John Macon
Brandon Swint
Benjamin Runyan
Sal Cenicola

Abstract:

In our MCHE 1940 class at the University of Georgia, students are required to design a launcher that will propel a modified foam glider and keep it in the air as long as possible. We generated several different designs inspired from both the U.S. military and hobbyists. These designs resembled a slingshot, a catapult, a spring loaded launcher, a crossbow, and a mechanical arm. We chose to pursue the crossbow launcher after using a decision matrix. This design consists of a main block, two limbs protruding from the end, and a bow string that will propel the glider. The glider will connect to the string with pin and be pulled back to lock into place at the end of the launch block, then it will be released with a pull string and shot into the sky. Our total projected budget for the project is $29.09; this is well below the maximum spending limit of $40. With a design fully drafted, we will start off the next half of the semester by acquiring materials to begin construction.

Introduction:

In our MCHE 1940 class at the University of Georgia, students are required to design a launcher that will propel a modified foam glider and keep it in the air as long as possible. This is a great way to start working on the skills engineers will need in their future careers. Just like in the real world, students are given different constraints that must be considered in there design.

We are constrained to a $40 budget with a maximum of $5 allocated for plane modification; the device must be able to be transported by one person; it must fit into a 2.5' x 2.5' x 2.5' cube; and the device must be reloaded in under two minutes for a second and third trial. Also, it must include a pull-string trigger mechanism to fire the glider and the launch method must be totally mechanical and cannot utilize chemical reactions. Most importantly, the device must be safe to use.

The goal of the competition is to mechanically launch a foam glider to produce the longest possible flight time while adhering to design constraints. The score of each group is produced by subtracting the total budget multiplied by from the total flight time (in seconds) of three launches multiplied. The group with the highest score wins. This presents a challenge for us to design a launcher that not only effectively and consistently launches the glider but also is cheaply made, and if we compromise these two perspectives of cost and flight time we will be able to produce a competitive score and even win the competition.

Concept Generation:

Our team considered many factors to optimize our launcher and glider design. The chief concern above them was the maximization of flight time, as this is the main performance goal of the project. The foam plane can not propel itself, so it is imperative that our launcher imparts the maximum amount of velocity for the glider to fly for as long as possible do to the fact that velocity is proportional to lift. With this consideration, we must select a launch system that is efficient at transferring stored energy from the launcher to the plane. A large amount of stored energy in the launcher will require stronger and more expensive reinforcements, and it could create a potential safety hazard as well as further increasing costs. Therefore, we are pursuing a design that does not max out the constraint dimensions and finds a balance between stored power and costs of material. This not only increases portability, but it will also ensure costs on materials is lower which will directly translate to a higher final score.

With these ideas in mind, we've looked at what industry is currently using to launch planes. Currently, the US Navy uses an aircraft catapult system to launch its fighter jets from aircraft carriers. The aircraft couples itself to a pin on the launch platform with it's landing gear, and through electromagnetic or steam power, the aircraft carrier rapidly accelerates the pin towards the end of the platform. At the end of the platform, the plane decouples from the pin and takes off, as the pin system has then accelerated the plane to the speed it needs to maintain safe flight (Harris, 2018). This system was attractive to us as it would allow us to accelerate the plane in a relatively safe and controlled way. This safety advantage is also a disadvantage; the pin would need to slide along the launch platform, which could cause a great loss in momentum from friction.

Hobbyists have implemented their own solutions for plane launches that we have also investigated. They commonly use a slingshot design in which a band or system of bands attaches directly to a part of a plane's fuselage and is released from tension, flinging the device forward ("Methods of Launching RC Gliders," n.d). This has the most potential for power as the momentum is directly transmitted, but predictability and safety of each individual launch is low. Furthermore, hobbyists use spring loaded mechanisms that releases a spring's potential energy upon firing, these mechanisms seem to provide very consistent launches, but a powerful spring requires strong building materials as the launcher must withstand a large compression reaction force from the spring, so typically launchers use relatively weak springs to control for said factors. Another launcher design idea was similar to a crossbow. This design seems stable and safe. Finally, we considered using a mechanical arm that would release from being nearly parallel to the ground to perpendicular to the ground at release. While this option is very simple and has relatively good controllability and power, it was difficult to come up with a decoupling method.

Concept Selection:

The decision matrix, shown in Table 1, was used to decide on which design concept to pursue. Concepts were compared on their cost, reload and setup time, consistency, portability, power, simplicity, and adjustability of each design. Each criteria was weighted by importance on a scale from one to three. Reload time and portability were given a weight of one; these will not be large issues considering we have four group members to carry, setup, and reload the launcher. The cost will have a large effect on our final score, and simplicity will likely correlate with cost, so both criteria were given a weight of two. Adjustability and stability were also weighted at a two. Lastly, consistency and power were given the highest weight of three. Power is crucial to our design because a more powerful launcher can transfer more momentum to the plane to maximize flight time. Consistency is also crucial because our score depends on the flight time of three different launches.

Decision Matrix:

Design Goals	**Weight**	**CrossBow(I)**	**Catapult(II)**	**Rocket(III)**	**Spring Cannon(IV)**	**Mech. Arm(Control)**
Low Cost	2	+	+	+	S	D
Fast Setup/Reload	1	+	+	S	+	A
Sturdy	2	-	-	+	S	T
Consistent	3	+	+	+	-	U

Portable	1	+	-	-	+	M
Power	3	+	+	+	+	
Simplicity	2	+	+	-	+	
Adjustable	2	+	S	S	+	
Weighted Total		12	8	7	6	0

Figure 1

Figure 1 denotes our decision process for selecting a design to use. We compared all our design concepts with a mechanical arm design as our datum. When comparing the total costs of each design, the spring cannon is ranked equal to the datum while all the other designs are ranked better than the datum, meaning they would be cheaper to produce. The reload and setup time of the datum is predicted to be the same as the rocket design and slower than all other designs. The spring cannon design is ranked with the same stability as the datum; the rocket is ranked better than the datum; and the crossbow and catapult are ranked as less stable than the datum. Concerning consistency, we believe the datum would be very inefficient at releasing the glider the same way each time compared to all the other designs except the rocket. The crossbow and spring cannon scored higher than the datum when comparing portability, but the catapult and rocket scored lower. Every design was scored higher than the datum when comparing power. The mechanical arm design is more complicated then every design concept except for the rocket. In the adjustable category, the catapult and rocket were ranked the same as the datum, and the crossbow and spring cannon were ranked better. The Crossbow design scored the highest on our decision matrix with a score of 12, followed by the catapult design with a score of 8, the rocket design with a score of 7, and then the Spring cannon design with a score of 6. Since the crossbow design scored the highest, we will use this for our project.

Proposed Design Description:

After discussion over what specifications our crossbow should have, we came to the conclusion to maximize the dimensions of it (2.5’ x 2.5’ x 2.5’) in order to obtain the largest amount of power. We also plan on using a variety of materials that are both cheap and strong. The crossbow itself is going to be 3-D printed using ABS, and Elastic materials such as bands or a recurve bow string will also be used in order to physically launch the plane from the device. Balsa wood is going to be used where we have weak points in the device or plane. Finally, a PVC pipe may be attached to the crossbow in order to securely holster the plane.

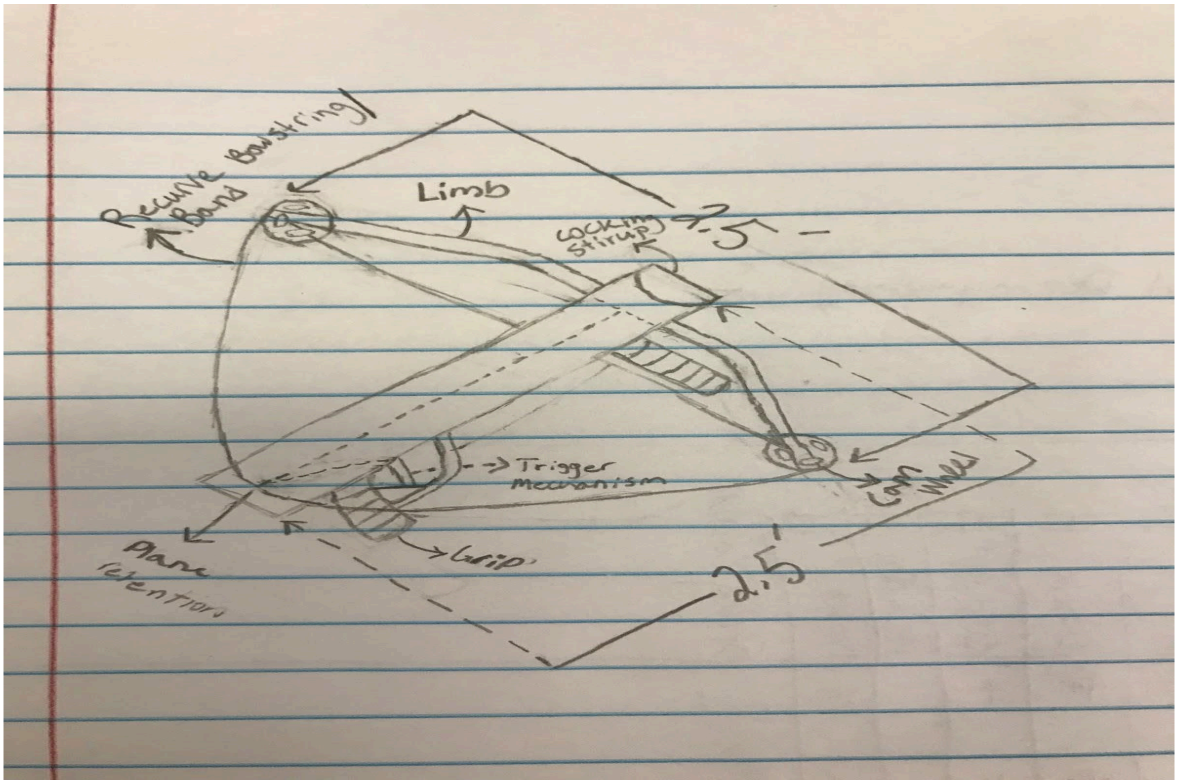

Figure 2

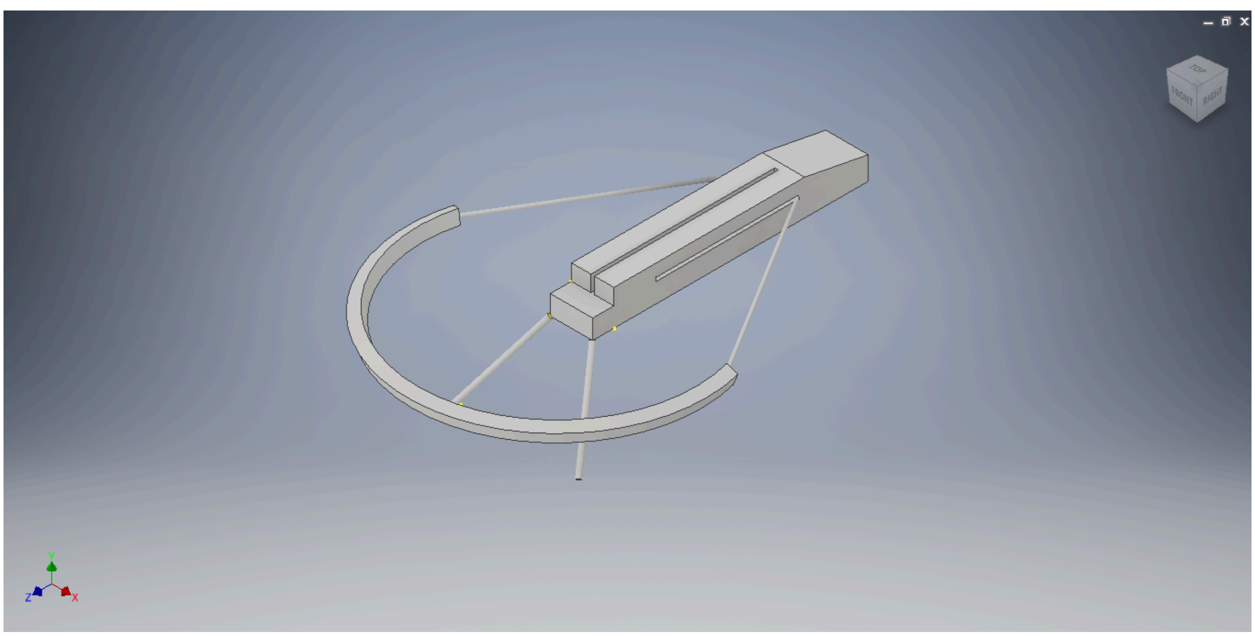

Figure 3

The operation of the crossbow is not very complicated. The first thing that has to be done is set the angle in which we want the plane to be launched from. This can be accomplished by adjusting a handle that would be located towards the front of the crossbow. For the handle to be locked into place, it will consist of several holes placed vertically throughout it, so depending on what angle is needed, a screw/button would insert into that specified hole. Then the plane would have to be loaded onto the crossbow and brought back with the elastic band/recurve bow string following behind it. Once the plane reaches a certain point both the string and plane itself will lock into place by a latch which is attached to the trigger mechanism. Therefore, once the trigger mechanism is pressed/released the latch will shift down from its position where it can no longer hold the string into place thus releasing the string/band and propelling the plane out of the device.

Proposed Budget:

Our total projected budget for the project is $29.09; this is well below the maximum spending limit of $40. This meager spending will give us leaway to spend more money along the way as we modify our design giving us $10.91 for funding any needed changes. The most expensive item we need is PVC pipe($8.44), followed by the bow string($5.99). We dedicated $4.50 to purchasing balsa wood in order to modify the foam airplane. Also with some modification parts of the plane being 3-D printed, we allocated $1 (4 hours of printing) for the filament. The rest of the budget being dedicated to other cheaper, miscellaneous things such as glue, wood, etc.

Budget Plan

Crossbow	**Spending**
PVC Pipe	$8.44
50" Recurve Bow String	$5.99
2 x4 Spruce Pine Fir Lumber	$4.62
3-D Printing ABS $0.25/hr	$2.50

String for Trigger	$0.95
Total:	$22.50
Plane Modification	
Super Glue	$0.59
3-D Printing ABS $0.25/hr	$1.50
Balsa Wood Block	$4.50
Total:	$6.59
Budget Information	
Starting Budget:	$40.00
Budget Spent:	-$29.09
Budget Remaining:	$10.91

Figure 4

Project Plan:

With a design fully drafted, we will start off the next half of the semester by acquiring materials to begin construction from online and hardware stores. After this, we plan to construct the first rendition of our design following our Autocad model and sketches utilizing the fabrication lab to build it. In addition, we will make modifications to the plane such as replacing the insertable wings with balsa wood cutouts and making 3-D printed parts. Then we will test the design, gathering data on its effectiveness and ability to elongate flight of the plane. After testing we will use the data and any issues we came across during testing to modify our device as needed. With a finalized and constructed design, we will present it in a video presentation that showcases our design as well as finalize our comprehensive report on our device and its development.

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Contributions rubric - Midterm report

Section	Drafted by (Date):	Revised by (Date):	Time spent revising:
Abstract	Benjamin Runyan(2/27)	Benjamin Runyan(2/27)	30 minutes

Introduction	**John Macon and Benjamin Runyan (1/29)**	**John Macon (2/14)**	**1 hour**
Concept Generation	**John Macon and Benjamin Runyan (2/1-2/12)**	**Sal Cenicola (2/21)**	**1 hour**
Concept Selection	**Sal Cenicola and John Macon(1/31-2/17)**	**Brandon Swint (2/21)**	**45 minutes**
Proposed Design Description	**Sal Cenicola and John Macon(2/18-2/26)**	**Benjamin Runyan(2/27)**	**45 minutes**
Proposed Budget	**Brandon Swint, Sal Cenicola, and Benjamin Runyan(2/14-2/27)**	**Brandon Swint (2/27)**	**15 minutes**
Project Plan	**Brandon Swint (2/27)**	**Sal Cenicola (2/27) Brandon Swint (2/27)**	**Both: 20 minutes**
Works Cited	**All (2/27/19)**	**N/A**	**N/A**
Figures / Tables	**All:Budget (2/27) Sal: Decision Matrix (1/31) Sal Cenicola: Figure 2 (2/12) John Macon: Figure 3 (2/26)**	**John Macon (2/24) Sal Cenicola (2/26)**	**John: 1.5 hours Sal: 2.5 hours**