Animatronic Dragon

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Advisor Approvals

APPROVAL 1: CAE

University of North Texas

Department of Mechanical Engineering

MEEN 4250 / MEET 4790 (Spring 2024)

Faculty advisor approval form 1

Instructions: This form is to be signed by the faculty advisor and attached after discussing the team's Project Plan, CAE Analysis and Optimization.

Team name: Animatronic Dragon

Faculty advisor: Mark Wasikowski

I confirm that the work presented to me by the team indicated above is sufficient for the team progress, and that the team has considered and implemented all my suggestion and comments to meet the course requirements.

Advisor signature:

Date: 2/14/24

APPROVAL 2: BLUEPRINTS AND GD&T

University of North Texas

Department of Mechanical Engineering

MEEN 4250 / MEET 4790 - Spring 2024

Faculty advisor/Client approval form 2

Instructions: This form is to be signed by the faculty advisor and attached after discussing the team's Engineering Blueprints with GD&T.

Team name: Animatronic Dragon

Faculty advisor: Yunwei Xu

I confirm that the work presented to me by the team indicated above is sufficient for the team progress, and that the team has considered and implemented all my suggestion and comments to meet the course requirements.

Advisor/Client signature: Yunwei Xu

Date: 3/15/24

Project Overview

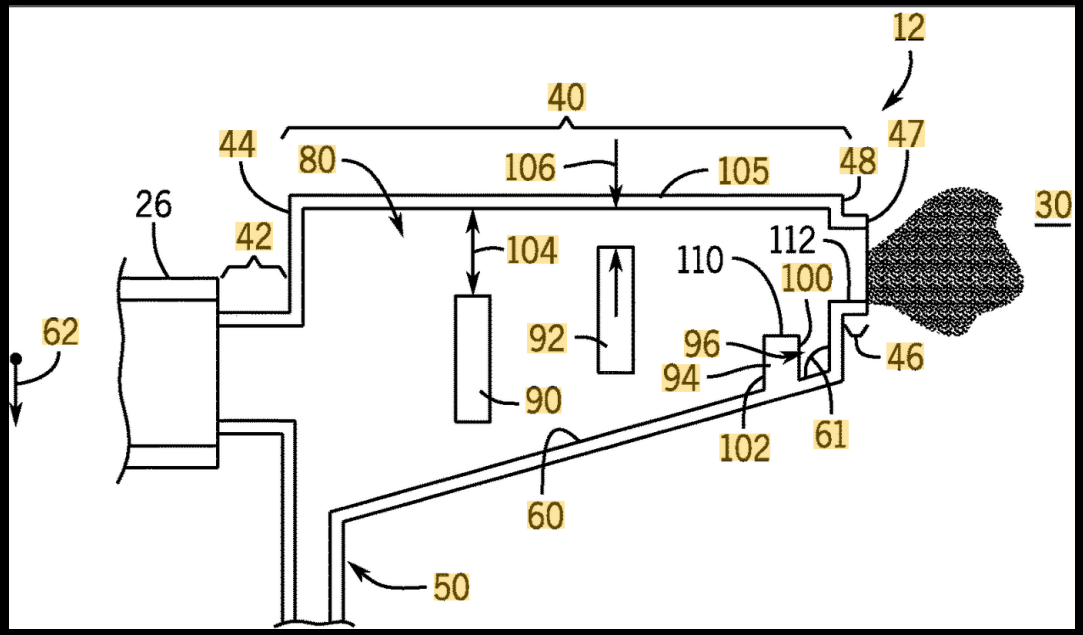
- Sponsor: James Brauer
- Objective: Design and build a western-style animatronic dragon that has...
  - Articulated Motion
  - SFX (i.e smoke, glowing eyes)
  - Detailed Aesthetics
  - Audio/Video integration with VR
- Product Performance: Animatronic Dragon will move and interact with the environment according to user input through VR or controller. The special effects will add to the client's Halloween environment.

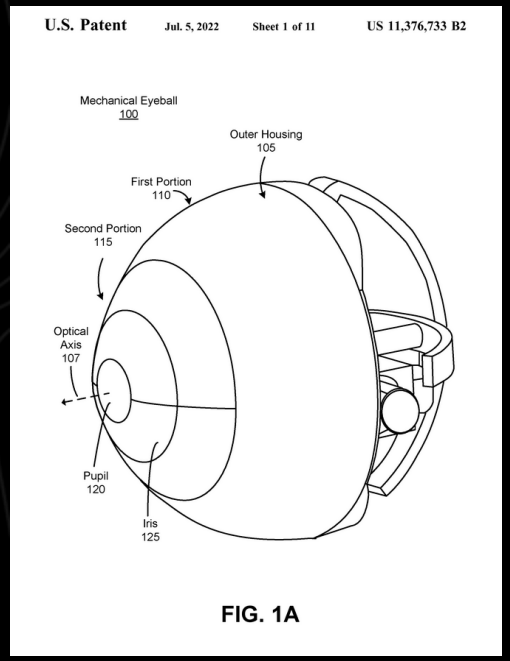
Product Design Specification (PDS)

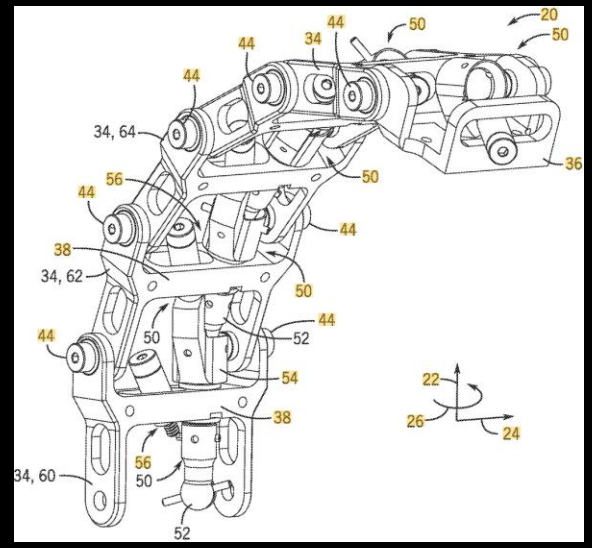
- **Operation**
  - Will move based off user input from VR/Controller
- **Dimensions**
  - No more than 5 feet tall when fully extended
  - Each component will not exceed 50 lbs.
- **Power**
  - Standard 15-amp garage plug
- **Aesthetics**
  - Typical western-style fantasy dragon
  - Realistic texture on features such as skin and horns.
- **Ergonomics:**
  - Can be handled safely by people when assembling/storing
- **User Interface**
  - User will be able to project voice and dragon will mirror movement based off user input from VR
  - User will be able to "view" from the dragon
- **Lifetime:**
  - Last 5 years, with long periods of inactivity between uses
- **Operation Loads:**
  - Able to withstand forces from its own weight, as well as added features such as the skin
- **Materials**
  - Frame and base will be composed of wood, metal, and PVC
  - Skin will be silicone rubber
  - Hard details such as teeth or horns will be hard polymers

Patents

- Patents:
  - US11203113B1: Linkage system
    - An advanced skeletal system design that is used as inspiration for our design. We opted to keep it simpler for budget reasons.
  - US11376733B2: Eyeball rotation system
    - One of the hardest aspects to tackle within budget. This eye helped us solve that problem
  - US20220371029A1: Nozzle system
    - Our usage of this is adding a 'fire-breathing' practical effect to our system.

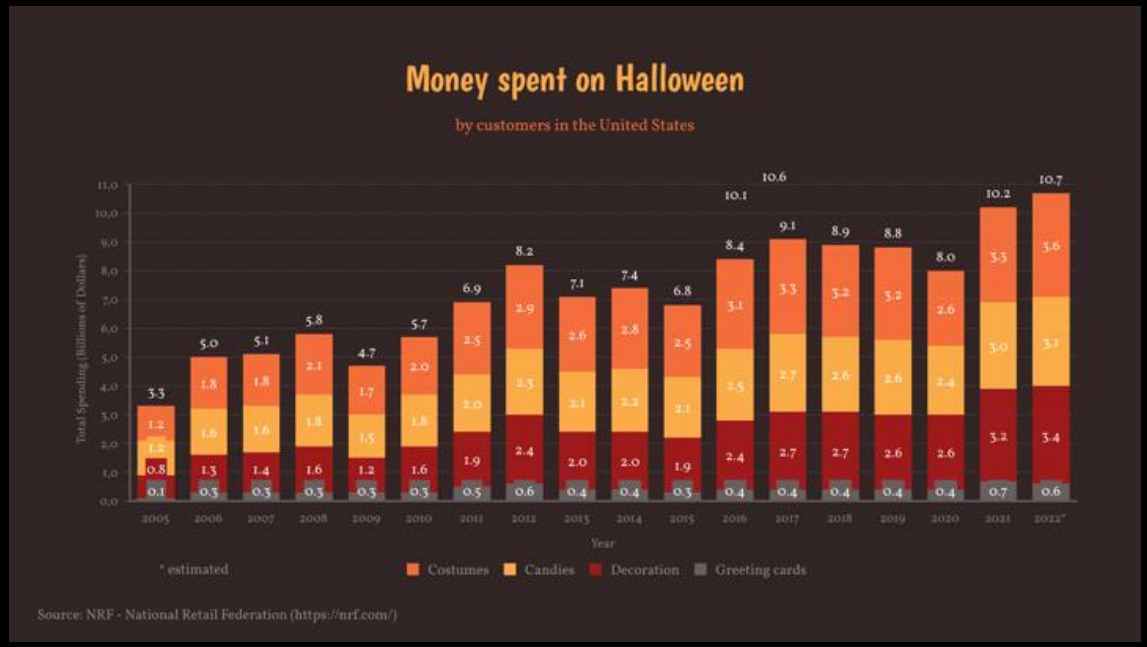






Patents and Market

- Market:
  - Primary Market: Residential Halloween
    - 3.4 Billion-dollar market
  - Other potential markets:
    - Theatre
    - Themed Entertainment
  - Potential competition/collaborators:
    - Walt Disney Imagineering
    - Garner Holt
    - Animax
    - Lifeformation
    - Billings production Co.



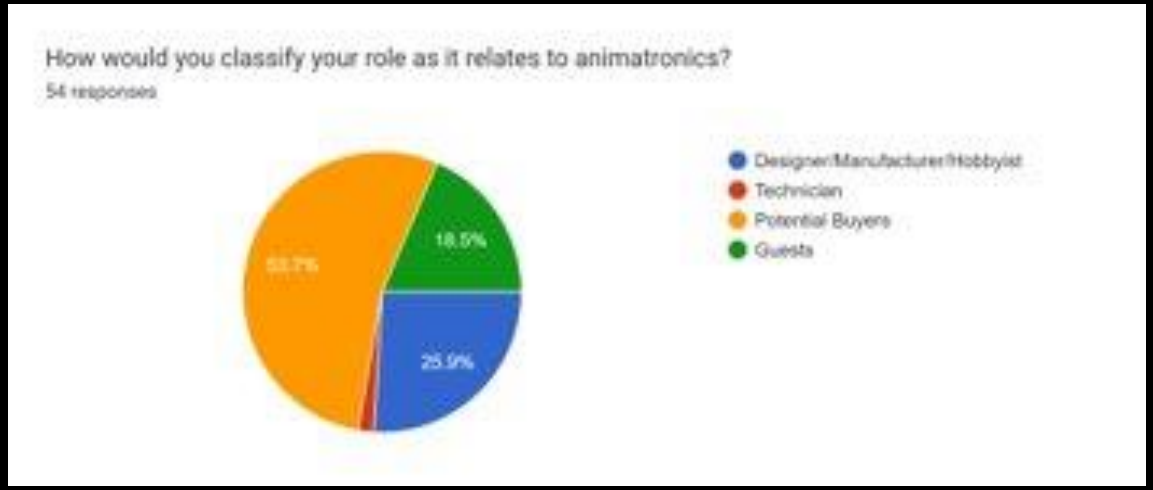
- For this project to have a large scale market release, more time would need to be taken to upgrade the design to the market's standard due to the nature of the companies competing.
- This project is a commissioned piece it is designed to the commissioners' specs. Rather than to be mass marketed.

Market Insight: IAAPA Expo

- Insight included
  - How patents are not typically used in this realm as it limits the creativity.
  - How when considering the hosing to attach to the fog machine will need a larger tubing than we may initially think.
  - Some companies don't use servo motors but
    instead utilize pneumatic actuators

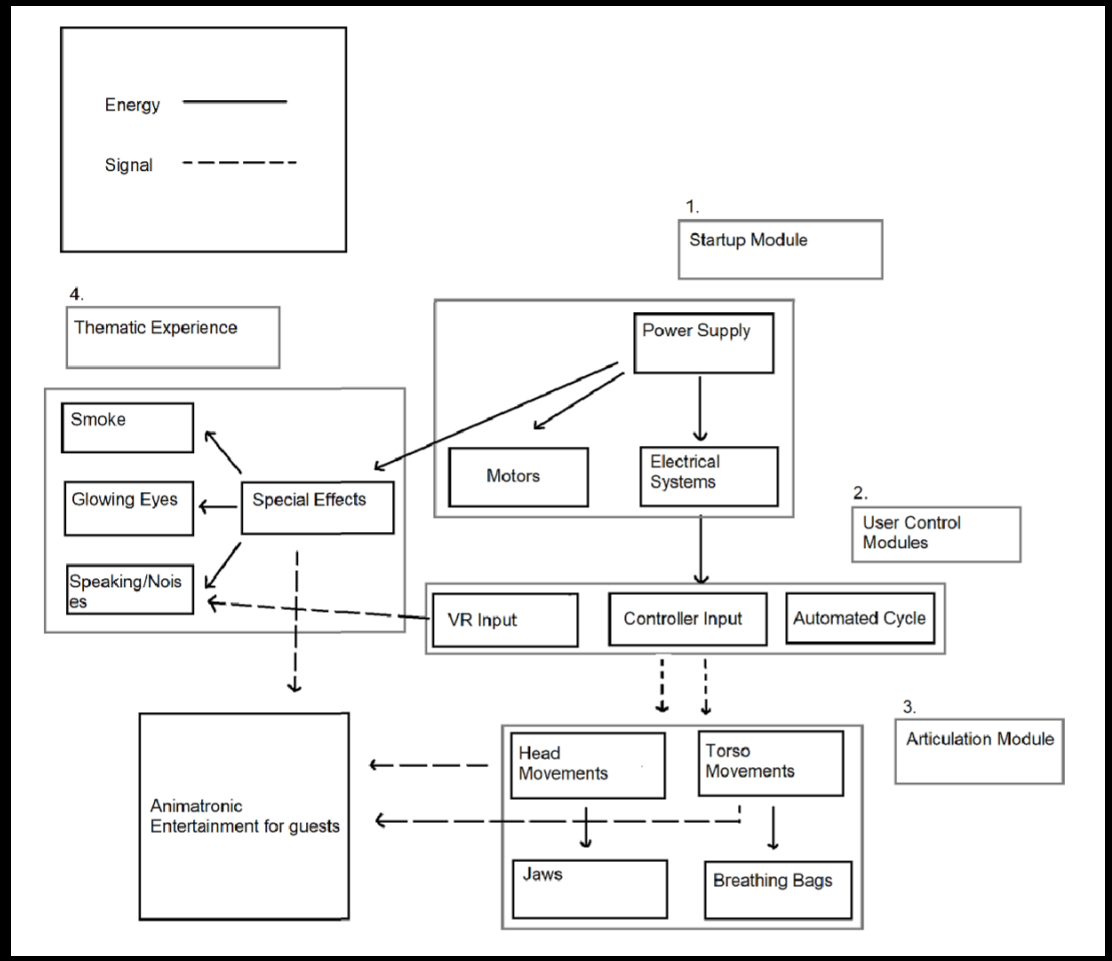
Customer Market Research

- Consumer Market Research:
  - A total of 54 responses
  - Of which we had 14 designers
  - Of which 29 were interested in purchasing within our proposed price
  - Most important Design Considerations
    - Top 3 (all had 86.3%)
      - Resilience
      - Aesthetics
      - Maintainability
    - Articulation (80%)
    - Special Effects (71.83%)



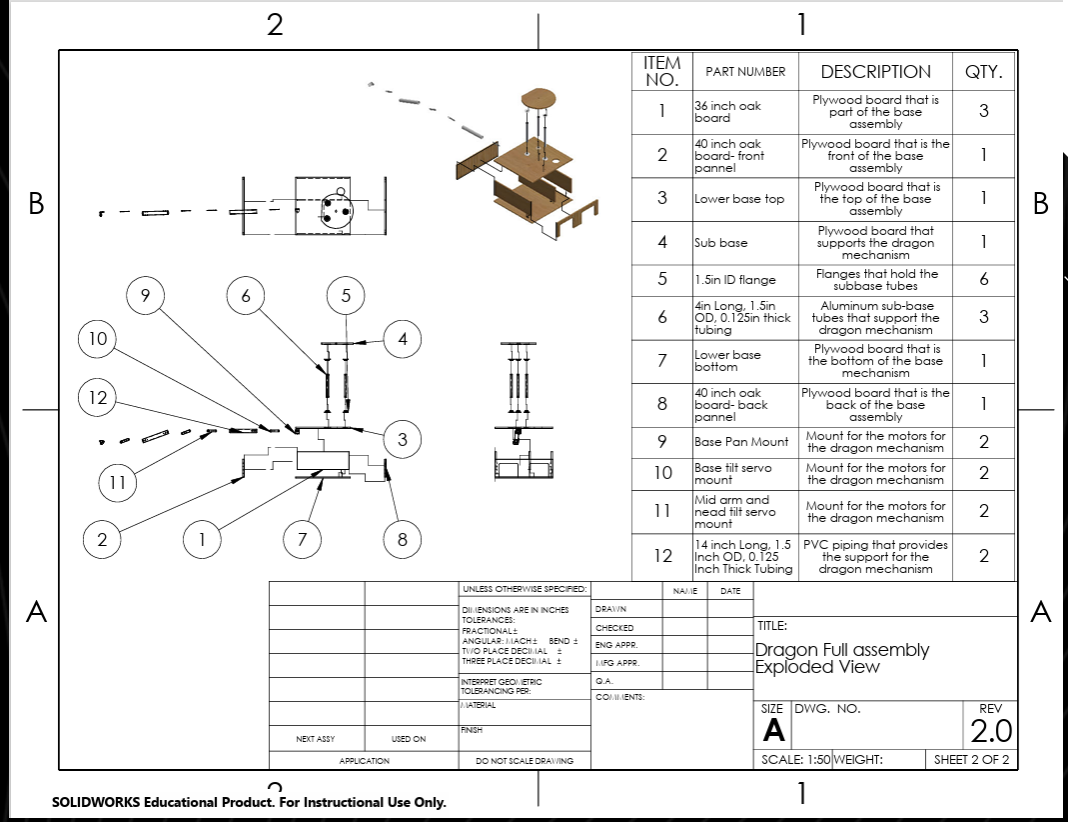
Product Architecture

- Startup Module: The startup module serves as the initial point of interaction for the animatronic dragon. It communicates with other modules to establish a connection, perform self-checks, and prepare for user engagement.
- User Control Module: The user control module is where the interaction between the dragon and the user primarily takes place. This module translates user commands into actions, controlling movements, sounds, and other features based on user input.
- Articulation Module: The articulation module is responsible for the physical movement of the animatronic dragon. It coordinates the motors, servos, and other mechanical components that control the dragon.
- Thematic Experience Module: The thematic experience module manages the dragon's audiovisual effects, including sound effects, lighting, and visual displays.



Conceptual Design: Assembly

- Dragon Full Assembly Exploded View: Visual guide for constructing a mechanical dragon, including an isometric view for clarity.
- Detailed Components: Parts list with plywood and aluminum pieces, servos, and PVC piping, each with a specific role in the assembly.
- Bill of Materials: Right side of the image enumerates parts with numbers, descriptions, and quantities, serving as an assembly checklist.
- Assembly Guidance: Includes an exploded view that spatially separates the components for better understanding of assembly and part relationships.



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	36 inch oak board	Plywood board that is part of the base assembly	3
2	40 inch oak board- front pannel	Plywood board that is the front of the base assembly	1
3	Lower base top	Plywood board that is the top of the base assembly	1
4	Sub base	Plywood board that supports the dragon mechanism	1
5	1.5in ID flange	Flanges that hold the subbase tubes	6
6	4in Long, 1.5in OD, 0.125in thick tubing	Aluminum sub-base tubes that support the dragon mechanism	3
7	Lower base bottom	Plywood board that is the bottom of the base mechanism	1
8	40 inch oak board- back pannel	Plywood board that is the back of the base assembly	1
9	Base Pan Mount	Mount for the motors for the dragon mechanism	2
10	Base tilt servo mount	Mount for the motors for the dragon mechanism	2
11	Mid arm and nead tilt servo mount	Mount for the motors for the dragon mechanism	2
12	14 inch Long, 1.5 Inch OD, 0.125 Inch Thick Tubing	PVC piping that provides the support for the dragon mechanism	2

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES
TOLERANCES:
FRACTIONAL ±
ANGULAR: MACH ± BEND ±
TWO PLACE DECIMAL ±
THREE PLACE DECIMAL ±
INTERPRET GEOMETRIC TOLERANCING PER:
MATERIAL
FINISH
NEXT ASSY | USED ON
APPLICATION | DO NOT SCALE DRAWING

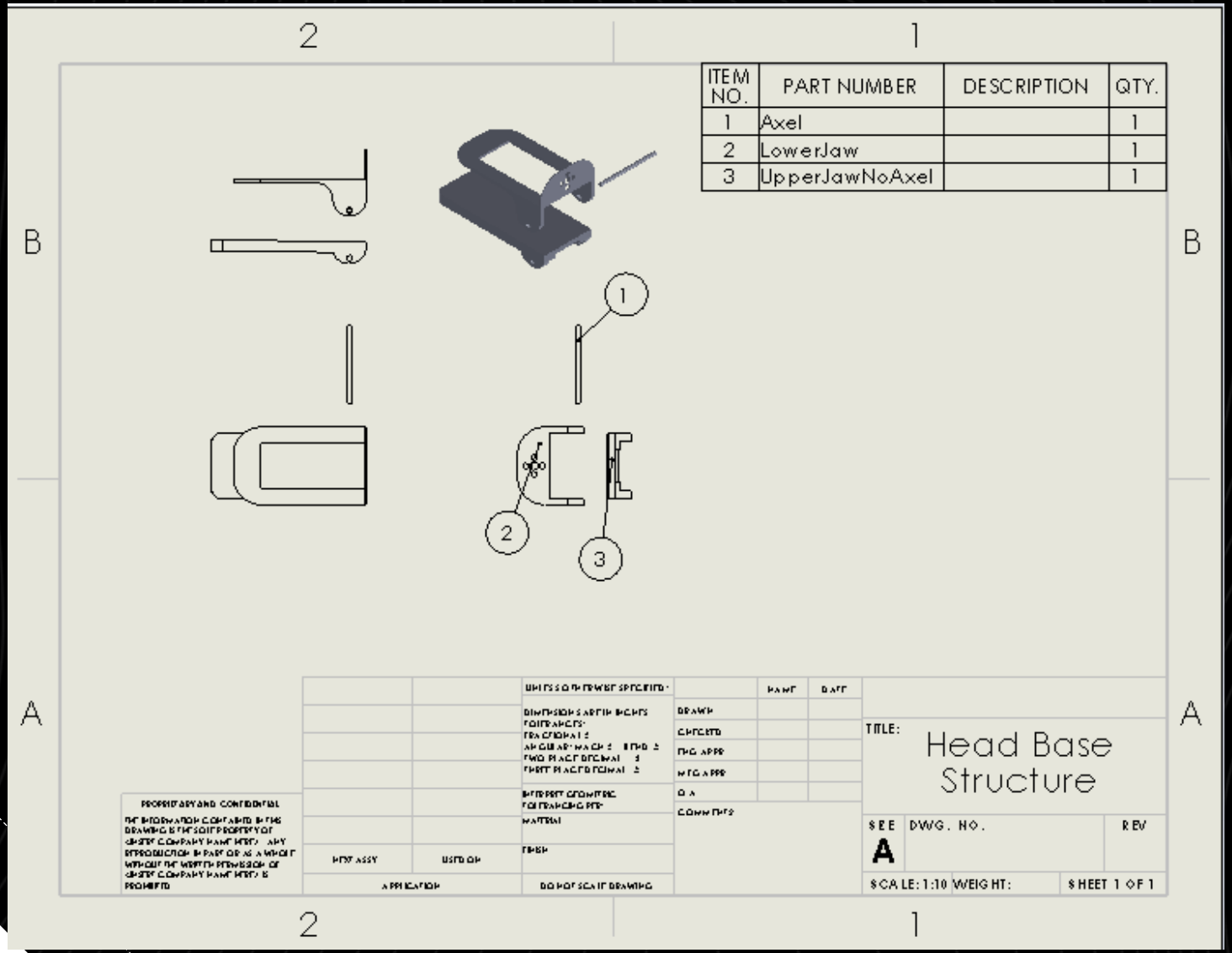
	NAME	DATE
DRAWN		
CHECKED		
ENG APPR.		
MFG APPR.		
Q.A.		
COMMENTS:		

TITLE: Dragon Full assembly Exploded View

SIZE A | DWG. NO. | REV 2.0
SCALE: 1:50 | WEIGHT: | SHEET 2 OF 2

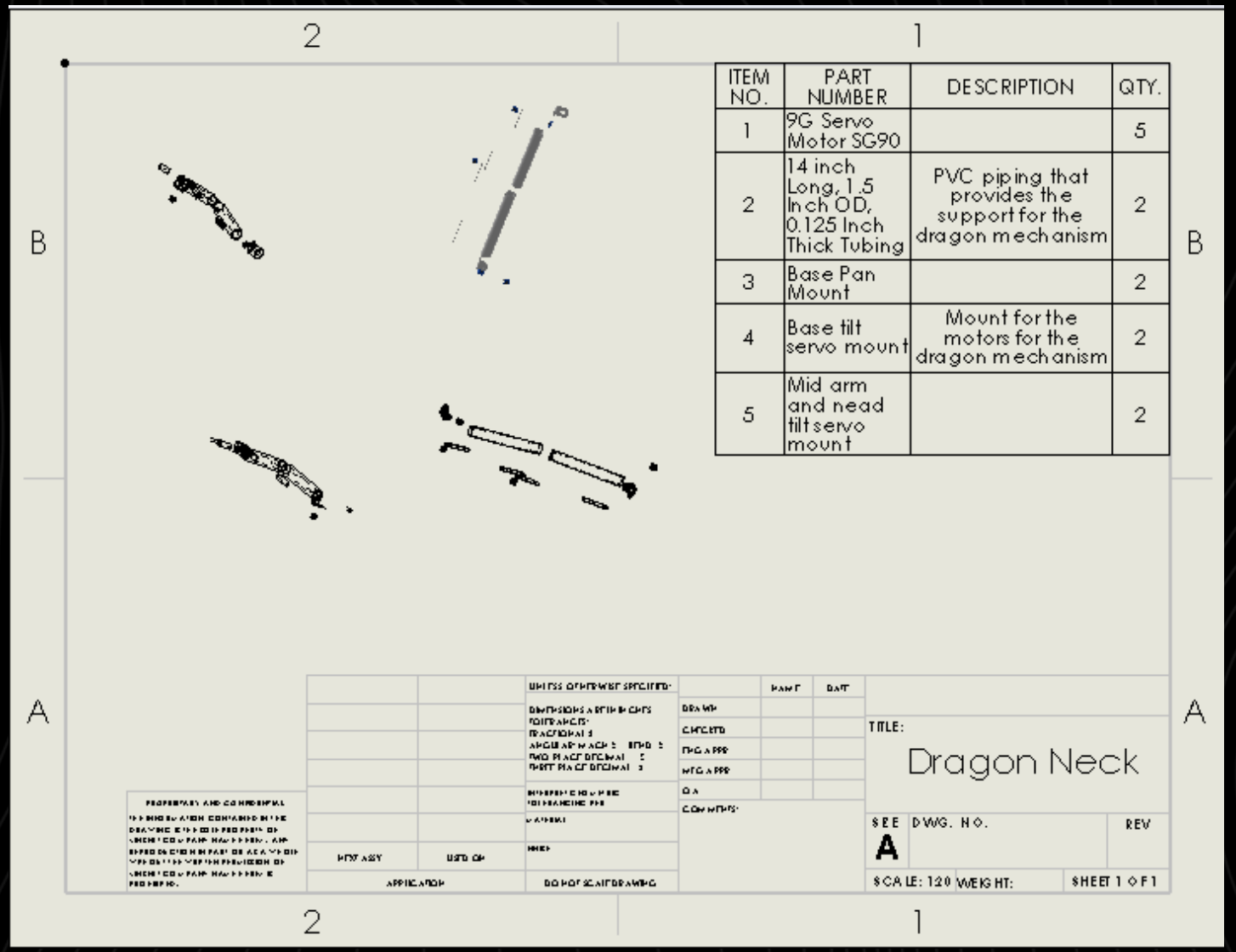
SOLIDWORKS Educational Product. For Instructional Use Only.

Conceptual Design: The Head



- Focused on the jaw mechanism of the head. With the upper jaw being relatively static compared to the lower jaw plate doing all the movement.
- The rest of the head is too complicated to model within Solidworks as it doesn't work well with modeling organic shapes.

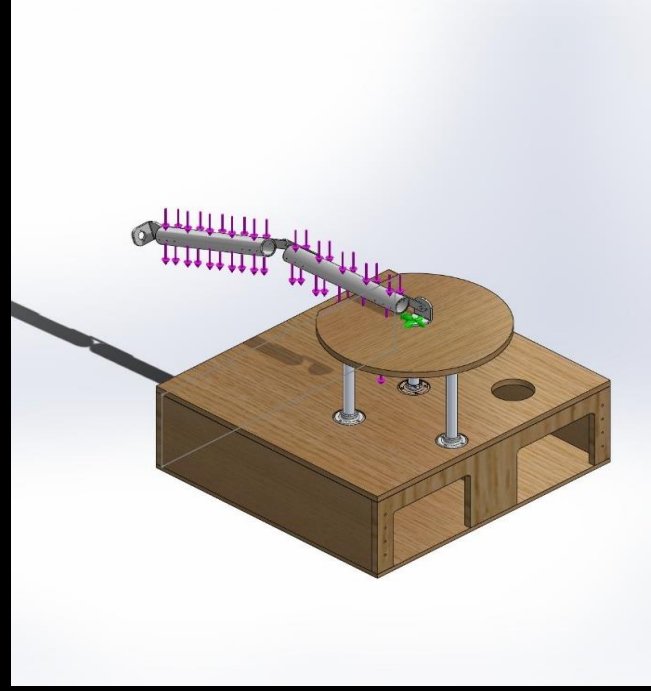
Conceptual Design: The Neck

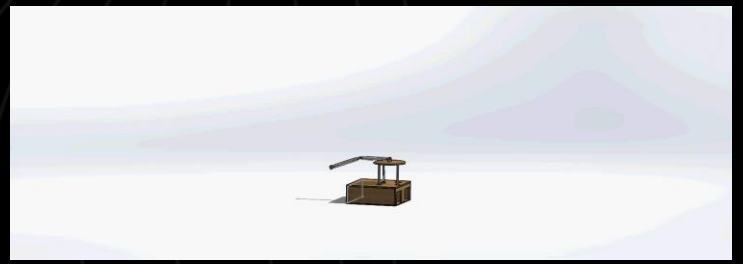


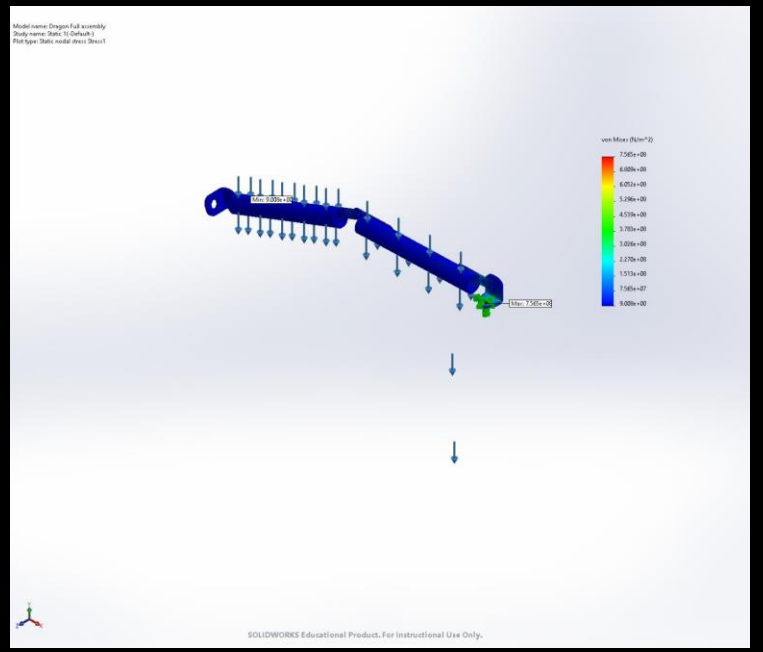
ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	9G Servo Motor SG90		5
2	14 inch Long, 1.5 Inch OD, 0.125 Inch Thick Tubing	PVC piping that provides the support for the dragon mechanism	2
3	Base Pan Mount		2
4	Base tilt servo mount	Mount for the motors for the dragon mechanism	2
5	Mid arm and nead tilt servo mount		2

CAE: FEA on Neck in extreme static position

- Our CAE focused on determining the points of deformation when an estimated weight of 50lbs of force was put on the dragon's neck while stationary at it's most extreme point when the neck is nearly completely horizontal
- Initial static studies showed a concern of the outer tubing being very weak due to high Von Messes Stresses on the vertebrae.
- Optimization study was conducted and resulting our forces shifting to a part that is a placeholder model for a store bought bracket.
- When optimizing the tubing to make the neck out of we tested aluminum tubing and PVC and found that 1 inch PVC was most efficient for our purposes based on our applied force.

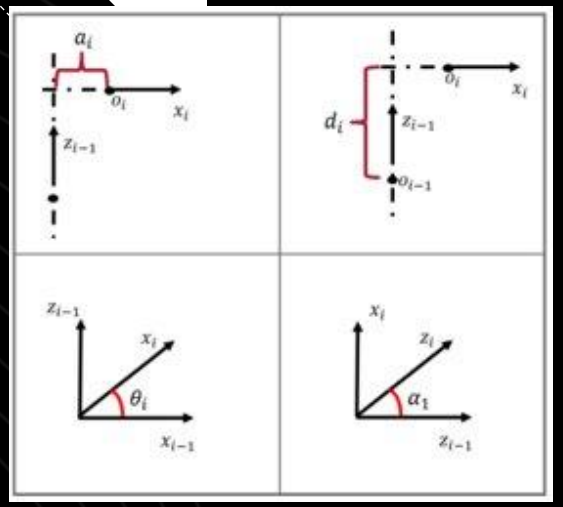


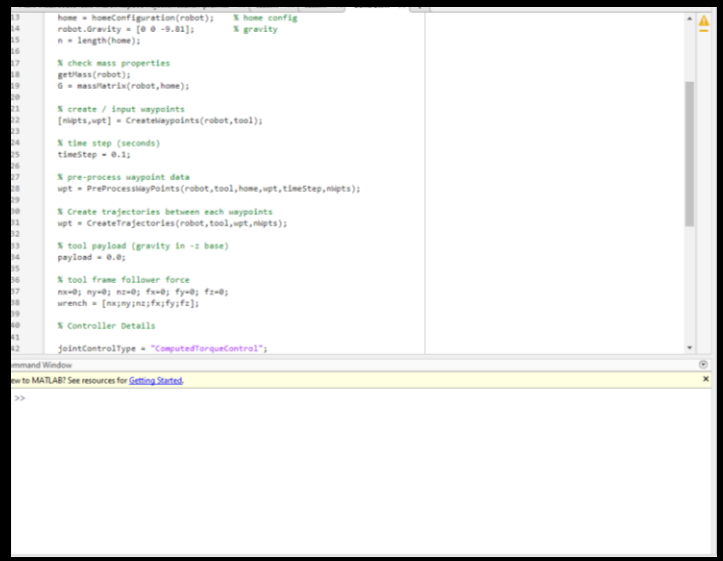


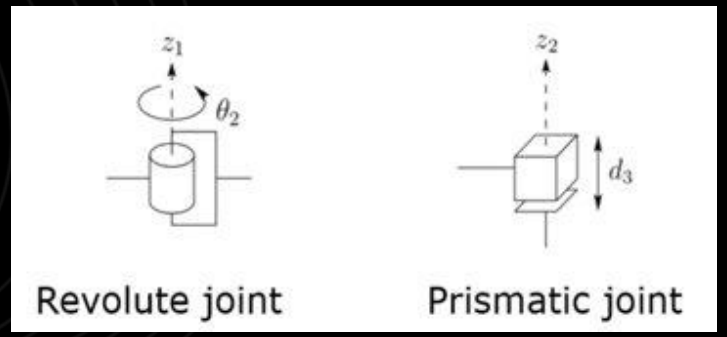


Motor Sizing

- Has been used:
  - Currently for our small-scale model we have been working to convert our SolidWorks Model into the Matlab Robotics Toolkit using the import Simscape Bodies feature. Once we do that, we will be developing our DH parameters to start running a trajectory analysis to show the limitations of our design between both Joint Space Trajectory and Cartesian Trajectory which are discussed in MEEN 4760: Robotics and Automation. These use concepts further break into concepts of Jacobean Matrices which are discussed in depth for both MATH 2700: Linear Algebra and MEEN 3250: Analytical Methods.
- Plan on using:
  - We plan to utilize System Dynamics and Controls along with more concepts from Robotics to determine the control system for the animatronic dragon. In addition, once we can visualize the movements and can determine the resulting force on the system we will use that information along with various chapters from the material science textbook to pick materials that are going to meet our desired conditions such as mechanical properties, corrosion, and failure rates.







$$J = \begin{bmatrix} \frac{\partial x}{\partial q_1} & \frac{\partial x}{\partial q_2} & \frac{\partial x}{\partial q_3} & \cdots & \cdots & \frac{\partial x}{\partial q_n} \\ \frac{\partial y}{\partial q_1} & \frac{\partial y}{\partial q_2} & \frac{\partial y}{\partial q_3} & \cdots & \cdots & \frac{\partial y}{\partial q_n} \\ \frac{\partial z}{\partial q_1} & \frac{\partial z}{\partial q_2} & \frac{\partial z}{\partial q_3} & \cdots & \cdots & \frac{\partial z}{\partial q_n} \\ \hat{\omega}_1^b & \hat{\omega}_2^b & \hat{\omega}_3^b & \cdots & \cdots & \hat{\omega}_n^b \end{bmatrix}_{6\times n}$$

DFM, DFA, and DFC Overview

DFM

- For most manufactured parts, hand tools or power tools will suffice
- The manufacturing methods are simple and low-cost, as well as there being a low number of steps to manufacture each part
- The most common tools being used will be saws, drills, and sanders

DFA

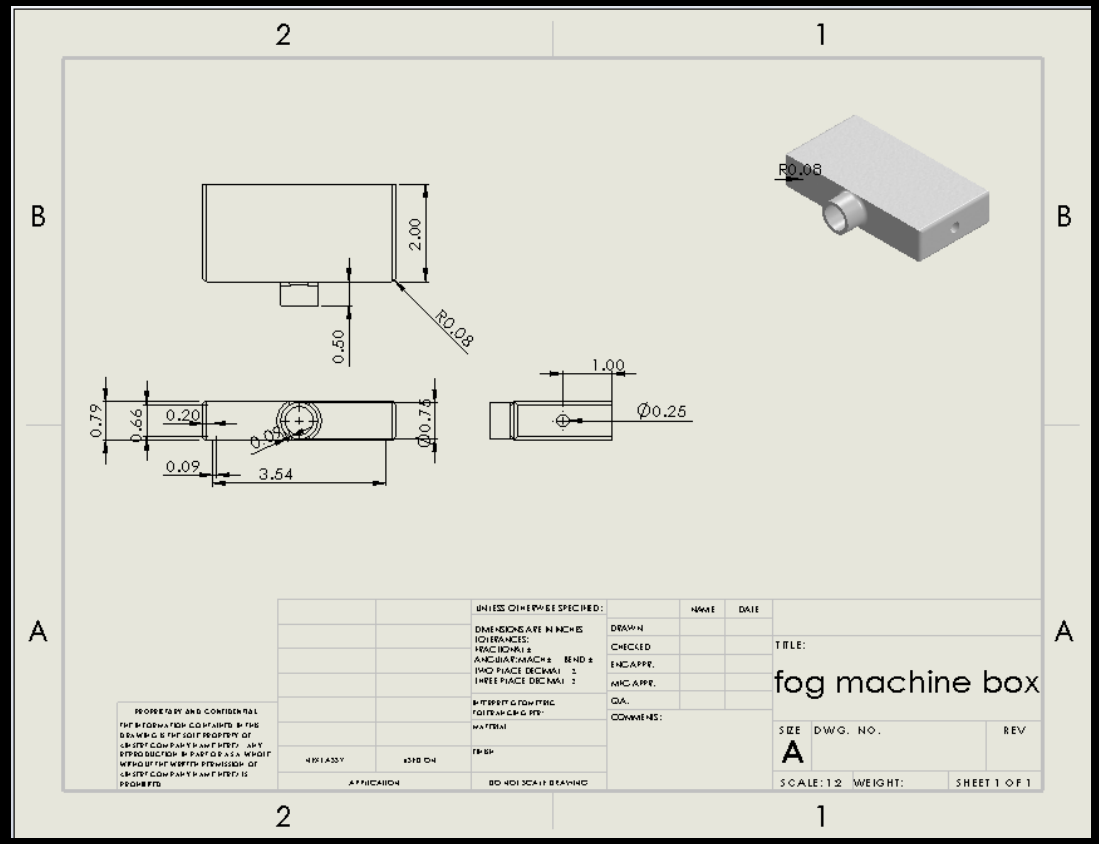
- 21 total components, including manufactured and purchased parts
- Improved design by removing a motor, saving 4 components
- Base size was also reduced to save cost for materials
- Overall score of 72%

DFC

- Overall, he raw material for the manufacturing is low-cost
- However, the scrap produced is of low value and is not worth selling
- If the manufacturing was outsourced, a majority of budget would be spent on labor and tooling
- The manufacturing of the dragon is currently in budget

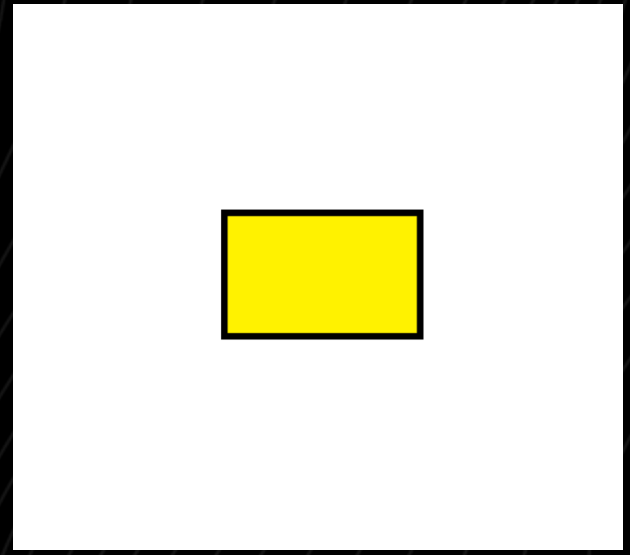
Special Effects- Jonathan

- Working to design an attachment that converts the Rectangular outlet of the fog machine into a circular outlet large enough for us to add the tubing over.
- Ran tests to determine the outlet temperature but was inconclusive at that time.
- In the coming week or two we plan on cleaning out the fog machine and determining the outlet temperature



VR/Programming - Max

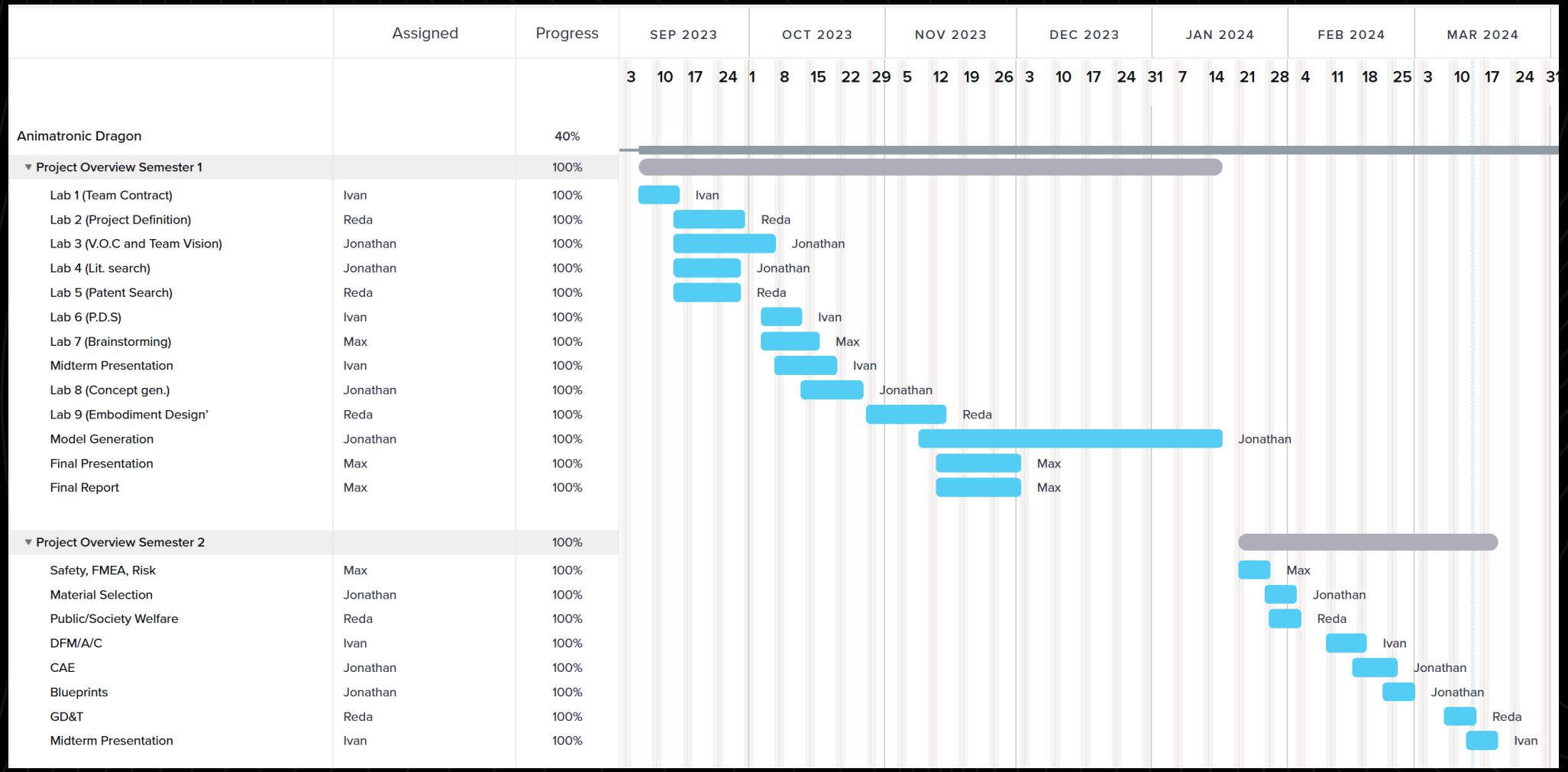
- Three-Pronged Approach
  - Translating the motion of the pilot in a gaming software into a grid
    - The software environment has been completed and needs to be tested
  - Taking raw numbers from the produced grid system
    - Cutom code as been made to read the data from the produced grid system
  - Converting the data from the grid into motion of the motors
    - A flow chart has been made and this is the current primary focus



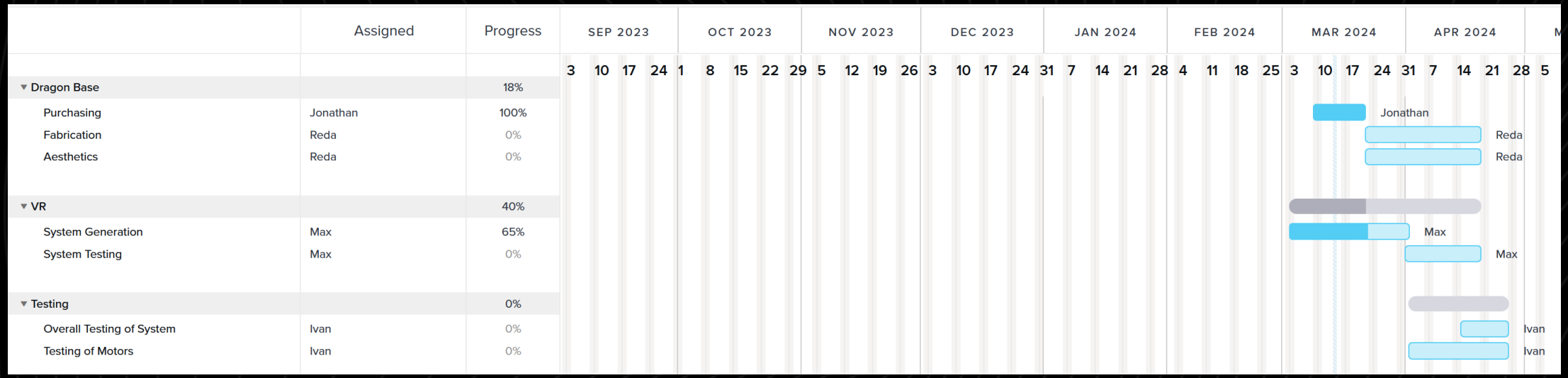
Aesthetics - Reda

- Manufacturing Methods: Forming and Casting
- The aesthetics will have the highest costing material for the dragon
  - Testing will be done to ensure materials will not be wasted
- Materials for aesthetics:
  - Skin: “Dragon-Skin” Silicone mixture/Fabric
  - Horns/Teeth/Small Details: 3-D Printed/Silicone Mixture
  - Color: Silicone Based Paints

Gantt Chart 2023/2024, Assignments



Gantt Chart 2023/2024, Manufacturing



Gantt Chart Overview

FIRST SEMESTER

- First semester focused on the background research needed to design the dragon's frame.
- Winter break was focused on further design changes and refining simulations

SECOND SEMESTER

- Second Semester will focus on building the dragon and programming the electronics.
  - The aesthetics of the dragon will also occur during the manufacturing of the dragon's "skeleton"
- Assignments help improve design, as well as outline manufacturing methods
- Purchasing and shipping times are accounted for to prevent any unexpected delays

Lessons Learnt and Planning Ahead

- Lessons learned:
  - Time management, open communication, and teamwork
- Senior Design 2 Plan:
  - Post spring-break: 100% focus on fabrication of the dragon and completing the VR program.
  - Testing time will be required at the end of the semester, will overlap with manufacturing since motors can be tested independently
  - “Smaller” manufacturing: When manufacturing, instead of requiring everyone present, small groups will be assembled depending on their strengths
    - This works better since team’s schedules are complicated to align