Automated Disc Thrower

Senior Design Proposal submitted to the
Department of Mechanical and Materials Engineering
College of Engineering and Applied Science
University of Cincinnati

in partial fulfillment of the
requirements for the degree of

Bachelor of Science

in Mechanical Engineering Technology

by

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Problem Statement

In disc golf, players use discs to complete designed holes with as little strokes as possible. They accomplish this by using different discs to shape the shot that is required. Each disc has its own flight characteristics that are unique to the mold and plastic of the disc. In order to describe the flight characteristics, manufacturers come up with flight numbers to help players buy their next disc. The flight numbers that are generated are not backed by any data, rather someone throwing the disc and deciding what numbers they think fit the flight of the disc. This discrepancy makes flight numbers generated by manufacturers useless. Our group plans to develop a way to generate consistent data that can help create more accurate and descriptive flight numbers.

Research

Background of the Problem

When starting disc golf as a beginner it can be hard to choose what disc might be right for you. It can be overwhelming to look through stores where there are hundreds of options. Something you might notice on these discs is there is a set of 4 numbers stamped on the back of them. These four numbers have great meaning. There is a number for speed, glide, fade, and turn (1). In 2009 Innova Disc came up with this system but there was just 1 problem. There isn't a machine to throw these discs to make the numbers more standard. They were just using a very experienced individual to test these discs. Since there is a lack of consistency between throws it is impossible to create a standard system to judge each disc.

There is currently no universal standard for flight numbers which is one of the major problems for people trying to buy discs. One of the problems that is commonly faced with an average person buying a disc is that two discs that are said to be very similar with flight numbers and feel dramatically different (3). Pros have the advantage of throwing every disc and choosing the ones they prefer. Though an average person without a sponsor has to just buy one and trust the flight numbers. One way that a lot of disc golfers research disc and flight numbers before buying a disc is watching a professional on YouTube review the disc and give their opinion on the flight numbers. Also while doing research I came across another problem that is making flight numbers inconsistent and that is inconsistencies in manufacturing of their plastics. Even though a disc is made in the same run and stamped with the same number the plastic property differences can add to the complexity of making consistent flight numbers.

During our research we figured the two biggest factors in disc flight are launch angle out of your hand and the velocity at which you throw the disc (2). They call the flight path of a disc when it is thrown the flight shape. Throwing a disc at an angle greater or less than flat will change the disc flight shape. One misconception of the speed rating is that the higher the speed the further it will fly, but it actually represents how hard the disc needs to be thrown to get the desired flight. There are several different types of shot shapes that can come from throwing discs differently such as a flex, turnover, or S shape (4). As one article states that these flight numbers are not produced in a vacuum nor by a robot making these numbers different from brands and people.

Applicable Standards

One applicable standard would be OSHA 1910.212 (1). This standard goes over machine guarding for robotic applications. We must ensure that we use sufficient guarding around our thrower to prevent impact or projectile hazards.

ISO 12100:2010 (2) is a standard that goes over general safe design for industrial robots. Ensuring that there is a proper risk evaluation throughout the robots life cycle, and including safety equipment like e–stops.

State of the Art

Currently, most products relating to this topic come in the form of dog toys. There are a lot of frisbee launchers that are used to throw frisbees for dogs (1). While this is similar to what we are looking to accomplish, they lack the distance and speed needed to fully test the capabilities of a disc. Another downside to these throwers is that they are fit for frisbees, not discs. Discs have different dimensions and thicknesses than frisbees.

Other throwers we found that are fit for disc golf are the EPEC Disc Launcher (2) and other handheld throwers (3). These products allow you to place a disc into the holder, adjust the grip to change distance, and whip the launcher to throw the disc. While this throws discs like we are looking to accomplish, it is a handheld device that still allows for human error. This will not get the consistent launch speed and angle that we are looking to achieve. Another downside to this product is that its top distance is only about 240 feet, which would not match the speed discs can be thrown at.

The last product we found best matches what we are trying to accomplish. This device was made by youtuber Stuff Made Here (4). In this video Shane created a device that was supposed to strap to his arm and throw the disc for him. This device is capable of throwing discs 550 feet. Where this device falls short is that it is throwing discs at a higher speed than humanly possible, and it does not produce enough spin in the disc. This design was also made to be handheld which introduces human error in the launch angle.

End User

The end users of our disc thrower would be the disc manufacturer themselves. Our product would work into the end of the disc development line. They would use the product to conduct multiple tests at different speeds and angles to see how the disc flys. From there they would be able to assign accurate flight numbers to that disc. Conversely, the disc manufacturers could use our product to help tweak their design if they are not getting the desired flight they were looking for. Another possible end user could be the PDGA, which is the governing body of disc golf that approves discs for tournament use. Although this is not done currently, it would be ideal if the PDGA were the ones that assigned flight numbers. This would allow for an unbiased third party source to uphold a flight number standard, regardless of the manufacturer.

Summary of Research

In conclusion we found that there is not a standard way for manufacturers to test their new disc (4). This causes an inconsistency in manufactures flight numbers making it frustrating for customers to buy a new disc (3). After researching applicable standards it was determined that we would need to make appropriate guards for our robot and ensure we have an end for good safety practices. When researching state of the art we found that there was only one product that was comparable with what we want to do though it fell short in many important categories that are needed for accurate testing. The end user for this product would be for disc manufacturers to use this robot to throw a disc to generate consistent flight numbers. This could also be used by the PDGA who could assign flight numbers to all new discs as well.

Quality Function Deployment

Customer Features

- Able to generate spin similar to being thrown in a hand
- Adjustable power/distance
- Safety guards to protect users
- Launch angle adjustments
- Able to throw both forehand and backhand?
- Thrown with minimal "wobble"
- Consistent launch speed and position
- Thrown with consistent nose angle
- Adjustable nose angle from

Engineering Characteristics

- Have grippers that work like fingers and generate spin
- Grippers that release at a consistent point
- A regulator to adjust the pressure of how much power is being used
- Guards around all pinch points and moving parts
- Have adjustment of 5 degree angle changes for Hyzer and Nose

House of Quality / Interview with Sponsor

During our research, we were able to get in contact with two disc manufactures, Discraft and MVP Discs, to ask about their process of disc testing. They were unable to disclose their methods of testing and how they generated the flight numbers, but Discraft's response mentioned that they have factory workers and disc golf professionals throw the disc for testing. See Appendix A for the email. We also asked these manufacturers if they would be able to answer a survey to help us with our house of quality. see appendix B for emails.

We have unfortunately been unable to get any responses from the survey so far. see appendix B for survey. For the house of quality, we put what we think was the best weighting for each customer requirement. Once we are able to get more responses we will change these weightings. From the house of quality we created, see appendix C for chart, we were able to generate a list of most important to least important requirements. Below is the list from most important to least important:

1. tolerance of Hyzer angle
2. tolerance of release speed
3. Spin rate of the disc
4. Speed of disc thrown
5. tolerance of wobble angle
6. Range of hyzer angle
7. Range of nose angle
8. can be thrown both backhand and forehand

9. tolerance of nose angle

Product Objectives:

- Reach up to ~1500 RPM tolerance of ±30
- Max launch velocity 85MPH tolerance of ±2 mph
- Hyzer angle of 0-45 degrees from flat tolerance of ±2 degrees
- Nose angel of ±10 degrees from flat tolerance of ±1 degree

Team Members and Responsibilities:

Braedon Flamm:

- Gripper design lead
- CAD lead
- Tester
- Data analysis
- Final report

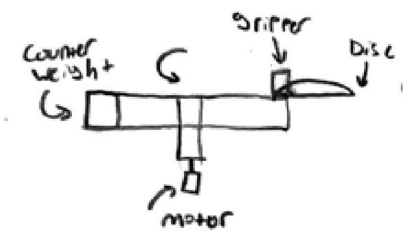
Daniel Wright:

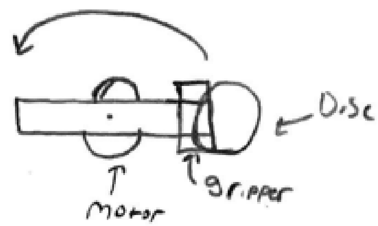
- Robot arm and joint design lead
- Meeting minutes
- Manufacturing lead
- Data analysis
- Final report

Concepts Drawings

Centrifugal Thrower:

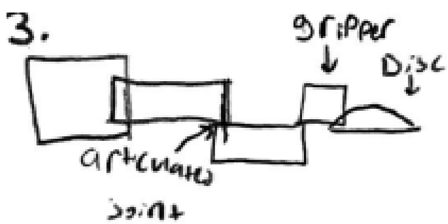
This design uses the concept of centripetal force to throw discs. A gripper that holds the disc is placed at the end of a rod, the rod is then rotated to a certain speed. Once the rod is up to speed, the gripper releases the disc, throwing it in the direction it was released at.

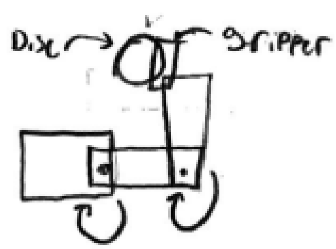




Articulated arm:

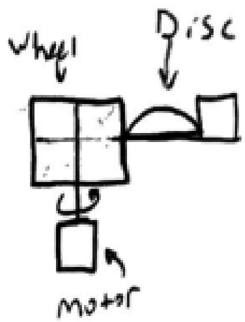
This design most closely relates to a disc being thrown by a person. This design will have 3 linkages with 2 joints that replicate a human arm moving along a horizontal plane. At the end of the arm is a gripper that will hold and release the disc.





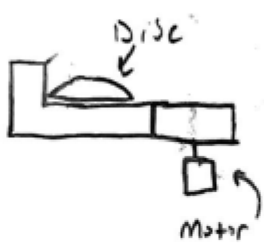
Flywheel:

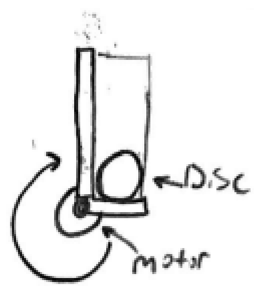
This design uses a flywheel system to throw discs, similar to how a football launcher works. A wheel will spin up and a disc is pushed into the wheel causing it to rotate and launch out.



Clay pigeon:

This design imitates a clay pigeon launcher. In this system, the disc sits in a "L" shaped rod. When the rod is rotated quickly the centripetal force causes the disc to rotate along the sidewall. Once the disc reaches the end of the rod it is launched outwards.

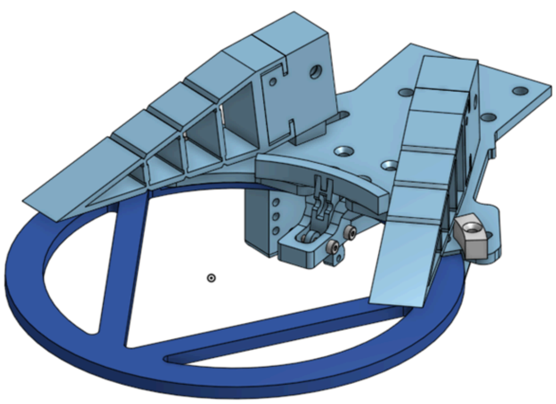


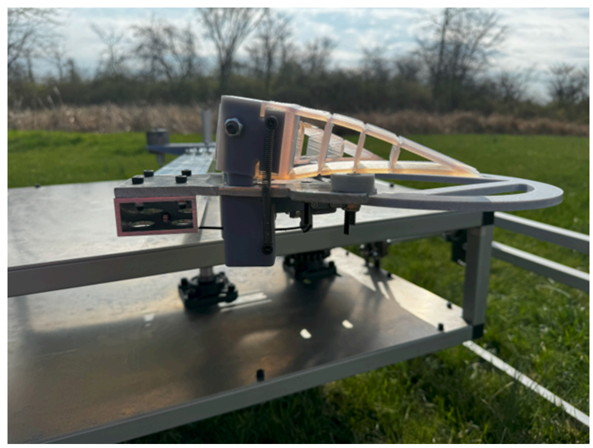


Final Design

Gripper

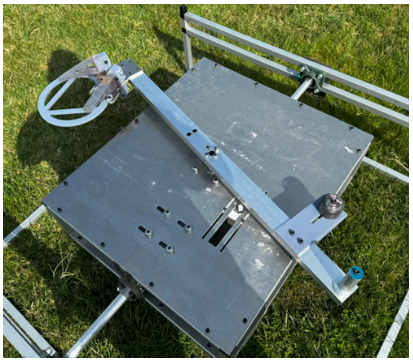
Our gripper needs to be able to hold all types of discs, be adjustable, and have a locking mechanism to release the disc. In order to accomplish this we designed 2 flexible gripper fingers that are 3D printed in a flexible material. These flexible fingers allow the gripper to be able to adjust and contour to any disc shape. These fingers are on sliding slots that add adjustability based on the thickness of the discs rim. These fingers are spring loaded downwards in order to produce a consistent force on the disc. In the middle of the gripper is our disc latch that holds the discs rim in place until it is triggered.

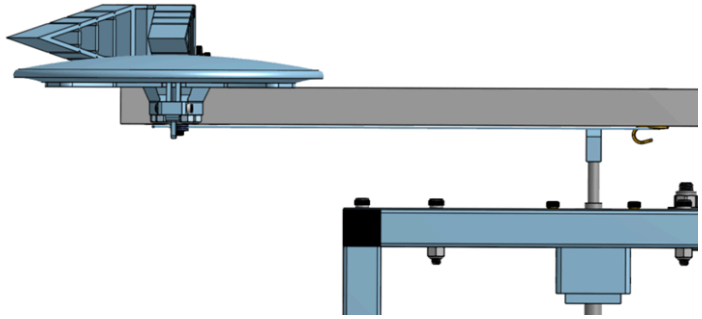




Arm

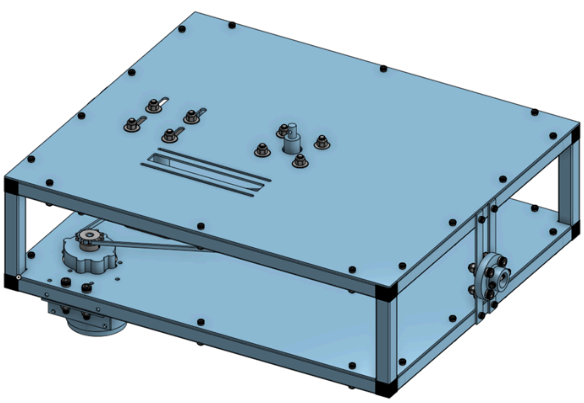
The arm subassembly houses the gripper, counterweights, and the trip wire. This is the part of the design that will rotate up to 680 RPM. It has a hub in the center that attaches to the main drive shaft in the saddle subassembly. The counterweights allow us to adjust the center of gravity to ensure that it is in the center of the axis of rotation. The trip wire on the arm acts as our timing mechanism to ensure the disc is released at the same spot each time. This is accomplished with a solenoid that is attached to the saddle. Once the arm spins up to speed, the solenoid is then triggered. The solenoid then trips the trip wire on the arm, which pulls on the latch mechanism, releasing it at that moment.

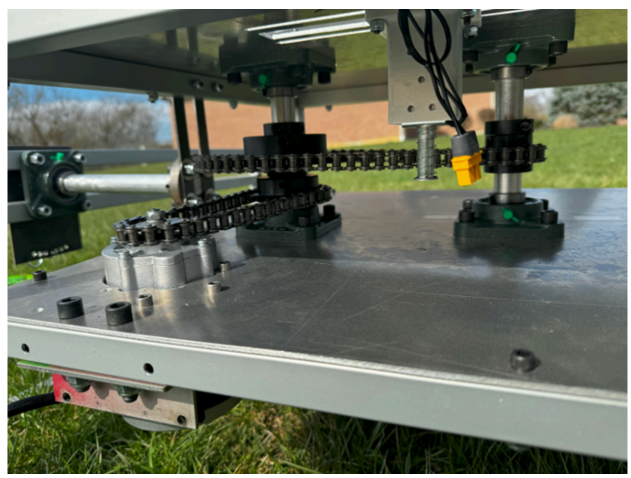




Saddle

This subassembly houses our motor, drive chain, and timing solenoid. It also holds our main arm subassembly. This saddle is mounted in the center of our frame floating between 2 shafts. This mounting orientation allows us to be able to rotate the entire subassembly to achieve our adjustable hyzer angles. We are currently using a 6:1 gear ratio to speed up the drive shaft.



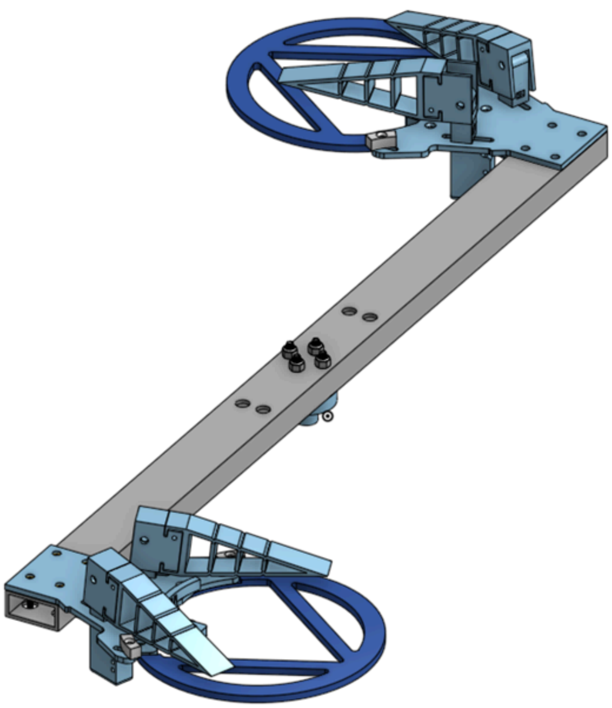


Frame

The frame subassembly houses our hyzer angle adjustment bearings, and the adjustment plate. The adjustment bearings is where the saddle mounts to. This allows for a smooth rotation when adjusting the hyzer angle. We have hyzer adjustment plates on either end of the frame. This allows us to lock the saddle in place once the hyzer angle is selected. The frame is enclosed by netting on all 3 sides, the front is open where the discs are launched out of. These nets are mounted using bungees, which helps dampen the load on the net if a disc is released early.

Results

We were able to test up to 55% power which resulted in a throw that was 35 mph and went 180 feet. These numbers were in line with what we thought our 100% test would result. We were limited to 55% power for two reasons being strength of gripper and latch material and the imbalance we had when the arm was slowing down after the launch. We are looking into CNC machining a stronger gripper and latch allowing us to spin up to higher speeds. Also to fix the imbalance problem we are looking into an arm design where we have a gripper on both sides. With this we can launch 2 discs 180 degree out of phase causing a less disruptive imbalance.



Project Management

Project Budget Limit

Our project budget is estimated to be $1,300 and is subject to change when testing and design results conclude in a failure or success. This project will be funded by the two of us.

Actual budget

For this project, we ended up spending $1,195 which is under our proposed budget. We were able to save money by using a metal outlet supplier for all our raw materials, instead of Mcmaster Carr. This is estimated to save us roughly $300. We were also able to save money by supplying our bolts from Bold Depot instead of Mcmaster Carr. This is estimated to save us roughly $50. The section we did not account as much for was the electronics. We spent nearly double what we expected in electronics. This is due to us not realizing some of the components we needed when first designing the electrical panel. Overall we were able to save about $105 in cost.

Key Milestones

- Deciding on a final design concept
- Concept testing
- Full CAD model
- Start Fabrication
- Finish assembly
- Testing of prototype
- Fixing bugs

- Final prototype
- Final report completion
- Final presentation -
- Tech expo - Mid April

Schedule

In our first phase of senior design 3 our first objective was to have all of our drawings and models completed which we were able to accomplish. We also ordered all of our parts on time and had no delays in shipping them. Where we first ran into problems was being able to complete all of our machining by our goal date of February 2. Our delays came from the parts taking us longer than expected to machine ourselves and the limited hours we had access to the machine shop. We made up time in our next two steps which were wiring up our motor and doing our full assembly. With these tasks being completed faster than expected we were able to be back on track. We were able to do the next 3 task on time which were the initial spin up, the final programming and the first ¼ speed test. After this we fell behind on every task to come and found several problems our design had. The task we fell behind on was the ½ speed test which we eventually completed once we made our latch out of a stronger 3D printed material. Though we did not ever get to complete a ¾ power and full power test due to our gripper strength and the imbalance we have after we launched.

Plan to finish

One of our limitations was a high force on our gripper/latch causing it to break at tests over 55% power. Our plan to finish includes CNC machining our gripper to increase the strength allowing it to withstand the g-forces that it expects to see. Another problem we encountered was an imbalance in our system once the disc was launched. We plan on adding a second gripper onto the opposite end of our arm and launching a second disc 180 degrees out of phase. With doing this we hope to only have our launcher unbalanced for 180 degrees making it much more stable on the slow down of the motor.

Sustainability and Material Usage

We used aluminum extrusion for the frame and saddle and quick connect components to make it easy to assemble and can be taken apart if it needs to be moved. Our main plates for the saddle were aluminum sheets that were plasma cut. Though our gripper latch was made out of a 3D printed material and had problems with it breaking too often. After a few cycles the material would wear out and break. In the future we want to make this out of metal so it is stronger and lasts longer. Also another wear item will be the wire we use to pull down our trigger. This will have to be a part that is replaced on a service interval and do not have a solution for this wire if it were to stretch and break currently. Along with that our chains will have a service interval of when they will need to be replaced making sure they never break.

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Appendices

Appendix A

Dear Discraft,

Our names are Braedon Flamm and Daniel Wright, and we are Mechanical Engineering students at the University of Cincinnati. We are looking to do our senior design project on an automated disc thrower to help generate constant testing. We have a small list of questions we are hoping to get answered about disc development. Would you be able to share any information on how flight numbers are generated for new discs? Would an automated disc thrower be able to aid in any other part of disc development other than product test? Lastly, are there any specific features that would be needed for our design to make it more useful (i.e. throwing both backhand and forehand)?

We look forward to hearing back with any information.

Thank you,

Braedon Flamm

Daniel Wright

Hi Braedon,

Thank you for reaching out, but we are not able to share concrete information on how flight numbers are assigned. They are determined by our experienced staff members, designers, and team players. Never a shortage of people wanting to throw a disc around here :)

Good luck with your project!

Regards,

Discraft Inc.

Appendix B

Dear MVP Discs,

Our names are Braedon Flamm and Daniel Wright, and we are Mechanical Engineering students at the University of Cincinnati. We are looking to do our senior design project on an automated disc thrower to help generate constant testing. We have a few questions we are hoping to get answered about disc development. Is there any specific features that would be required in am automated disc thrower that would make it useful (i.e. throwing both backhand and forehand)? Lastly, would you be able to share any information on how you test new discs to generate flight numbers? We look forward to hearing back with any information.

Thank you,

Braedon Flamm

Daniel Wright

Hi Braedon and Daniel,

Thank you for reaching out to us!

Due to the proprietary nature of our discs, we are unable to share any information regarding our quality and testing procedures. We apologize for any inconvenience this may cause!

Additionally, I have forwarded your inquiry about an automated disc thrower to the appropriate departments for further review. If we are able to provide any additional information, we will reach out to you!

Please let us know if you have any further questions or concerns. We are always happy to help!

Blessings,
Sheridan

Hello,

Thank you for getting back to us about this. My partner and I are currently working on a small survey going over the importance of criteria of an automated disc thrower are. This survey would help us figure out which design we should work on by weighing the importance of different criteria. Once we finish creating the survey, is this something that you would be able to forward around so we can get some feedback?

Thanks for the help,

Braedon Flamm

Mechanical Engineering Technology

Class of 2024

M13302577

Hi Braedon,

Thank you for your response. We would be more than happy to forward it around once it is completed.

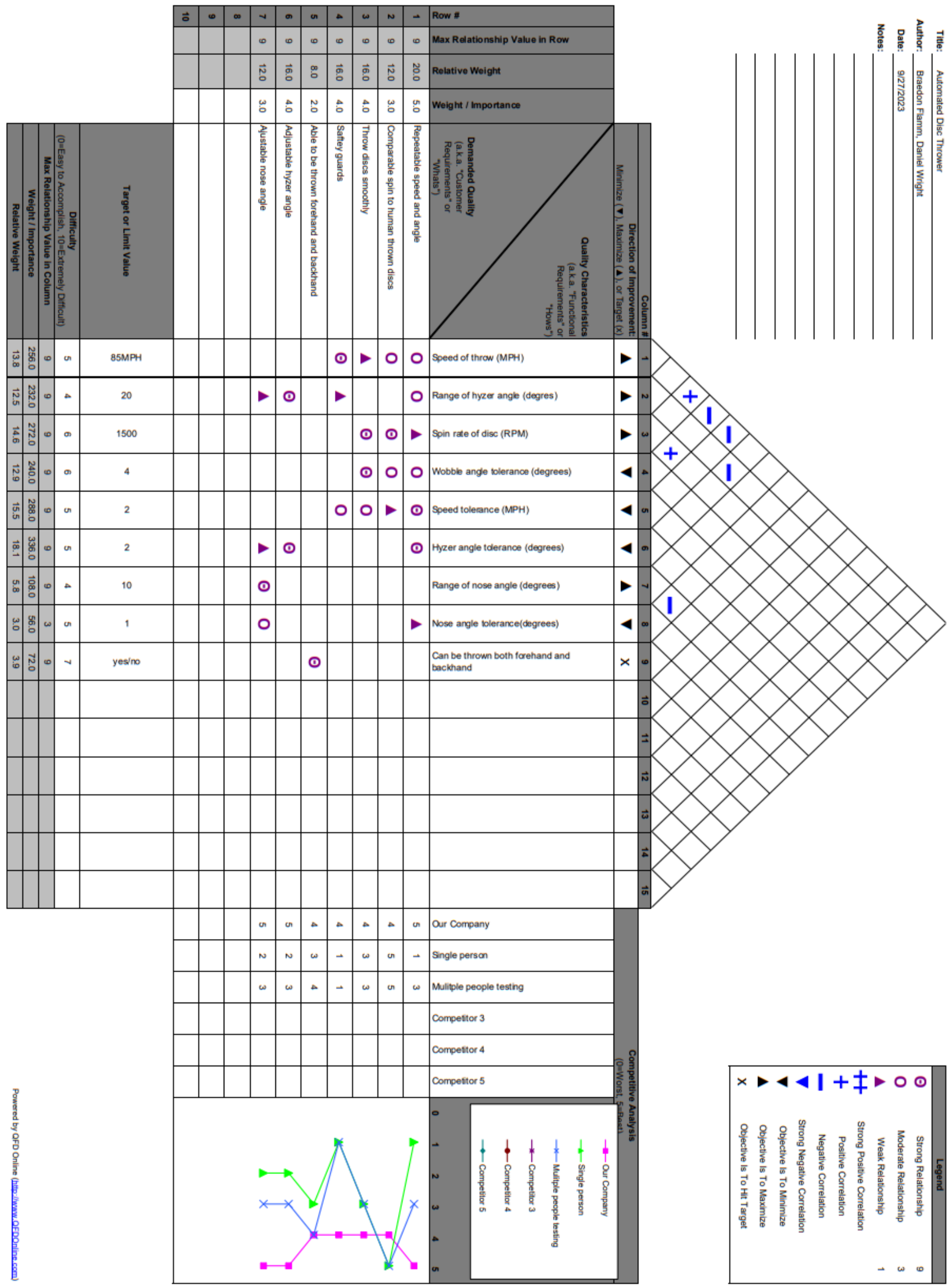
Please let us know if you have any additional questions. We will be happy to help!

Have a great day!

Best wishes,

Brittany

Appendix C



Appendix D

Automated Disc Thrower

This survey will help us rate the importance of different characteristics for our automated disc thrower

What do you think is a sufficient top launch speed in miles per hour?

What is an allowable launch speed tolerance?

What is a sufficient range of launch hyzer angle?

What is an allowable hyzer angle tolerance at launch?

What is a sufficient nose angle range?

What is an allowable nose angle tolerance at launch?

On a scale of 1 to 5, how important is it to launch discs at a repeatable speed and angle?

On a scale of 1 to 5, how important is it to launch a disc at a comparable spin rate to a human throwing it?

On a scale of 1 to 5, how important is it to launch discs smoothly (with little to no wobble)?

On a scale of 1 to 5, how important is it to launch discs both forehand and backhand?

On a scale of 1 to 5, how important is it to be able to adjust the hyzer angle?

On a scale of 1 to 5, how important is it to adjust the nose angle?

On a scale of 1 to 5, how important is it to have guarding around the disc thrower?

Is there any other variables not listed above that you think would be important for an automated disc thrower?