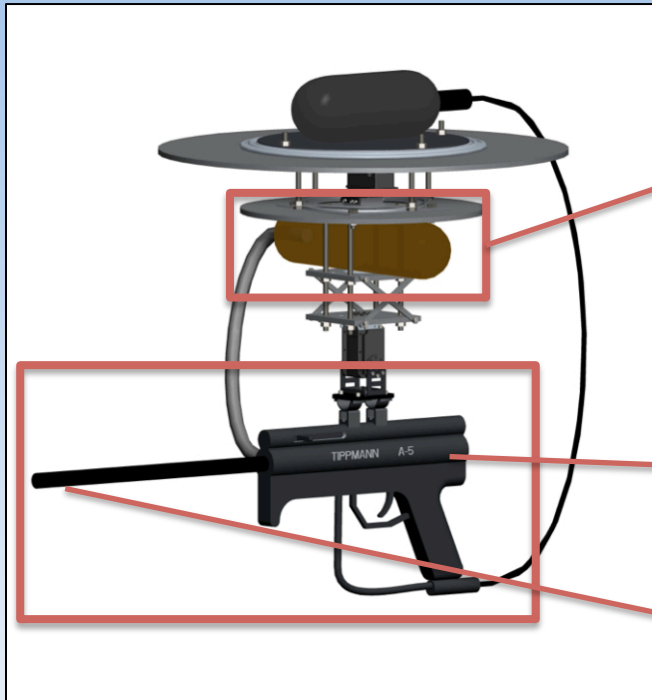
System Programming

- Arduino IDE
 - Used for the embedded program uploaded into the Arbotix.
 - Version 0018 used to allow function calls from Bioloid Library

- Python
 - Used for the User Interface (UI) to control the marker.
 - Required to control the Arbotix remotely.
 - Both position selection and target sequence and firing controlled from the UI.

Firing System

Firing System



Firing System

Tippmann A5

- Pros
 - Light Weight system
 - Reliable, easy to use internal firing mechanism
- Cons
 - Does not have built in regulator

Paintballs

- Tournament Evil
 - Thick, heavy paint
 - Very consistent ball shape
- Rap4 G.O.L.F.
 - Dimpled Shell
 - Chalk instead of paint

Firing System

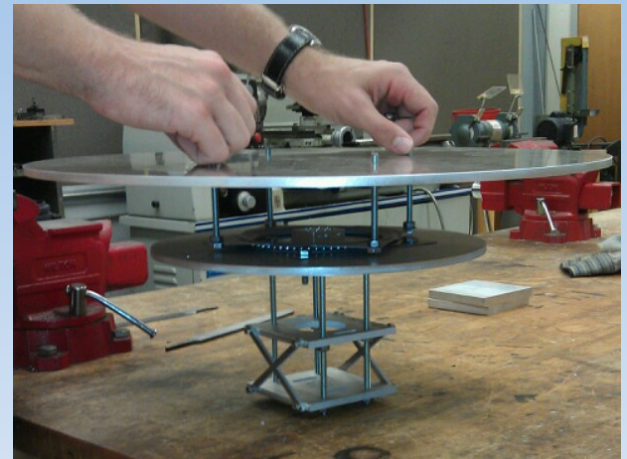
- Hammerhead Battle Stixx Barrel(14" and 16")
 - Internal barrel rifling
 - Fins to match ball gauge size
 - Muzzle air feedback system
- Stock Tippmann A5 Barrel
 - 10" length
 - Unrifled



Frame Design

Frame Design

- Need durable materials for outdoor environment
- Light materials for weight limit
- Aluminum 6061 for all plates
 - Easy machined
 - Durable
 - Relatively light weight
- (Stainless) Steel for all assembly materials
 - Tough, will keep a rigid frame
 - Does not interact adversely with Al 6061 or weather



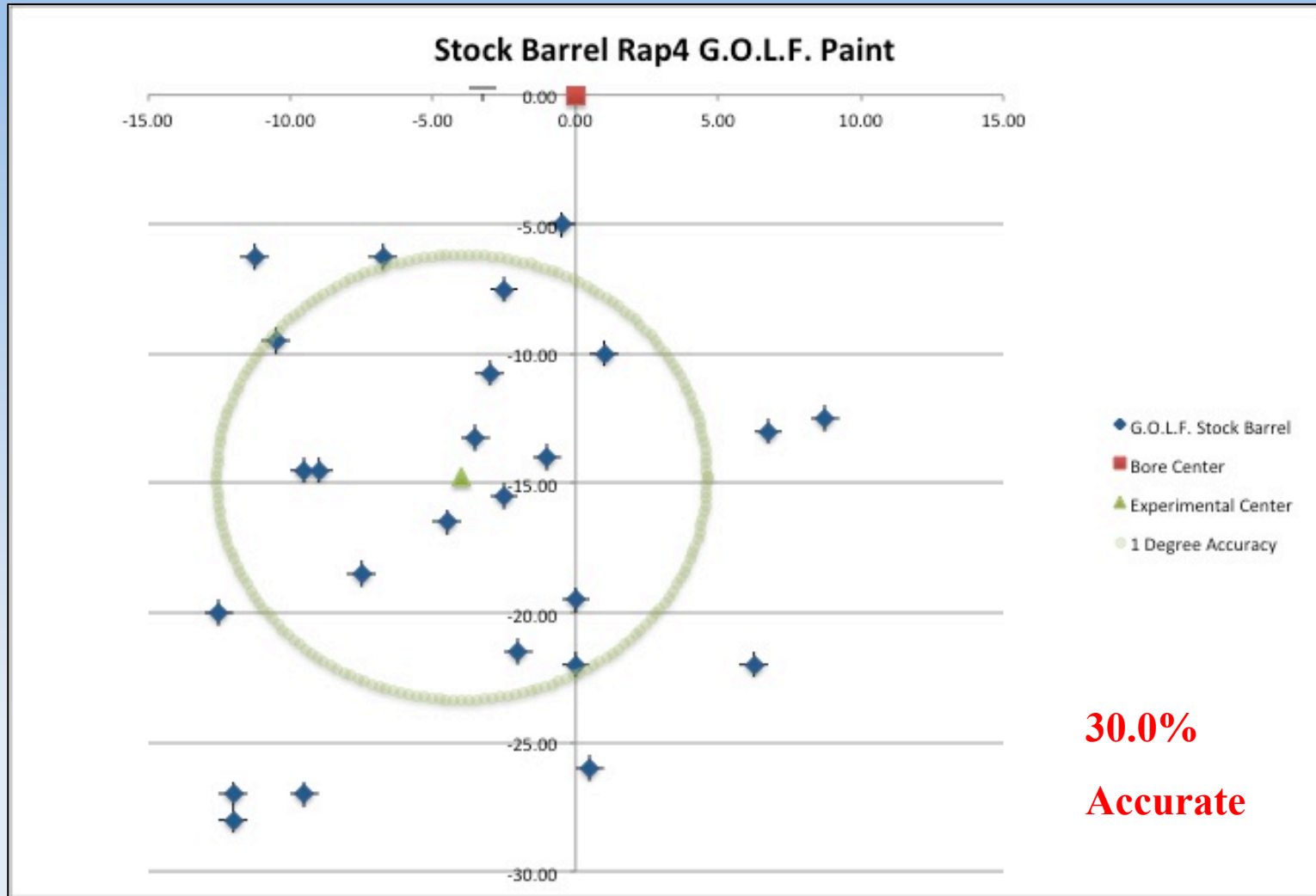
Accuracy Testing

- Distance: 82 feet
- Constant Velocity

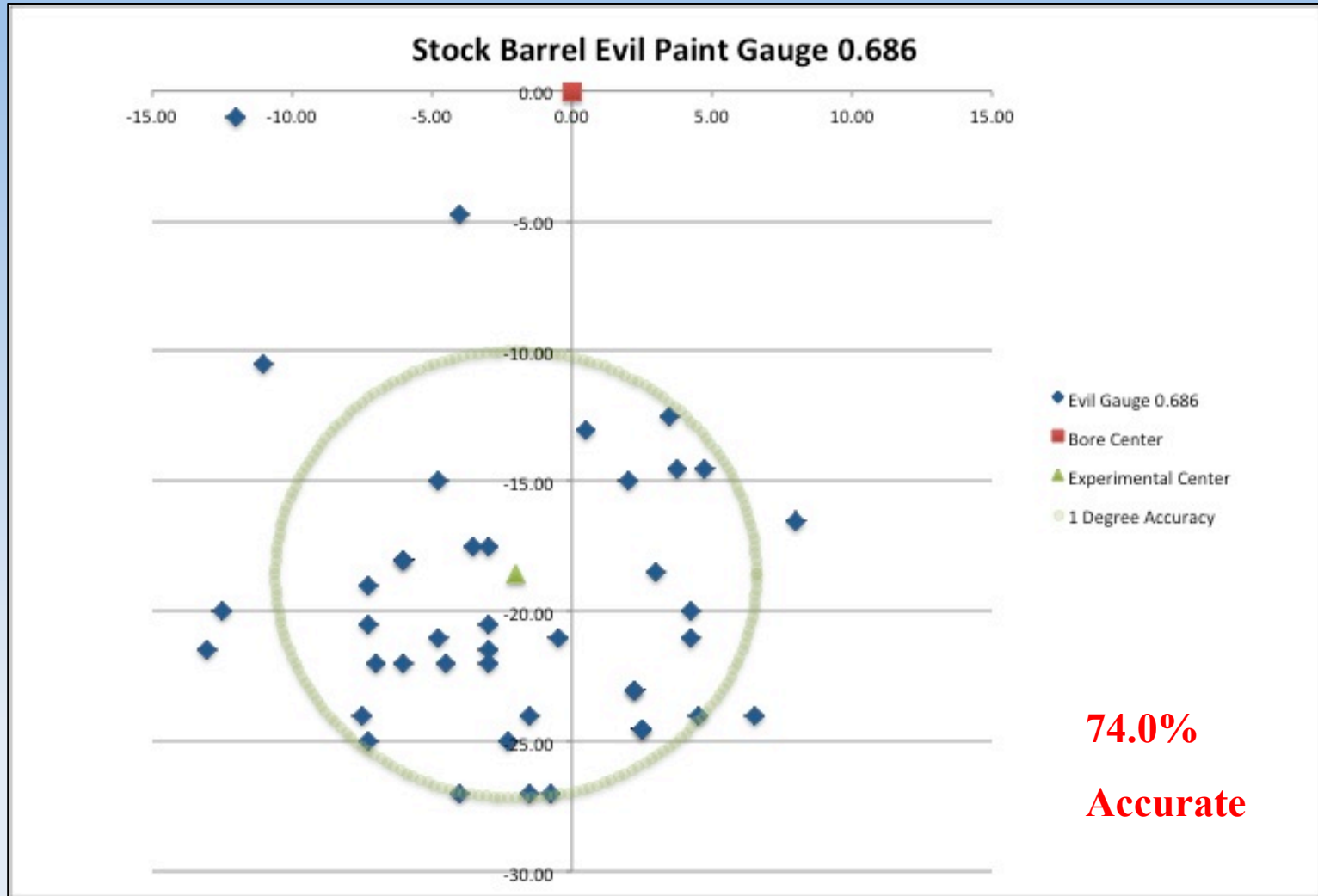


- Test Variables:
 - Stock Barrel, 14" Hammerhead, 16" Hammerhead
 - Rap4 G.O.L.F. Paintball, Tournament Grade Evil Paint

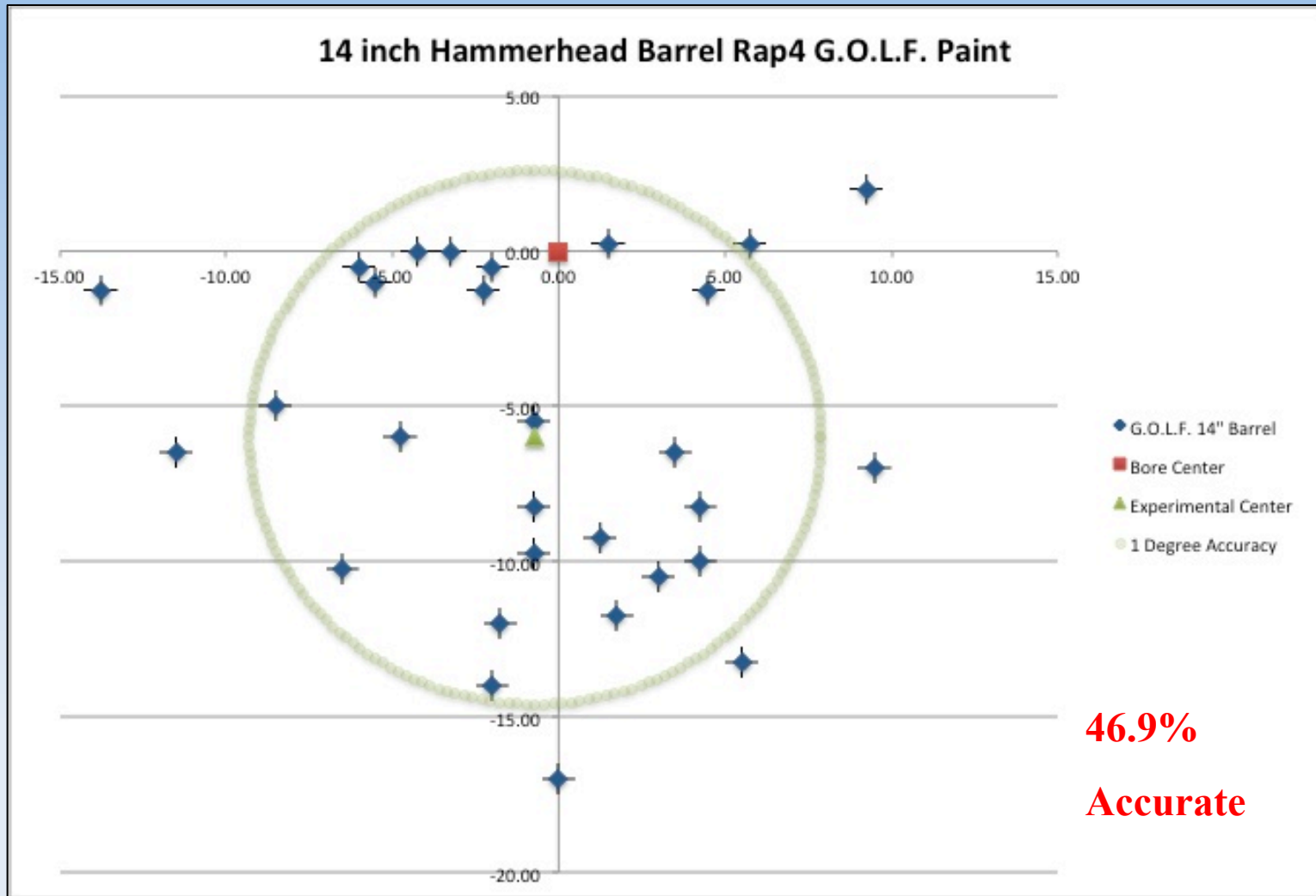
Accuracy Test Data - Paint



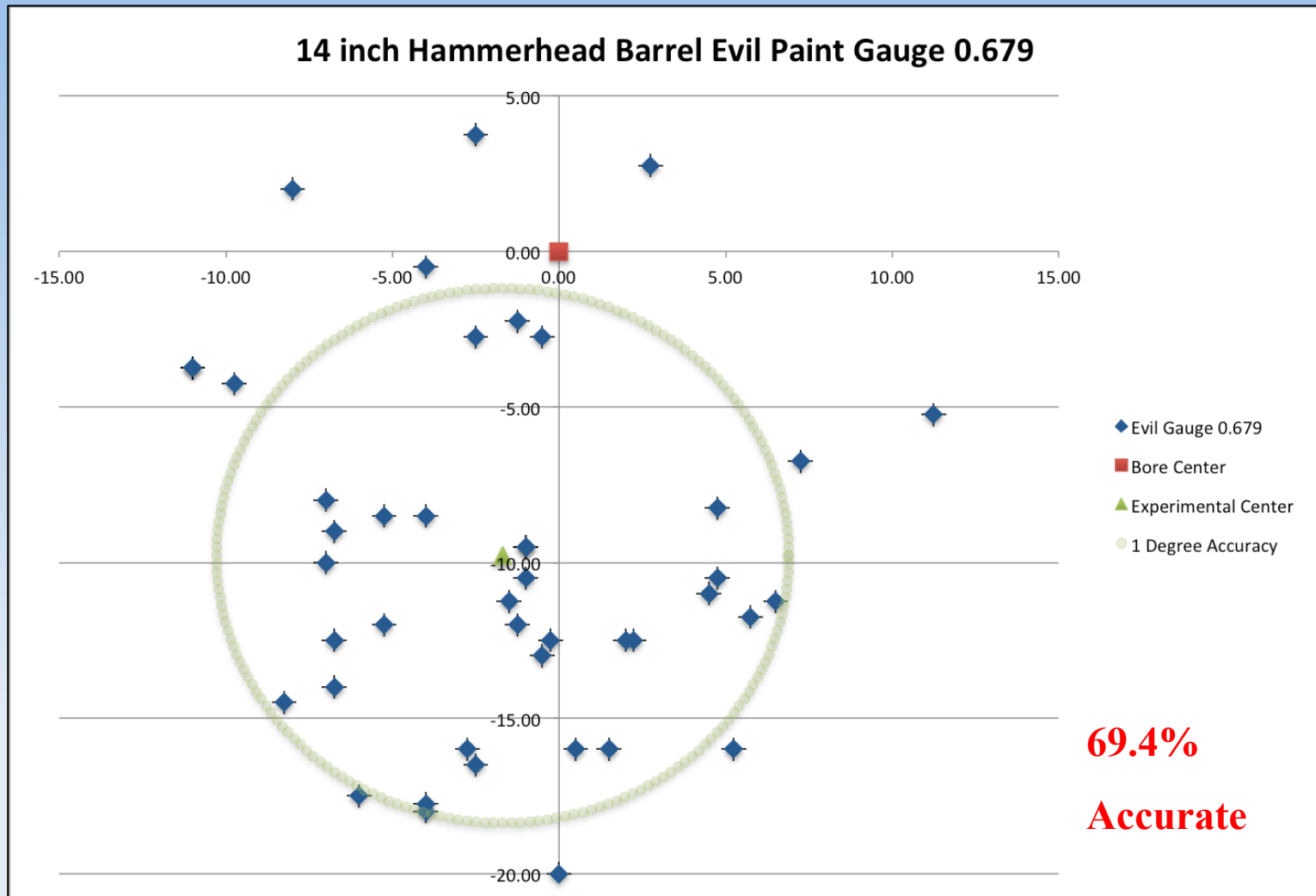
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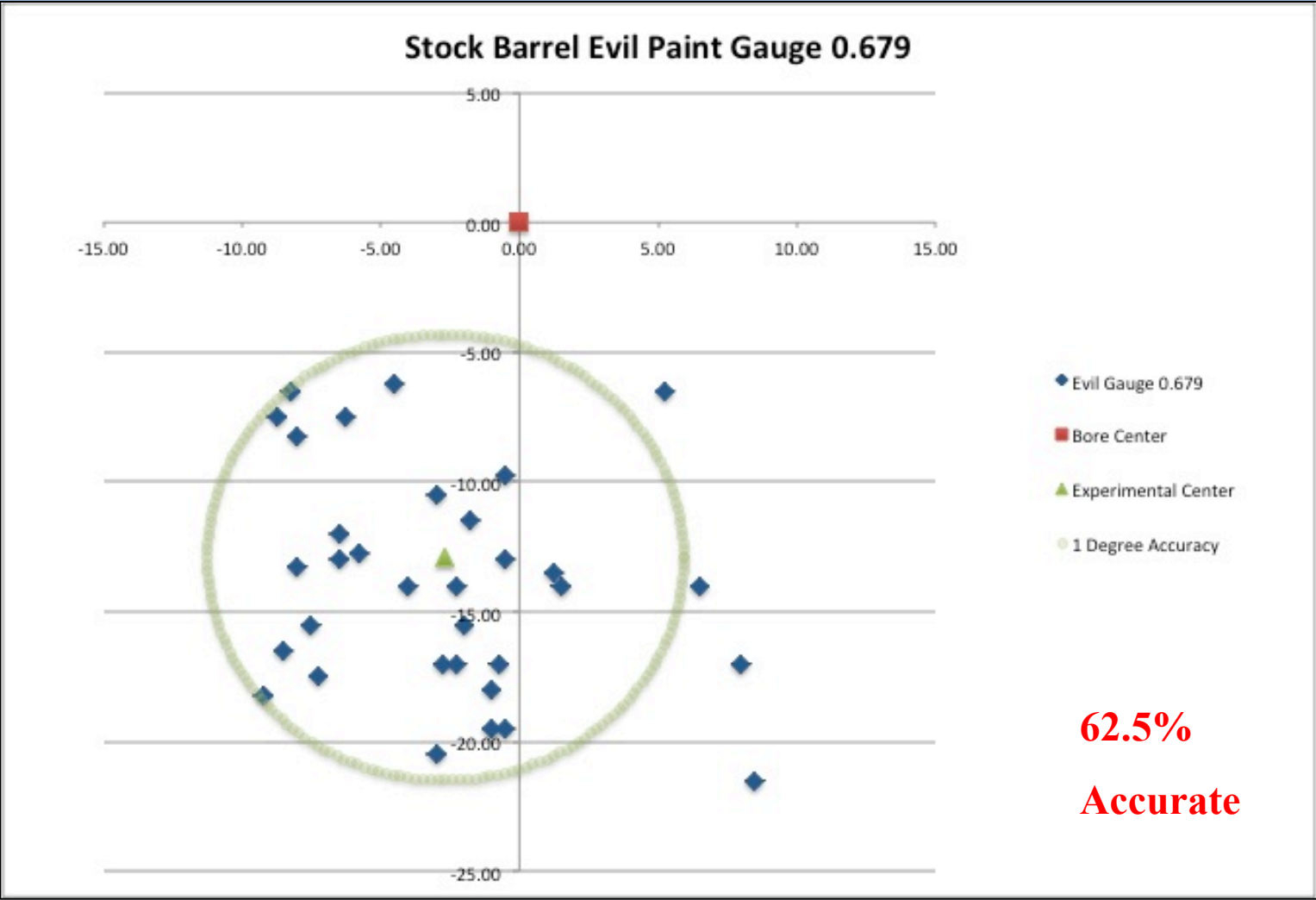
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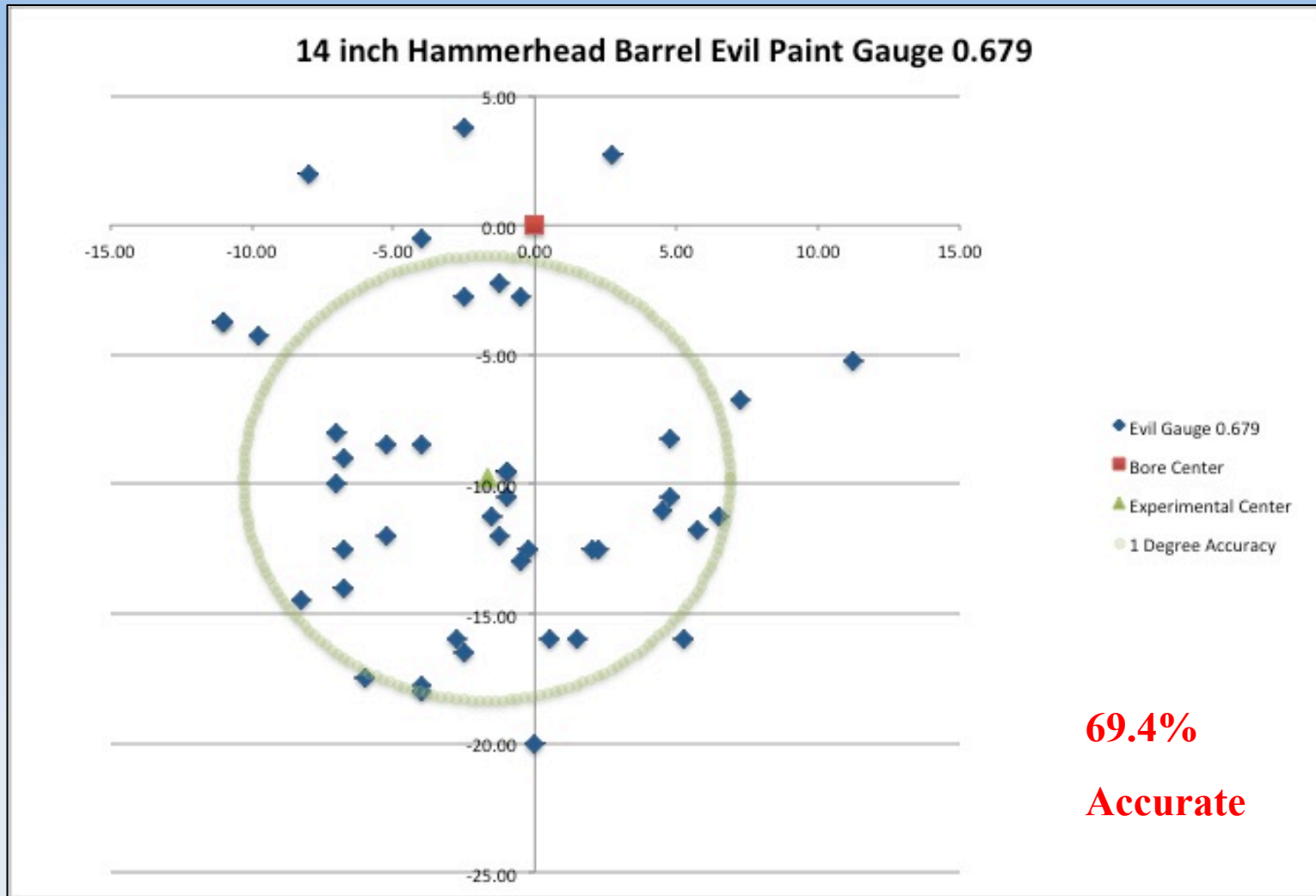
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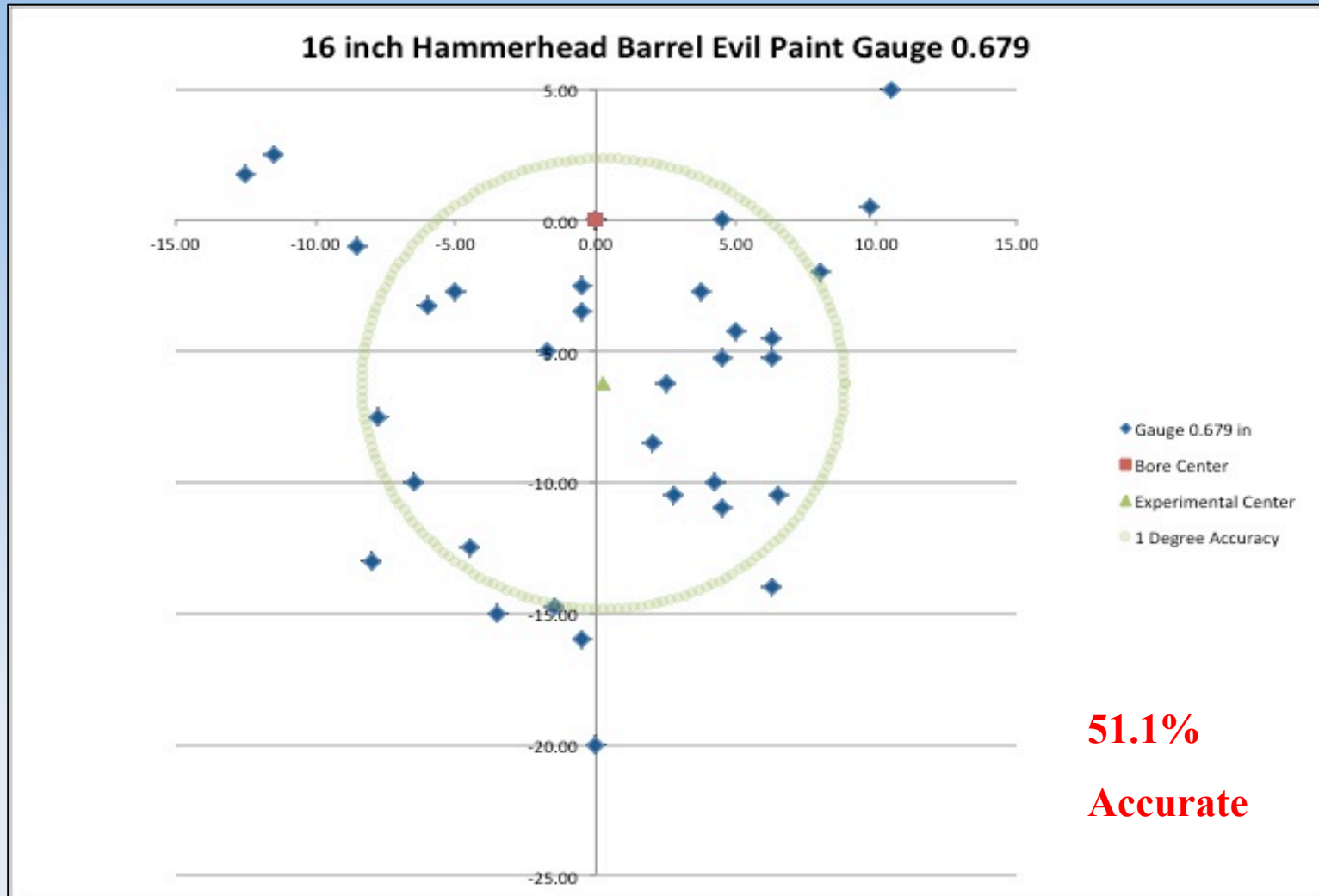
Accuracy Test Data - Barrel



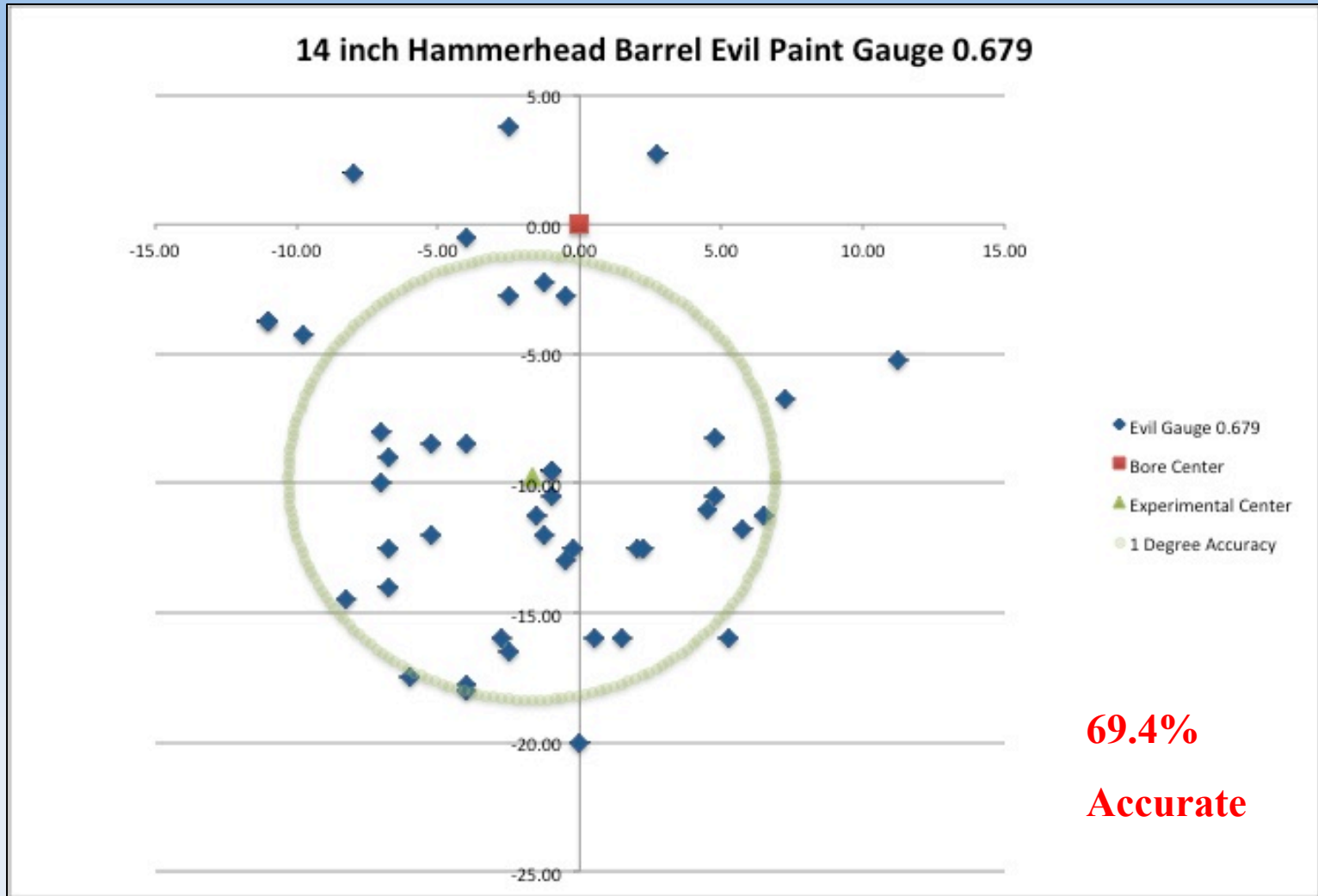
Accuracy Test Data – Barrel



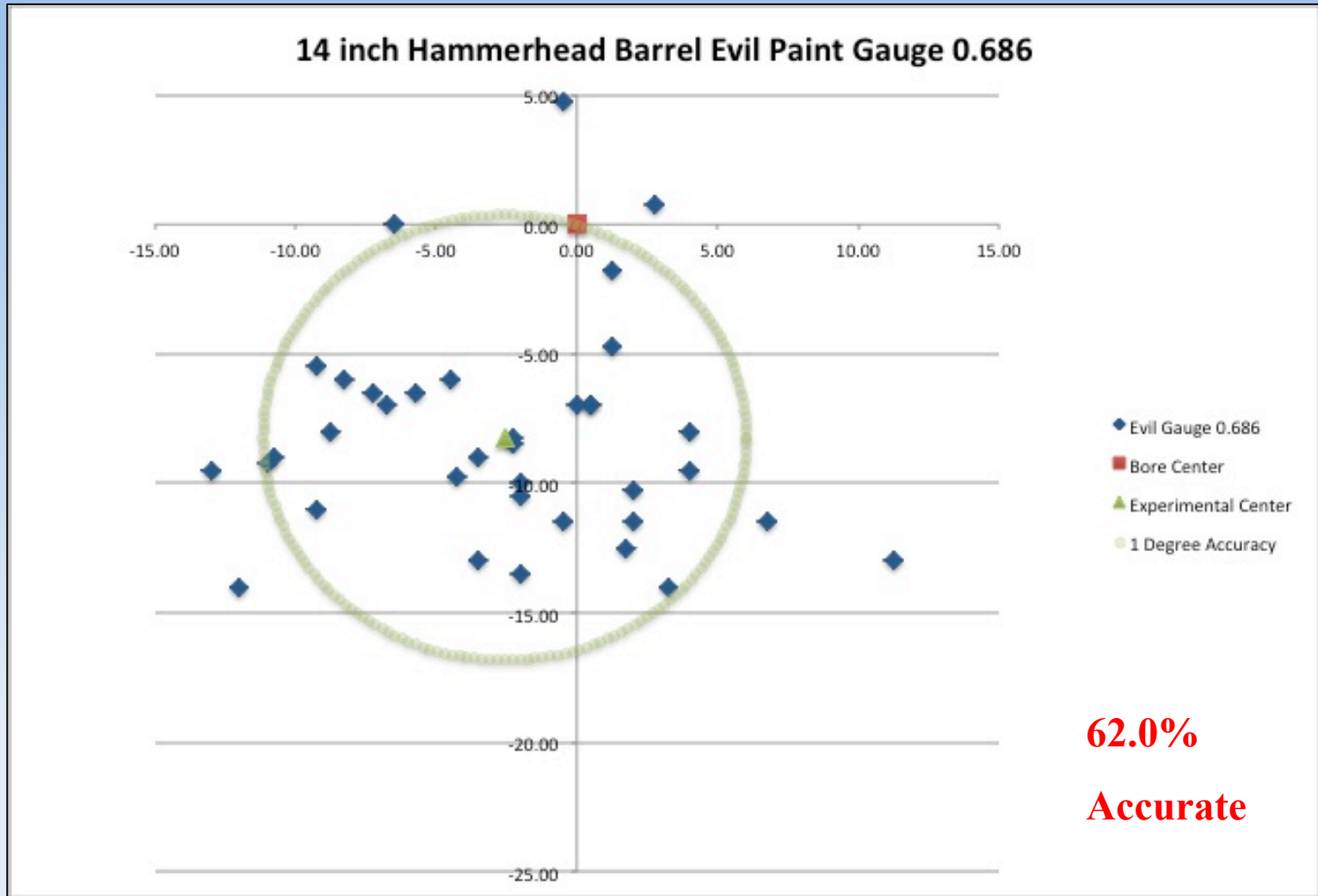
Accuracy Test Data – Barrel



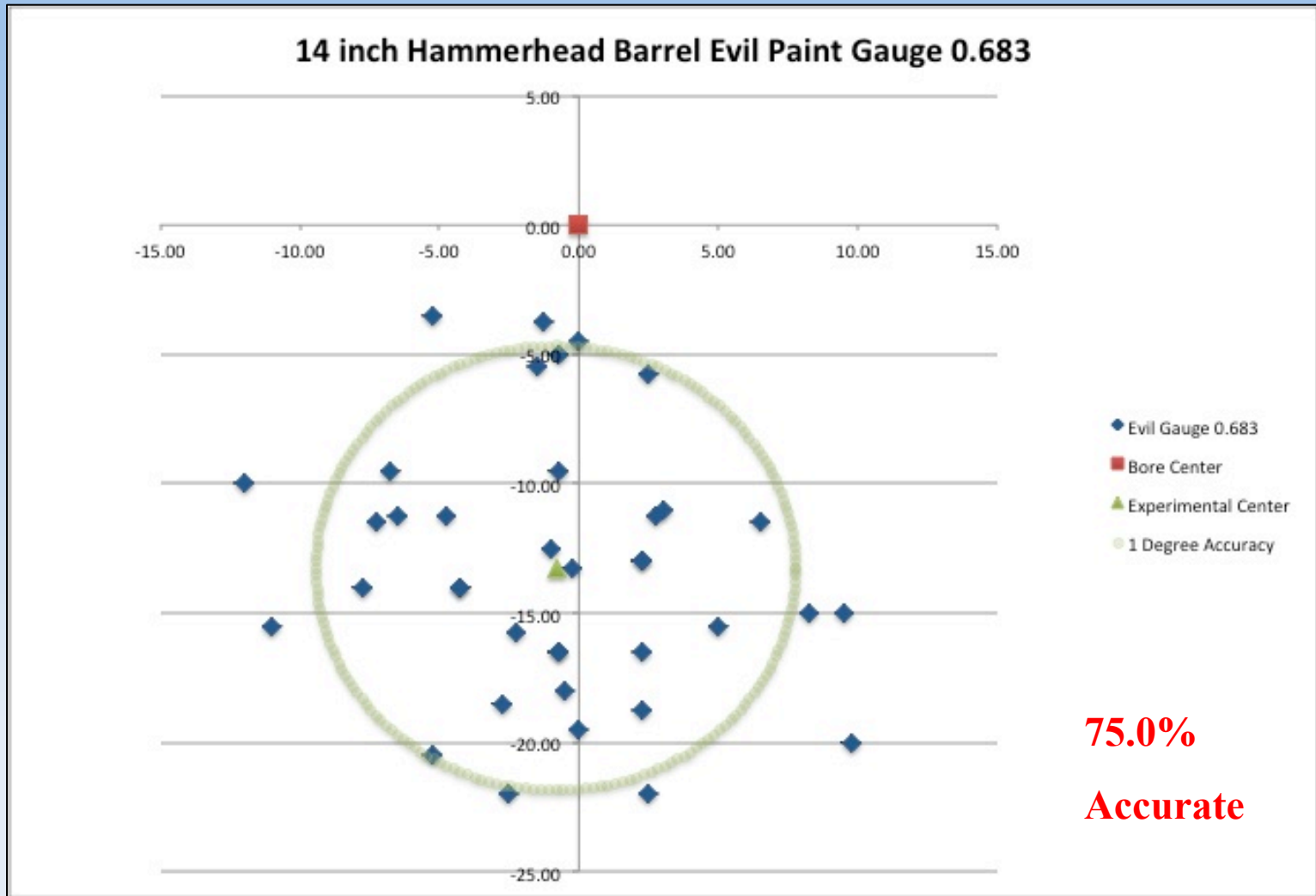
Accuracy Test Data – Gauge Size



Accuracy Test Data – Gauge Size



Accuracy Test Data – Gauge Size



Accuracy Test Data

- Poor overall accuracy
- No true regulating system
- Bad paintballs

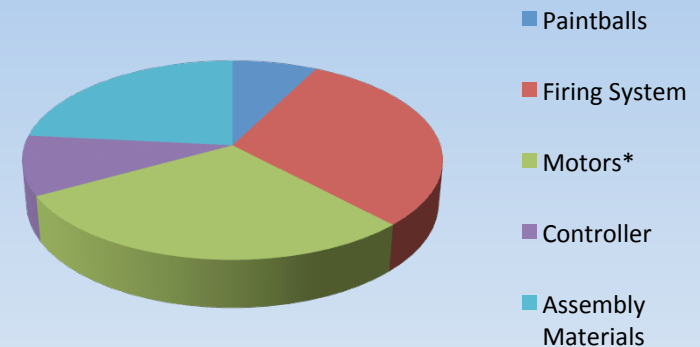
Environment, Health & Safety

- Paintball Residue
 - Paint made of thick food dye
 - Shells are water soluble
- Safety Firing Precautions
 - No mechanical trigger present
 - Keyed switch in between controller and relay
 - Cuts off relay before it could send a signal

Engineering Economics

Materials	Quantity	Price
G.O.L.F. Paintballs 500 ct.	1	\$40.01
Regular Paintballs 2,000 ct.	1	\$105.41
Tippmann A5 Marker	1	\$368.45
Hammerhead Barrel Kit	1	\$59.00
Air Tank	1	\$129.90
Coiled Hose	1	\$30.00
RX-64 Motors	2	\$559.80
Brackets & Hardware		\$91.60
Wireless Receiver	1	\$21.95
Wireless Remote	1	\$24.95
Controller & Bridge	1	\$139.94
Assembly Materials		\$360.00
Total		\$1,930.60
Remaining		\$69.40

Budget Breakdown



*Motor price excludes larger EX-106 motors

Conclusion

Specification	Value	
Maximum Range	82 ft.	<input checked="" type="checkbox"/>
Azimuth Range	360 deg	<input checked="" type="checkbox"/>
Elevation Range	90 deg	<input checked="" type="checkbox"/>
Angular Velocity	≥ 360 deg/s	<input checked="" type="checkbox"/>
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Motors	Servos	<input checked="" type="checkbox"/>
Tagging System	Paintballs	<input checked="" type="checkbox"/>
Budget	\$2000	<input checked="" type="checkbox"/>

Conclusion

- Durable System
- Meets Specifications:
 - Fired accurately at 82 feet
 - Weight under 50 lbs. (~30 lbs.)
 - Traverse full range under 1 sec.
 - Azimuth and Elevation range 300°
 - Sufficient to cover entire view of ground
- Future Testing Recommendations:
 - Upgrade marking system with pressure regulator



Acknowledgements

- Robert Orgusaar
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- Dr. Shih, Dr. Dalban-Canassy, Dr. Kosaraju



Questions?