Design Components & Final Design

Overview-

Initially, the team was able to develop an overall theoretical concept of how the launcher would work. In order to decide how it was actually going to work, it was determined that the launcher could be broken up into different components. Because the launch system components are supposed to work together, it is obvious that design concepts of certain components influence other component's performance or feasibility. The team chose to explore all possibilities and during concept selection, design with the ability to integrate with other component concepts. This would insure that the team would not choose certain component concepts that will not work well with other concepts. The first component of the system deals with how the carriage would be released upon the pressure build in the charge chamber. This is called the Releasing System. The second component is that of the "carriage", which would be the part that attaches to the UAV and carries it down the barrel only to release it at the end of the barrel. This will be referred to as the Carriage Component. The third component of the system is of the charge chamber itself, particularly how to keep it airtight. An airtight seal would insure that the pressure build is sufficient to launch the UAV at the speed required. This will be referred to as the ATS (Air Tight Seal) component. The fourth component is dependent on the Carriage and Releasing System components. It addresses the problem of how to stop the carriage from exiting the barrel of the launch tube without damaging itself or the barrel. The fifth and last component is material/Misc. part selection. The reason the team considered this a component was that the materials within or on the launcher will be under high stresses and pressures. These high stresses and pressures are influenced by the length of the charge chamber. Once the overall design was chosen, the team was able to select the appropriate materials. All of the system components went through concept generation and selection.

Releasing System-

Tube Shape –

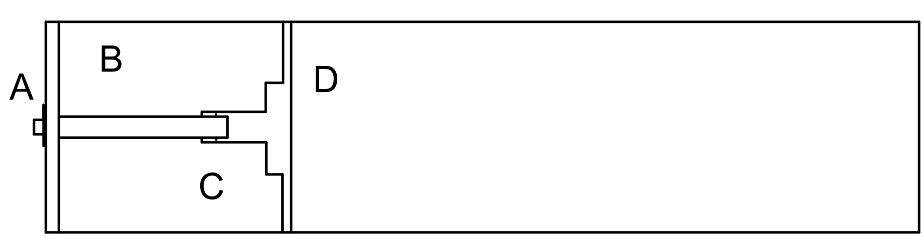
One of the first decisions that had to be decided in each pneumatic design was the geometry of the launch tube. The maximum dimensions for the launch tube were given for square and cylindrical tubes in the project specification. Using these maximum dimensions, the ratios of cross-sectional area to perimeter were calculated. The highest possible ratio was desirable, because it would yield the highest force behind the UAV with least amount of contact with the tube in the form of friction.

Active Release –

An active release mechanism, in the sense of this project, is one that the user has complete control over when the UAV will be launched. In this design, there is only the reservoir tank and a charge chamber. This concept moves the charge chamber inside the barrel and eliminates the use of an actuated/electronic valve. Since this concept eliminates the need of an actuated valve, it allows the team to make the charge tank larger, which decreases the pressure that the tank will need. Essentially, the user would be able to open a manual valve from the reservoir tank and build the pressure in the charge tank. The back of the carriage will be one side of the charge chamber. Once the desired pressure is reached, the user shuts off the valve to the reservoir and the carriage is actively held in place until the user wants to launch. This concept requires that there be some sort of device that can trigger the launch without the user having to be too close to the launcher. The customer does not want to have to touch the launcher in order to launch the UAV.

Push Pin –

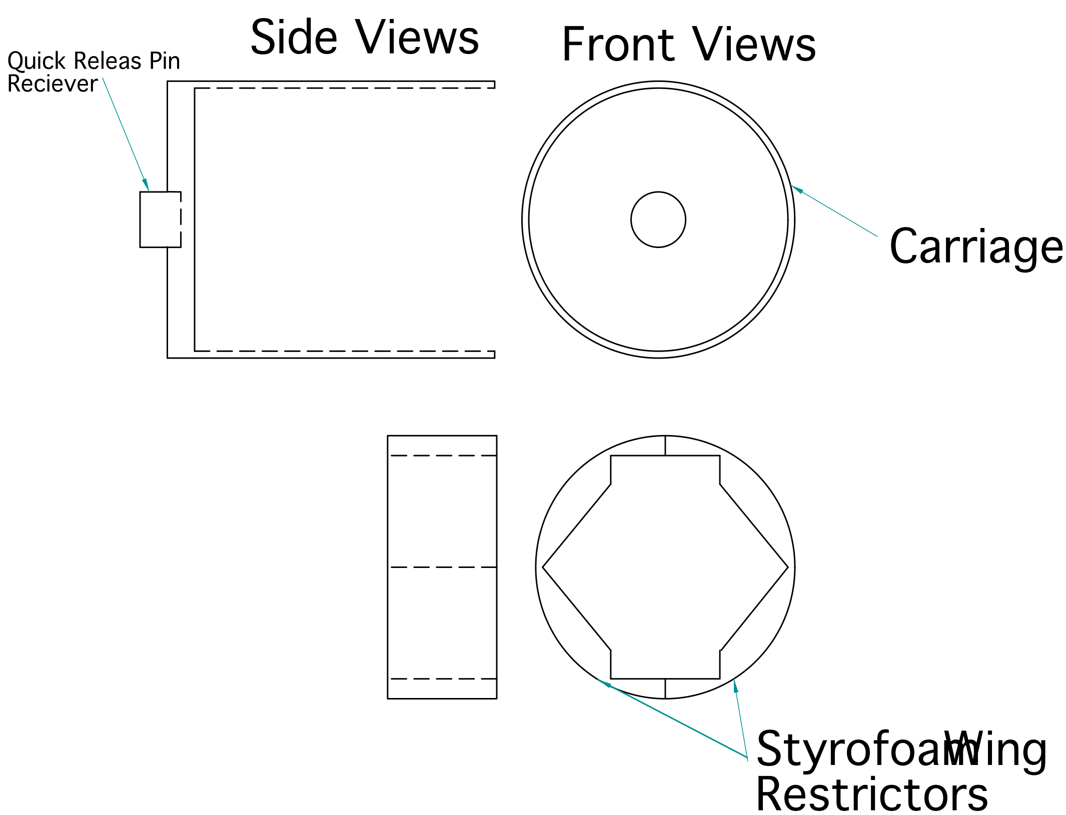
The push pin concept implements the use of a spring loaded quick release pin. The button of the push pin will extrude out of the back of the charge chamber. This is represented by point A in the picture below. The Charge chamber is labeled as point B. The carriage will be locked into the pin via male and female connections; point C. The pressure will build in the charge chamber and create shear stresses on the connection point where the carriage and pin are connected. Since the pin stays attached to the rear of the launch tube, it will be easily reset by simply loading the UAV onto the carriage and pushing it down the tube until it locks onto the pin connection. The Carriage is represented by D.



<u>Carriage Component-</u>

Carriage with Styrofoam Insert -

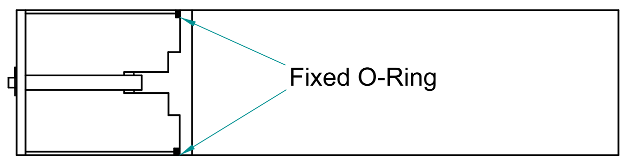
The carriage in this design would be a thin cylindrical shell with a solid backing. The backing will be thicker than the shell, because most of the forces are acting on the backing directly. These forces include the initial (highest) force and the stopping force. This shell will help minimize the blow by, because the shell will fill up the entire cross-sectional area of the barrel. The pressure will only act on this cross-sectional area during the launch. The quick release push pin receiver will be mounted to the back this solid backing. The back of the UAV will be flush with the back inside of the carriage. To restrain the wings from scraping along the inside of the barrel two Styrofoam inserts will be placed around the UAV in the front of the carriage. These inserts were called Styrofoam Wing Restrictors in the diagram below. These inserts will hug the wings keeping them in their locked position during the launch. They would then fly out of the barrel with the UAV and then detach from the UAV. If damaged, these Styrofoam inserts would have to be replaced.



Airtight Seal Component-

Fixed O-Ring-

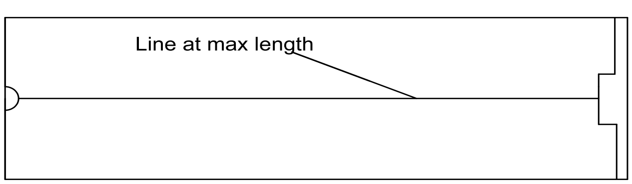
When considering the nature of an airtight seal at a relatively high pressure, the team realized that by nature, it would be extremely difficult to create a method of maintaining an airtight seal while allowing the object to move. Out of this dilemma, the fixed o-ring concept emerged. A rubber o-ring will sit against a lip inside the pressure chamber. In order to create an airtight seal initially, the bottom of the carriage will be forced backwards against the fixed o-ring. When the carriage is released for launch, the seal is broken, and the carriage is allowed to slide smoothly against the barrel. To prevent excessive blow-by, metal or felt rings will be used to provide enough of a seal to launch successfully.



Carriage Recovery System-

Tethered Line –

A fairly lightweight, non-elastic, filament will be attached to rear center of the launch carriage as well as the inner, rear center of the launch tube itself using Al clamps. The filament will basically have sufficient slack to allow the carriage to reach its maximum travel distance yet preventing it from exiting the tube itself. There are several pros to this design including a minimum amount of moving parts, a simple, cheap, effective design. One obvious downfall to this design is the severe stresses exerted on the filament itself. If used, the carriage will accelerate from rest to an estimated velocity of 60ft/sec then back to rest over a distance of only nearly 18 inches in an estimated .05sec of travel time. With forces of this nature, an inappropriate filament and poor connection pieces could suffer major damage and may fail over a short period of time. This is why the team must make sure that the filament can withstand the necessary forces. One immediate solution that came to mind when trying to resolve the stress on the filament was to implement a spring that would elongate when force is applied. It was also mentioned that, if an appropriate filament was found that was fairly inexpensive, it could always be replaced when it has reached its life cycle.



Side View

Material/Misc. Part Selection -

Specifications –

In order to meet all of the team's project specifications, the team needs to determine which materials are most appropriate for each component of the entire system. The material should be fairly available, cost effective, and provide an appropriate about of safety without sacrificing weight. It should also be able to be machined, cast, or have other accurate means of being constructed.

Reservoir Tank –

The team made a fairly easy decision when choosing how to hold a large amount of compressed air within a small amount of space. After initial research was complete, the team looked deeper into compressed air tanks. The paintball industry has provided consumers with a large selection of compressed air tanks and accessories. The team found the lightest tank that was on the market that met the specified dimensions and pressure ratings. The nitrogen tank is made by Guerrilla Air and weighs in at 1.8lbs.

Washers/Nuts –

Due to the nature of the project, having an airtight seal is essential to achieving maximum efficiency. The pin and the wire connector are going to be breaching the seal of the charge chamber and will need to have an airtight seal to prevent leaks. McMaster-Carr provided the team with many different ways of ensuring an airtight seal. The washers that were chose are specially made for pressure sealing. It consists of a molded Nitrile sealing element mechanically locked into a zinc plated steal washer. They come in many different sizes so that they can be applied to both the pin and the wire connector. The nuts that will be used to decrease the probability of leaks come in similar sizes and also incorporate a rubber and metal combination. It uses an O-ring to seal the hole that the pin or wire connector is threaded through. The team will be working with pressures less than 100 pounds per square inch and the O-ring is rated for 6000 pounds per square inch.

High Pressure Braided Line –

The high pressure braided line was needed to transfer the air from the tank regulator to the charge chamber. It needed to be flexible enough so that it could be bent into a shape that will allow the team to easily select where it will fit onto the back of the charge chamber. It could not be placed directly onto middle of the back of the charge tank due to the fact that the push pin was going to be located in the center. The air, since it will be loaded into the charge chamber slowly, could be loaded off center. The line is rated for 1000 psi, which is more than will be loaded into the reservoir tank.

Protection Rods –

The protection rods were needed to protect the UAV launcher components behind the charge chamber. The protector rods also gave these components support and restrain their movement. Their primary function is to protect the launcher components against the impact force caused by the launch process. The team decided to construct three rods to surround the reservoir tank, regulator, braided lines, and trigger mechanism. The components will be zip tied to the rods to give the user the ability to detach all of the components. The rods will be 3/8" diameter aluminum rods. The team selected aluminum as the material because it will be able to support the weight of the reservoir tank and the other components while remaining relatively light. Also, aluminum has the ability to be welded together, which gives more variability if the team decides to place the rods in alternative places.

Tank Regulator –

Since the team had decided to use a reservoir tank to feed air pressure into a subsidiary tank, there needed to be a way of regulating the pressure that was in the reservoir tank. There were a few options on the market, but virtually none that met the requirements. The regulators that dealt with high tank pressure and could reduce the outgoing pressure to an accurate, workable amount were too heavy or bulky for the application. The pressure regulators that were small, light, did not have the right amount of accuracy when regulating the air pressure. There were two options as far as where to place the regulator; in line with the reservoir tank and tube or at the mouth of the tank. The team, through professional product advice, chose the tank regulator that replaces the existing tank regulator. The particular model chosen has an adjustable range of 0-1000 psi.

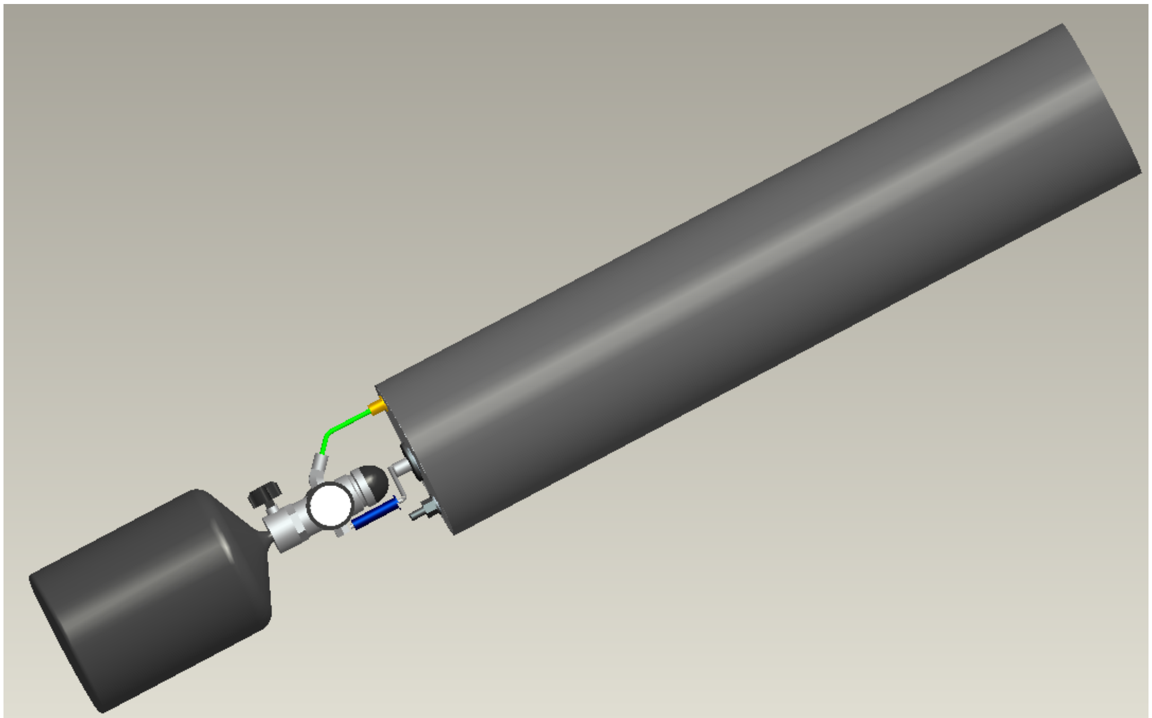
Launch Tube Material –

In an effort to reduce the weight of the overall design, carbon fiber was chosen as the material to be used for the launch tube. It has mechanical properties that compare to aluminum, but with two thirds of the weight. Many companies did not have the tools or machines for the dimensions the team was looking for. Because of this, some changes had to be made to the inner and outer diameters of the launch tube. Once these changes were made, a quote was given by Nim-Cor. They specialize in carbon fiber tube fabrication. It was explained to the team that carbon fiber, unless it is molded, cannot be woven onto flat surfaces. Carbon fiber can only be woven onto convex surfaces and would not be able to be woven in a way that it closes the back of the tube. In order to achieve this, an aluminum mold would have to be placed into the tube and bonded with the carbon fiber with a space grade adhesive. This would give the end of the tube a convex shape on which they could weave the carbon fiber. This adds weight and complexity due to the curve of the aluminum where the pin would be inserted. The team opted to mold an aluminum piece with a flat back and adhere it to the inside of the carbon fiber tube. This would mean that there would not be carbon fiber on all surfaces of the tube, but the aluminum backing would give a better working surface and help increase the safety on the charge chamber.

Carriage Material –

The carriage will be under both high impact force and high pressure forces. The weight of the carriage is crucial to the overall weight of the launcher as well, so the less it weighs without sacrificing performance; the better. Also, if the carriage is lighter, less pressure will have to be loaded into the charge chamber. Considering these specifications, a mixture of materials was chosen. The back of the carriage will experience the bulk of the forces, and will be made of aluminum. In order to reduce weight, the aluminum will be bonded to the inside of a carbon fiber tube, similar to the design for the launch tube. Aluminum is a very workable metal and it will be easier to drill and thread the appropriate holes for the pin receiver and threaded wire connectors. With Styrofoam inserts holding the wings in place, the UAV will sit in the carbon fiber tube upon being launched.

Final Design Review-



Above is a Pro-E assembly of the Launcher and its components. This is still conceptual, however, the individual components should work together to make this an effective UAV launcher. In order to clarify how the launcher will work in this final design please read below.

The reservoir tank (component at the very left) will store air at a very high pressure. The user will be able to turn on the pressure regulator, which will slowly feed air into the charge chamber (inside the launch tube). The charge chamber is located inside the launch tube and is created when the carriage that carries to UAV is locked into the push button pin that is located on the back of the charge chamber. The pressure builds up in the charge chamber, causing the carriage to want to move (expand the chamber). The pin counters the force of the pressure acting on the carriage. Once the pressure is built up to the desired level, the user will shut off the pressure regulator. The compressed air that will be used to launch the UAV is now completely housed in the charge chamber. The user will then step back and use the hydraulic trigger release to apply pressure on the quick release button of the pin. The pin will release its hold on the carriage. When this happens, the carriage will be free to move and the pressure built up behind it will cause it to accelerate through the launch tube.

In order to stop the carriage, the team chose to use a nylon coated wire that was rated for 1200lbf. The length of the wire will be just short enough so that the carriage does not exit the tube. This stopping motion will cause the UAV's momentum to carry it off of the carriage and into flight.