The Arcane Game Board

University of Central Florida

College of Engineering and Computer Science

EEL4914 Senior Design 1

Divide and Conquer – Initial Project Document

Group 22

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Customers

Self-Funded Project for Public Consumption

PROJECT NARRATIVE

Board games have long been a staple in leisure activities, with many using a simple grid system of tiles to constrain possible moves. A good example of this is Chess. Chess has been around for hundreds of years and utilizes a simple 8x8 grid - within which the players can move their pieces about. Despite the board's simple layout, the game itself is anything but. Another popular example is Tabletop Roleplaying Games (TTRPGs), such as Dungeons & Dragons, which use a standard grid system comprised of 1_{inch} x 1_{inch} tiles and function much the same way that chess tiles do.

As a result of recent mass media, Chess and other boardgames have seen a rise in popularity among the general public and the ability to play these games in a unique way may appeal to many. However, due to current world events and social distancing, many people are now resorting to virtual versions of these classics as a means of entertainment and online interaction. Additionally, games such as Dungeons & Dragons are often forced to be played online due to the time requirements, number of players, and distance between long-term game groups. While these online versions suffice, the physical component that is so integral to the game experience is missing. Well, what if you could play these games on a physical board while still maintaining the benefits of playing online?

Enter the Arcane Game Board (ACB). Utilizing a system concealed beneath the play space, the ACB moves pieces about the board without the need for human intervention. This does not mean that players are restricted from moving their pieces by hand, instead that there should never be a point at which the user must act out of their turn. Tracking the pieces, communicating with an external control system, and managing the game space are all required in order for the product to work as intended.

MOTION

In order to achieve motion, the pieces will be fit with magnetic material at their base. Beneath the board a cartesian robot will operate an electromagnet able to reach all of the play area, as well as significant areas of the border. When the system needs to move a piece across the game board, it will move to the tile beneath the piece, activate the electromagnet, and then drag it across the gameboard. Pathing algorithms will allow for obstacle avoidance and – if required – temporary obstacle clearance when pieces would be able to "jump" over each other.

All motion will be driven by the on-board controller, with commands being translated into cartesian movement via commands similar to G-code. Belts will guide the 2 axes along aluminum extrusions, with each having a dedicated stepper motor capable of providing precise movement. The x-axis will be moved along the y and contains the electromagnet as well as any sensors used to identify pieces during play. Since loose wiring could potentially disrupt motion, a wire chain will be used to tuck away all of the wires necessary to power the "head" of the robot.

In order to ensure that it stays within alignment, the y-axis will have 2 belts on either side of the game board and the rod run through the stepper motor. If the lengths of the tracks are sufficiently close the axis should be impossible to misalign. During homing stop switches will indicate the end both this axis and the x-axis.

EXTERNAL CONTROLLER-APP

The arcane gameboard will utilize an external computer in order to reach all of our goals and stretch goals. The eternal laptop can be connected by either a USB wire, or a wireless WIFI connection. This connection will allow the commands to be sent from the laptop, similar to how a 3D-printer utilizes a laptop. This will allow our design to reduce the on-board hardware necessary for event planning and decision making. The arcane gameboard will also include computer enabled controlling of the pieces.

A User Interface (UI) will be designed in order to provide a friendly User Experience (UX). The UI will be carefully designed in order to be intuitive and easy to use. The UI will include a live virtual representation of the physical chessboard, a feedback system in order to monitor real-time statistics of the gameboard, and a historical log of all of the moves made during that game. As a stretch goal, our team would also like to include the ability to select a previous move, and have the board rearrange the pieces back to that move, for the user to study and revaluate other potential plays from that move.

The UI will communicate with a database via an API in order to store move data. The database will also receive event data from the PCB. This data can then be used to update the UI and keep it real time with the physical game board. The database will run locally on the same laptop as the UI. Time permitting, we plan on hosting both the UI and database so that two players will be able to connect and play from anywhere in the world.

ON-BOARD CONTROLLER

A micro-controller will be required to drive the motors, act as an interface with the external controller, and track the state of the game board. Existing platforms which are capable of this are widely available due to the similar requirements of a 3d-printer, easing cost of development and manufacture. However, the mapping and pathing will both require novel solutions.

GAMEPLAY

Gameplay will comprise of turn-based movement between the board and the user. The order of play is determined by which player is the lighter colored team as in normal chess.

On an AI turn the board will plan a move, locate the piece on the board according to its internal map, and then instruct the cartesian robot to move the piece as needed. For knight pieces it may be necessary to dodge other pieces on the board. Moving in a semicircle around them will be the most common solution. In cases where the knight is surrounded by many pieces the AI will attempt to move the knight between 2 of them without disturbing the other pieces.

Player turns operate much the same way, designating moves on their system which will then be carried out by the board without the need for physical intervention. Since only one move is allowed per turn, the player does not need to signal that they are done; only move the piece in virtual space.

Spaces off of the center of the board will be designated retirement zones for pieces removed from play. When captured, pieces will be dragged back to their designated retirement tile, allowing them to be retrieved by players in the event of a pawn promoting. When a player captures an AI piece, they will press the captured piece down into the board. The system will recognize that the piece should be retired, move it to the retirement area, and then move the player's piece into the now empty tile from its original position.

If time and budget allow for the design and implementation of piece tracking the flow differ. When the player moves their piece, they will press down on the tile– signifying which piece is being moved and its original position. They can then place that piece wherever they wish and then press down again. Point of origin, the piece moved, and the final position are all noted by the backend in order to inform its next move on the board.

TRACKING

If the design of the initial board goes smoothly enough, piece tracking is the direct continuation of the project. To accomplish this, a system of pressure-sensors will be built beneath the gameboard. When the board flexes downwards, it will register the tile where the pressure came from. The pieces will not be heavy enough to trip the sensors on their own. When a player wishes to interact with a piece they will press down on the piece – effectively tripping the sensor.

If budget and time allows, a NFC sensor could be affixed to the head of the robot. Allowing for piece ID to happen during play to verify the state of the board in real-time, searching for pieces in the case of a "miss," and automatic set-up before play. Pucks fitted with passive NFC antennae and ferrous bases could be used in conjunction with any existing chess pieces. Allowing for games other than chess, novelty pieces the user may not want to modify, and quick replacement in the case of a failure.

REQUIREMENT SPECIFICATIONS

Arcane Game Board Requirements and Specifications	
Board Requirements	***Specifications***
Must be able to distinguish between different chess pieces	
Must be able to locate the position of all chess pieces on the board	1 – 32 pieces
Must be able to move chess pieces to desired location without human intervention	
Pieces should move at a reasonable speed	< 2 inches/second
Board moves should be completed within a reasonable amount of time	< 15 seconds
Board must be able to handle piece movements that involve "jumping" over other pieces	
Board must be able to recognize captured pieces	
Board must be able to recognize and adjust to promoted pieces	
Board should be able to react quickly to user inputs	< 2 seconds
Board should be reasonably light-weight	< 10lbs
Board dimensions should not exceed standard size by more than 3 inches	< 24in x 24in
Software Requirements	***Specifications***
Must track all piece movements	>= 32 pieces
Must have a user interface with a desktop view	
Must have virtual representation of the physical board	
Must be able to programmatically send commands to PCB via cable or WIFI	
Must have a database in order to record game moves	
Must provide opponent play decisions via AI	

Table 1: Project Requirements and Specifications

STRETCH GOALS

The following bullet points contain our potential stretch goals in order of priority:

- Allow the player to move their own pieces physically and board tracks these movements
- Two player functionality
- LED animations
- Support multiple games (Chess, D&D, ect)
- Leverage display technology and PC to show suggestions and effects during a match
- Support voice control

HOUSE OF QUALITY

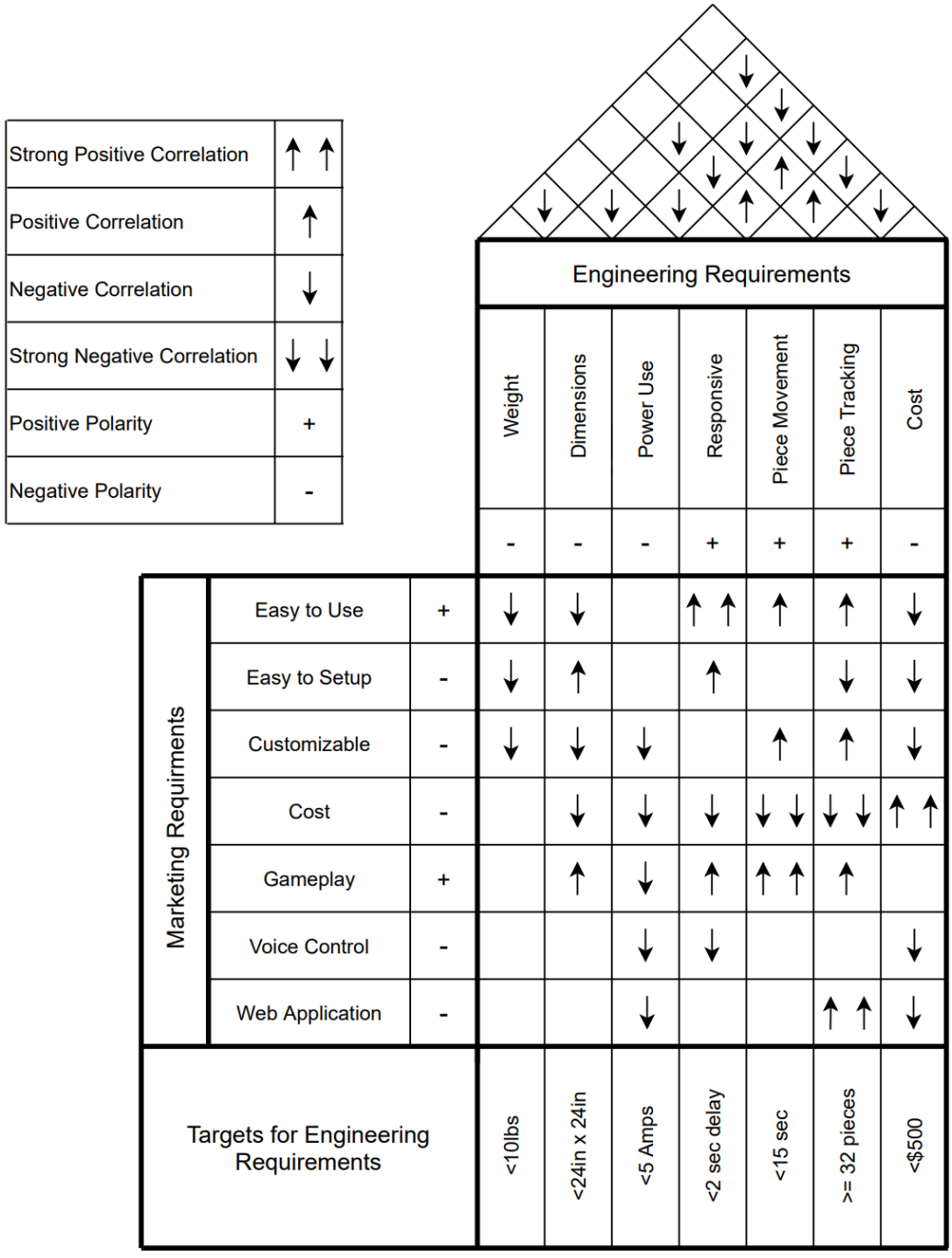

Figure 1: House of Quality

BUDGETING AND FINANCE

Arcane Game Board Estimated Budget				
Description	***Quantity***	***Estimated Cost***	***Total Cost***	***Reference Product***
600mm Linear Motion Rod	4	$5.5975	$44.78	Reliabot Rod
Linear Ball Bearing	10	$1.199	$11.99	ucxcell LBBs
Timing belt + Pulley Wheel	1	$10.99	$10.99	Houkr GT2
Electromagnet	1	$14.49	$14.49	uxcell
Control PCBs Estimate	1	$50.00	$50.00	Estimated
Power PCBs Estimate	1	$40.00	$40.00	Estimated
Construction Material Estimate	1	$100.00	$100.00	Estimated
Stepper Motors	2	$16.49	$32.98	Owned
PLA Plastic Spool	1	$19.99	$19.99	Owned
Total:			$325.72	

Table 2: Estimated Project Budget

MILESTONES

Milestones and Due Dates		
Senior Design 1		
Week	***Date***	***Task***
1	1/17/21-1/23/21	Project Ideas/Brainstorming
2	1/24/21-1/30/21	Project Selection
3	1/31/21-2/6/21	Project Specifics and Finalization
4	2/7/21-2/13/21	Divide and Conquer 2.0
5	2/14/21-2/20/21	Design Research
6	2/21/21-2/27/21	Decision on piece moving mechanism
7	2/28/21-3/6/21	Complete first 30 pages of Report
8	3/7/21-3/13/21	Research and report
9	3/14/21-3/20/21	Decision on piece identification
10	3/21/21-3/27/21	Decision on power supply
11	3/28/21-4/3/21	Complete/submit first 60 pages of Report
12	4/4/21-4/10/21	Report writing
13	4/11/21-4/17/21	Complete/submit first 100 pages of Report
14	4/18/21-4/24/21	Finalize Report
15	4/25/21-5/1/21	Complete/submit Report (120 pages)
Senior Design 2		
0	5/2/21-5/15/21	Plan and Order Parts
TBD	Mid-May	Board assembled and PCB finalized
TBD	Late-May	Everything wired and verified
TBD	Late-July	Testing
TBD	Mid-August	Presentation and final report

Table 3: Project Milestones and Due Dates

BLOCK DIAGRAMS

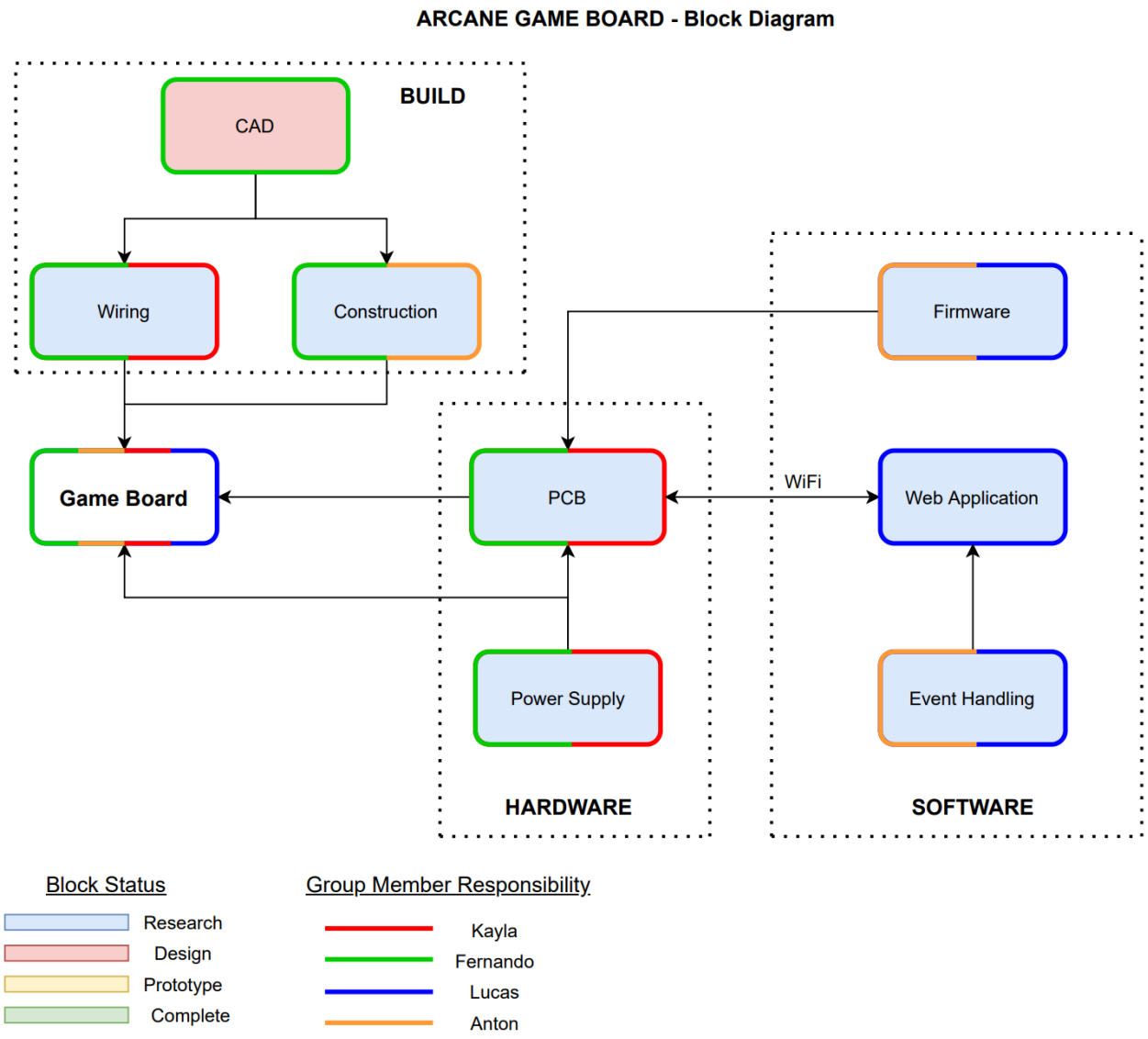

Figure 2: Overall Block Diagram - Status and Member Responsibility

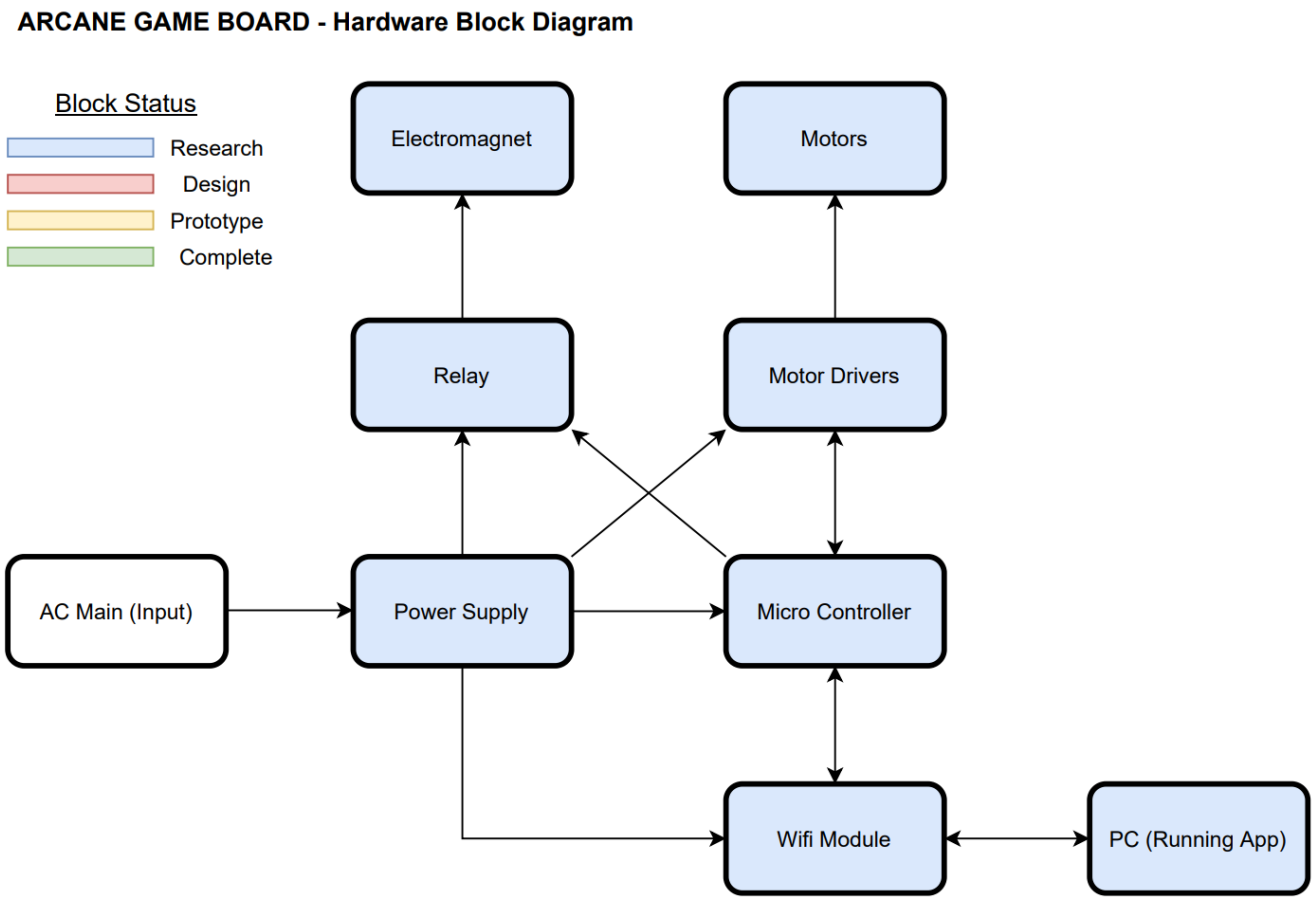

Figure 3: Hardware Block Diagram

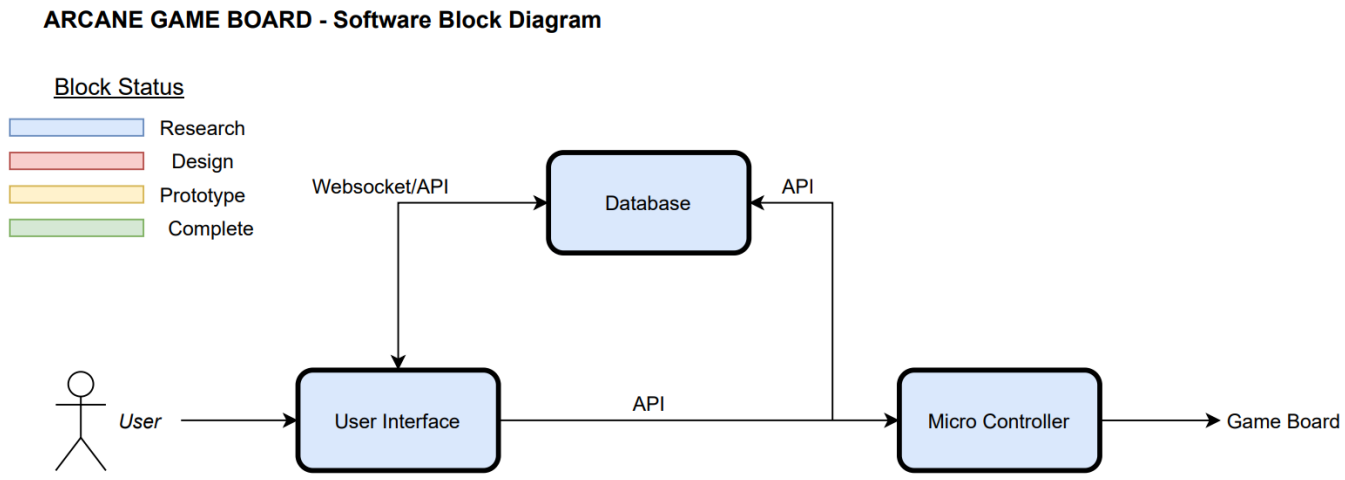

Figure 4: Software Block Diagram

CONCEPT DRAWINGS

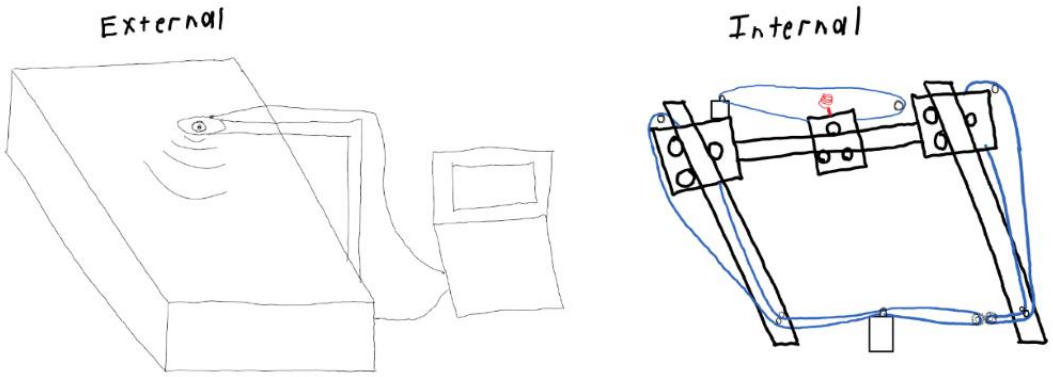

Figure 5: Napkin Drawing

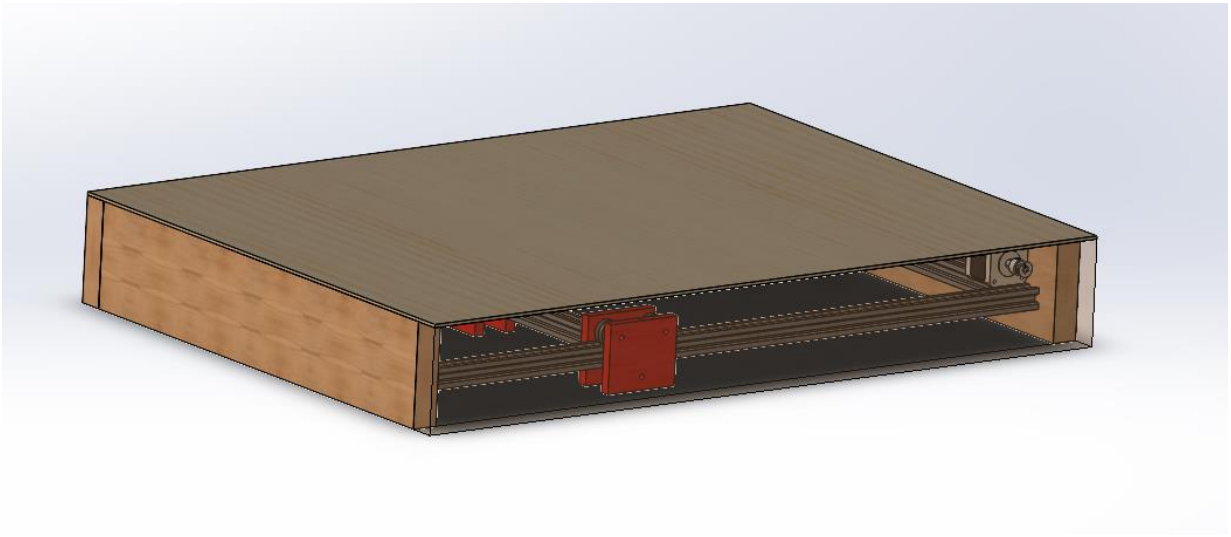

Figure 6: CAD Concept Drawing

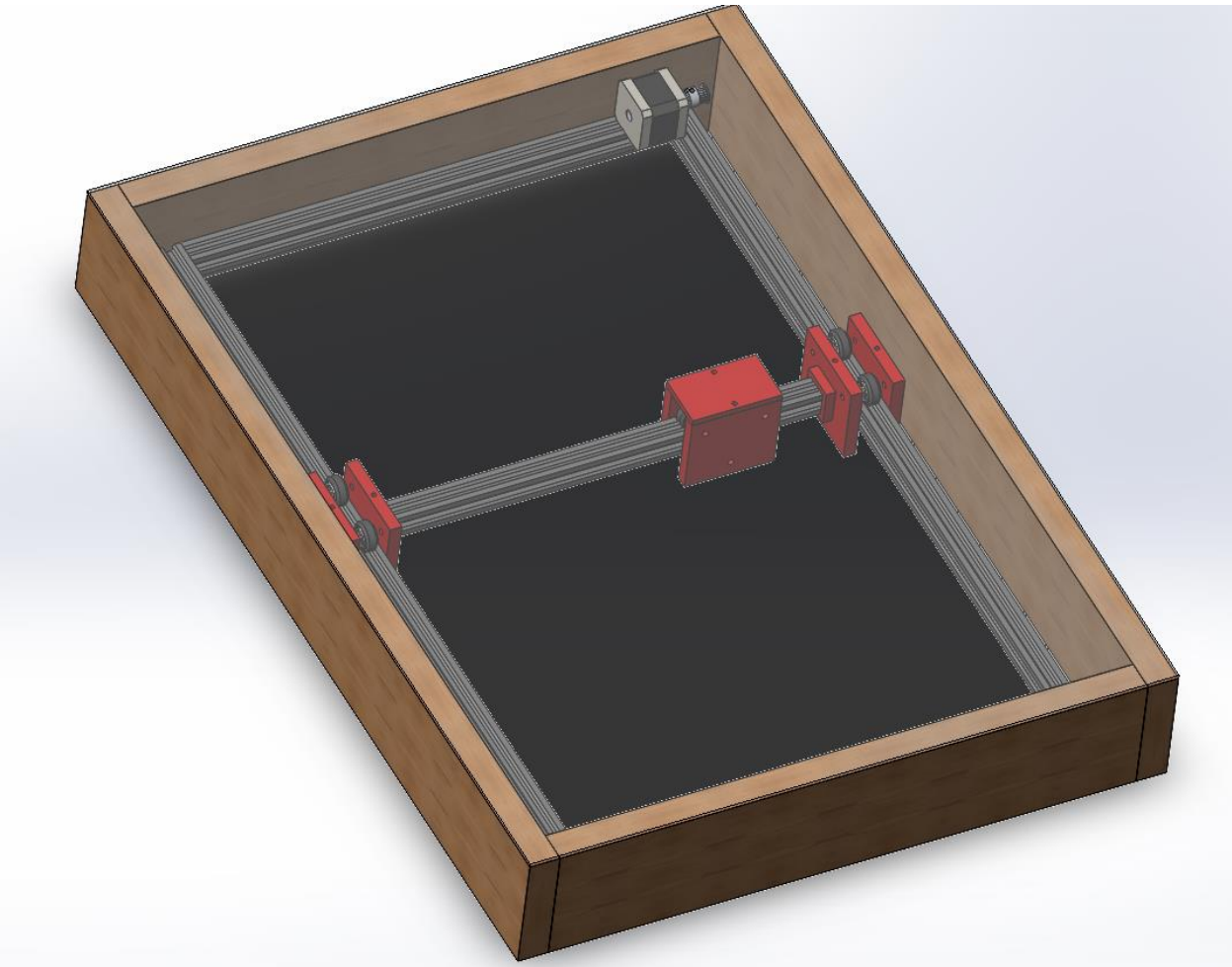

Figure 7: CAD Concept Drawing