Team 16: Kite Generator

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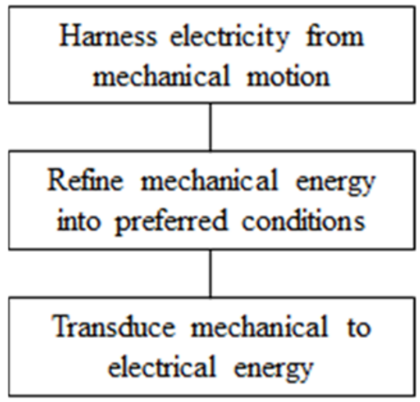

Figure 5. Generator functional decomposition.

Electrical Subsystems

Much like the Base Subsystem, every post generation electrical subsystem currently holds a low priority to the project. The project's innovation exists within the mechanical components of this project as currently existing electrical components already exist to fulfil the functions required for the success of this project.

1.4 Target Summary

Targets of the Kite Generator system are determined for each function of the system. The targets are defined by metrics to measure and achieve the aforementioned functions. Data analysis and customer preference dictate each target and its metrics. As seen in the Target Catalog in Appendix C, 5 kW of power output is set as a suitable target for the kite generator system. The power index is obtained by benchmarking gas generators currently on the market which usually yield 8-10 kW of power. These generators are typically used to power products necessary for life such as electric stovetops, light, and food refrigeration. Referencing the average power and surges for these products, our group feels that 5 kw is sufficient to provide necessary power to individuals following disaster situations.

Another key target is to keep the combined weight of all the subsystems under 200 lbs. with each subsystem weighing less than 50 lbs. With the principles of portability and disaster relief in mind, two people should be able to assemble, operate, and disassemble the kite generator system.

The last notable target was the power to weight ratio of the overall system. The power to weight ratio helps to facilitate comparisons between different forms of sustainable energy as well as other kite generator companies such as Makani. Aiming to produce 5 kW of power with a maximum weight of 200 lbs, the power to weight ratio of the whole system calculates to 25 $\frac{W}{lb.}$.

Some targets were developed with the help of Physics equations shown below.

$$P = I * V \qquad \text{Eq.1}$$

$$V = I * R \qquad \text{Eq.2}$$

$$P = \frac{B^2 * A * L}{(dt * \mu)} \qquad \text{Eq.3}$$

From these equations the team concluded that the strength of the magnet, B, as seen in the equation above, has a significant impact on the overall power produced. Based off the facts the group found the strongest magnet on the market, Neodymium, which operates at 1.32 Tesla. Further examining the power equation, the team evaluate the length, L, and cross sectional area, A, of the inductor. The inductor and its wrappings should possess a weight under 50lbs while covering the largest possible volume. Area and length of the solenoid have initial values of 0.018 m^2 and 1 m, respectively. These values may change following experimental analysis of the induced voltage power generation. This and future experiments will provide the necessary data for confirmation or alteration of the existing targets.

1.5 Concept Generation

To facilitate the concept generation, each member of the group was instructed to find individual background research on the power generation and kite aeronautics. Members were encouraged to perform background research on basic theories and benchmark companies with similar products. Each member then presented his or her own ideas without any interruption or criticism. This technique produced maximum concept generation and chemistry between members. Following every member's presentation, the group debated the concepts to keep, join, and discard producing the list below.

Power Generation Concepts:

Concept 1

This design consists of a slidable permanent magnet attached to a spring disposed within a housing which also contains tightly wrapped inductor coils. As the lift force increases, the tether will pull the magnet through the inductor coils, producing an emf. When the lift load decreases, a spring will bias the magnet in the reverse direction, which will then again produce an emf. This repeated motion will generate electricity. The housing pivots with respect to the direction of the attached tether. This design was the original build suggested by the previous design team during 2016.

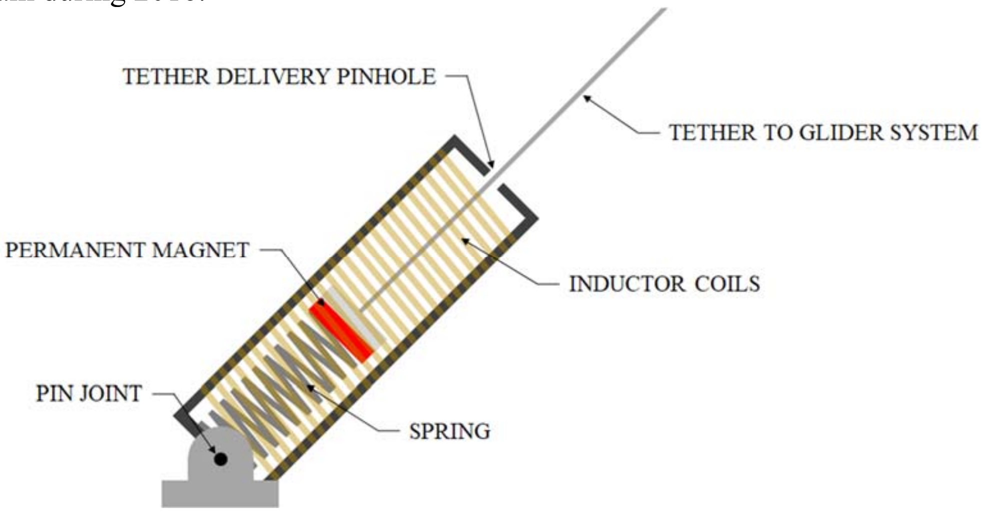

Figure 6. Spring Loaded Design Basic Schematic.

Concept 2

This design is similar to the previous concept, but rather than a spring, gravity is solely used to pull the magnet back to the ground.

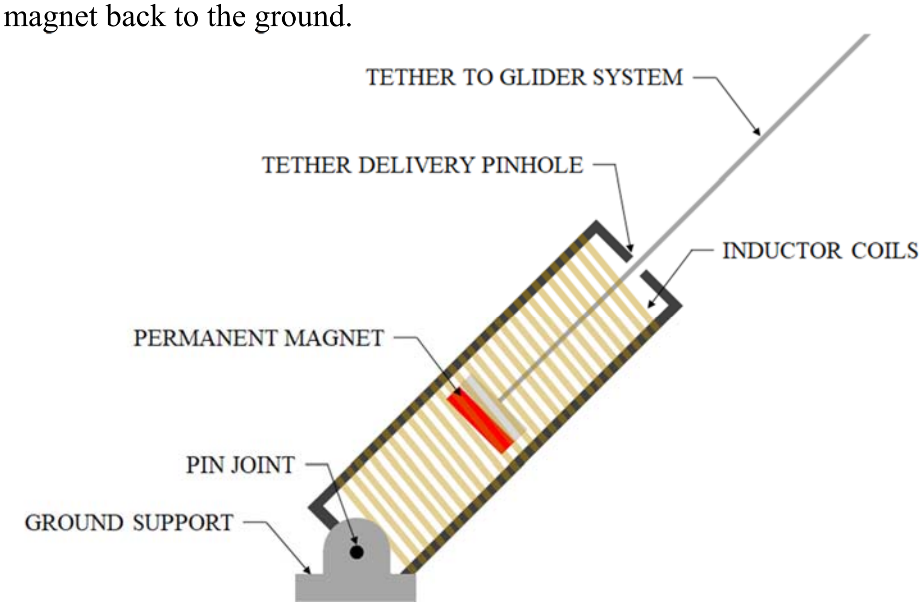

Figure 7. Gravity Fed System Basic Schematic.

Concept 3

This design is similar to the previous designs but now a tether spool allows for varying length of the tether. When the kite reaches a sustainable altitude, the tether is clutched to make sure the magnet is able oscillate. Additionally, the movement of the magnet is assisted by a spring. Unlike Concept 2 and 1, the magnet is oscillated in a fashion which eliminates the additional stress applied by gravity.

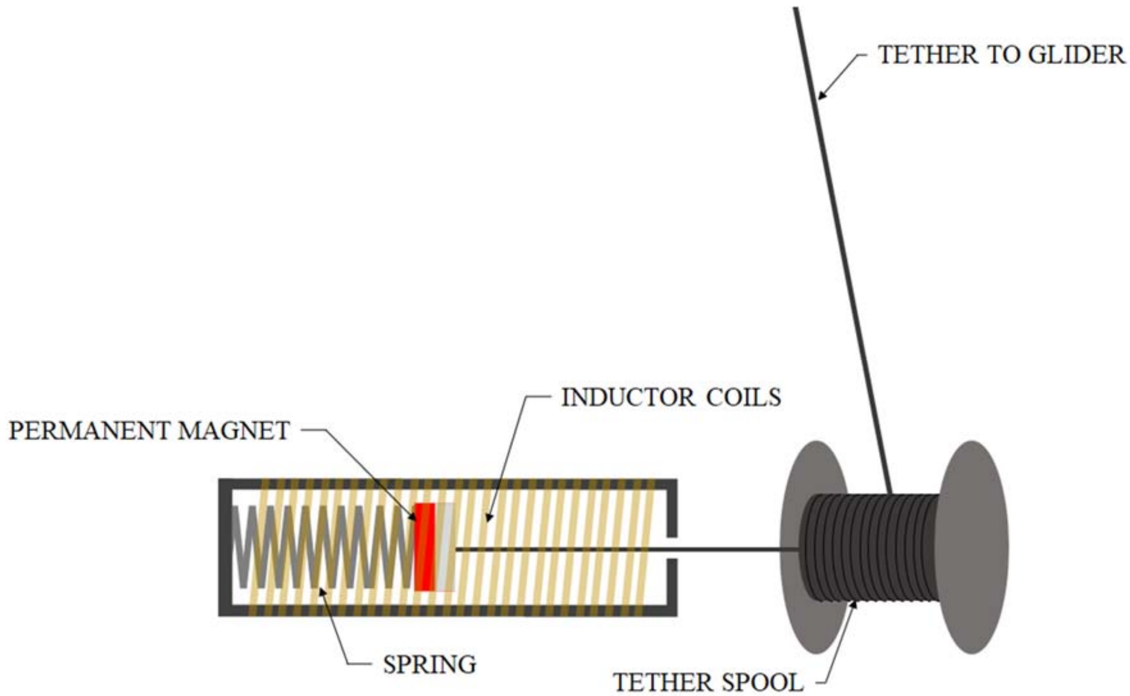

Figure 8. Spring Assisted System Basic Schematic.

Concept 4

Concept 4 utilizes two kites attached to opposite sides of the same solenoid. Depending on the movement of the wind, one of the kites will pull more strongly on the magnet, and the oscillation will generate electricity. In this design the housing is stationary.

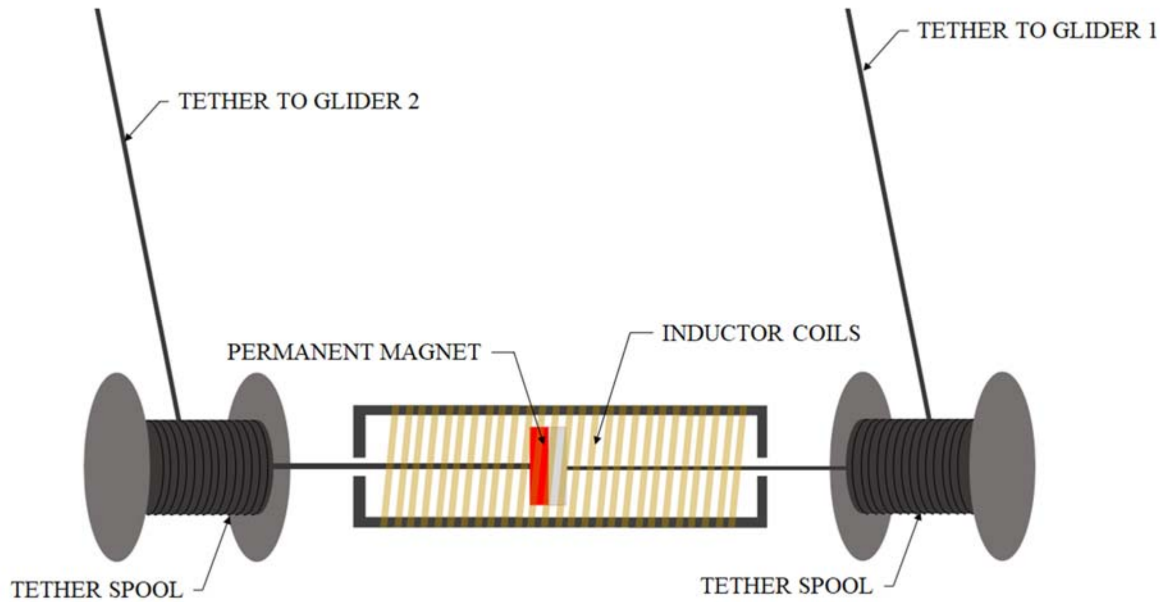

Figure 9. Dual Glider System Basic Schematic.

Concept 5

Concept 5 uses Concept 2's gravity fed build, but includes a transmission system. This transmission could include a clutch and a gear train such so that the force applied to the tether could be increased or decreased based on varying conditions.

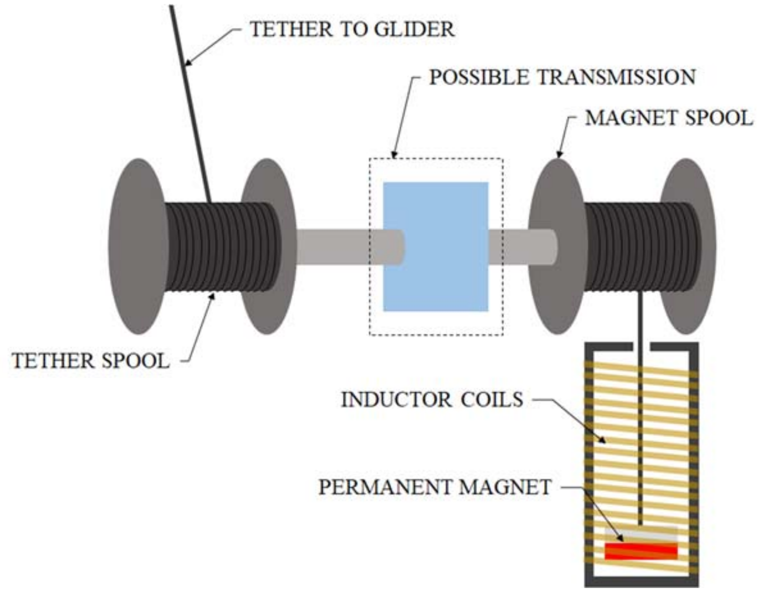

Figure 10. Gravity Fed System with Transmission Basic Schematic.

Concept 6

Concept 6 uses a similar build to Concept 5 and Concept 3, using the transmission and the spring assisted system without the influence of gravity.

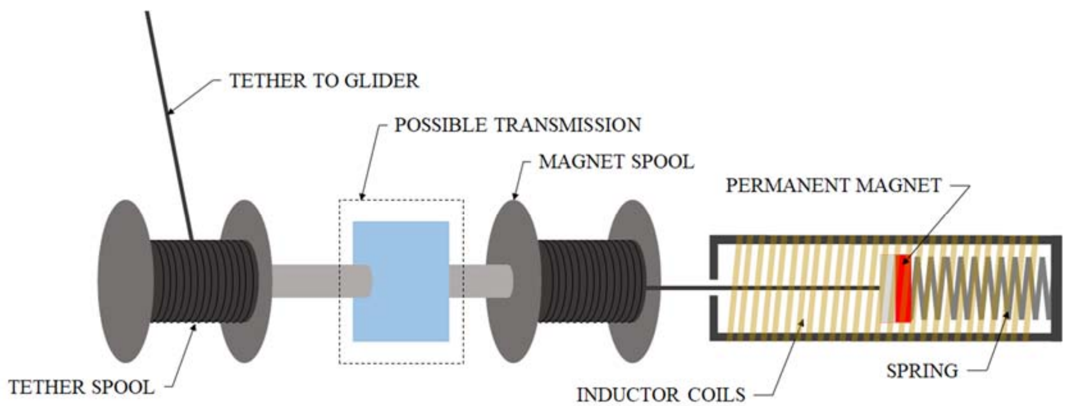

Figure 11. Spring Assisted System with Transmission Basic Schematic.

Concept 7

Much like the previous concepts, this concept is an expansion of Concept 4 combined with the transmission expansion of the other ideas. Two gliders in 180 degree offset flight help rewind and unwind each other as they force the drive shaft to oscillate. Here a flywheel is included to dramatically increase the freedom of the motion of the glider's flight. This flywheel could be included as the transmission discussed in any of the designs which harvest the rotational momentum of a spool.

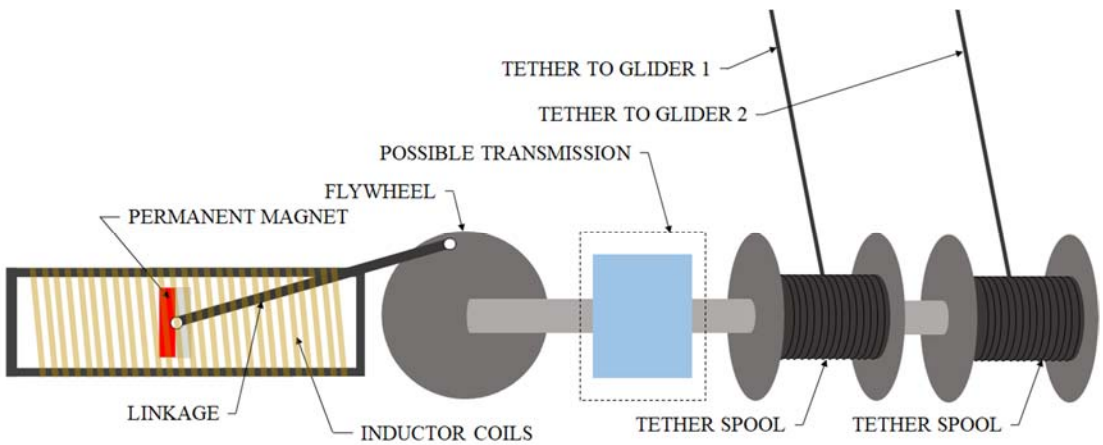

Figure 12. Dual Kite System with Transmission Basic Schematic.

Concept 8

Concept 8, 9, and 10 are iterations of the previous designs with one major change. Instead of using the solenoid, the team thought it wise to consider alternative methods of electrical power collection. Concept 8, 9, and 10 yield no new ideas but include a standardized alternator attached to the main shaft of the systems rather than passing the motion through a solenoid magnet pair. The three concepts build off of the gravity fed, spring assisted, and dual kite oscillation builds

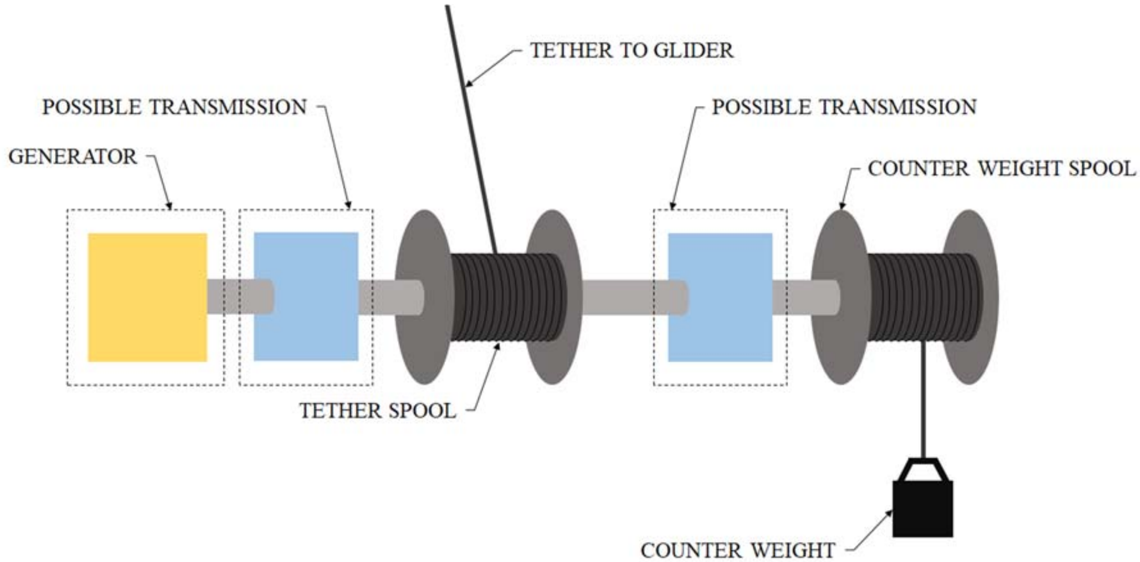

Figure 13. Gravity Fed Alternator System Basic Schematic.

Concept 9

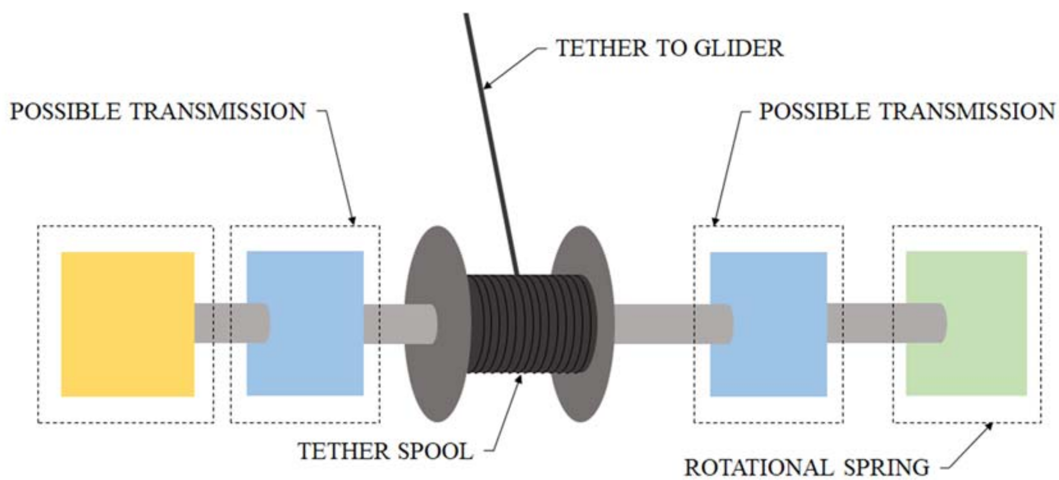

Figure 14. Spring Assisted Alternator System Basic Schematic.

Concept 10

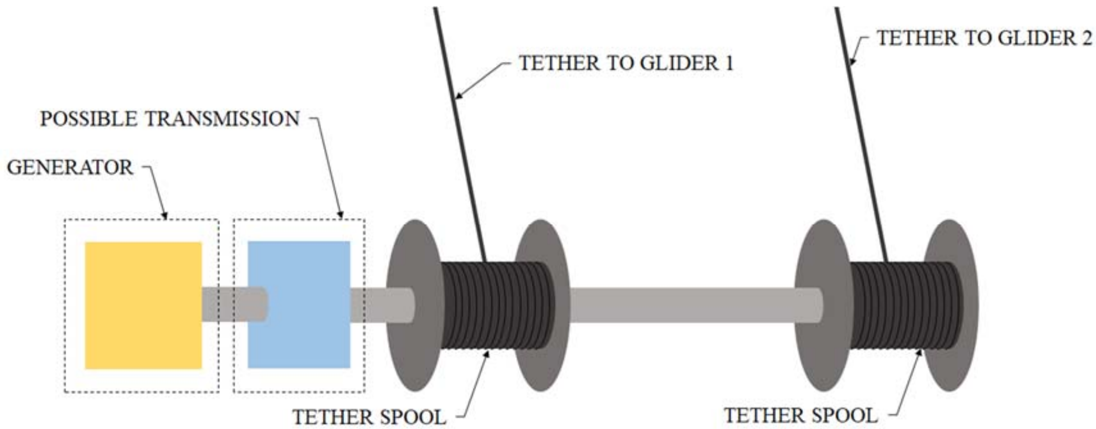

Figure 15. Dual Kite Alternator System Basic Schematic.

Concept 11

Concept 11 goes way out of the project scope's range, as the team was requested to study the capability of harvesting the motion of a glider with a ground centralized generator. The reasoning behind this restraint was because most of the power generation systems that rely on airborne turbines have already been patented. However, one concept was thought of, and written down just in case it proved to open the door for other ideas. Here in Concept 11, solenoids can be built onto the glider system with a freely unrestrained magnet within them. Upon any form of angular change, the magnets within the solenoid will fall to the lowest point possible, and generate emf as they move. This concept seems out of the ordinary when considered for large scale systems, but might prove beneficial for powering onboard sensors.

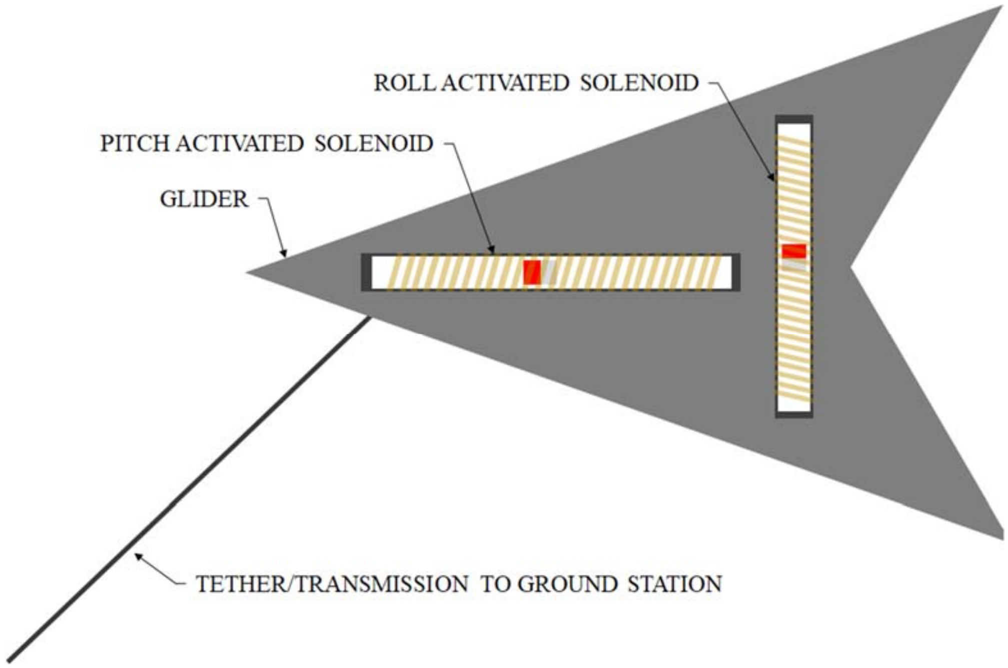

Figure 16. Solenoids Built Onboard Glider Basic Schematic.

Glider Delivery System Concepts:

Much of the team's focus has been centralized around the different methods of harvesting the generated power of the glider's motion. The success of this function is independent on the glider and it's ability to lift itself into the air. So the design team took a modular approach to the concept generation, and began considering a new pair of concepts to fulfil the other requirements.

Concept 12

With the next concept the group focused on finding a way to have the fix wing aircraft lift itself up to the desired height. Therefore, in concept 12 the aircraft has propellers that can move the aircraft in a vertical position and also change to be able to move in a horizontal position. The autonomous portion of the aircraft can change the orientation of propellers in order to create the desired motion. This concept has similarities to a conventional drone in which the takeoff and landing can be controlled.

Figure 17. VTOL Glider Example Image from FAMU/FSU CoE [1].

Concept 13

This design is the only build that considers not using propellers. It is the simplest design and is the only design that does not require electrical input to get the glider into the air. As every other design concept requires some initial energy to setup the system to a desired altitude. Unfortunately, this system has some major drawbacks to these huge advantages. Creating a fully autonomous system with this balloon may prove more challenging than just using a drone with a few propellers. Likewise, the function of the balloon cannot promise the life expectancy the team my desire. Although seemingly positive, the design may require some major changes if it were selected.

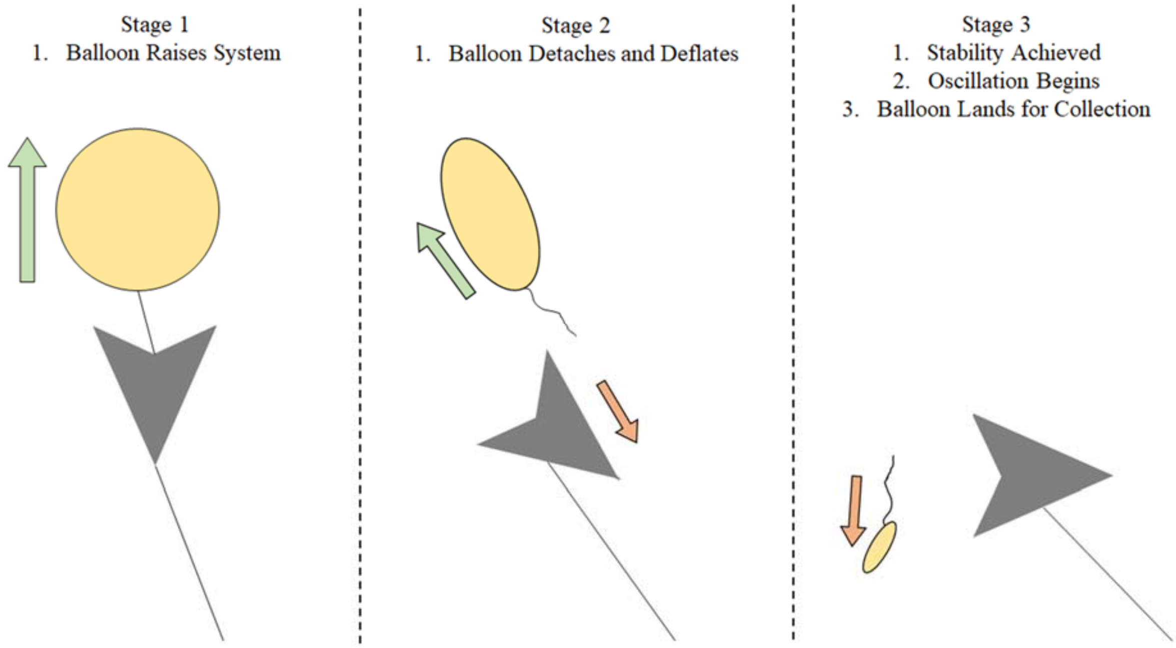

Figure 18. Balloon Delivery System Basic Schematic.

Concept 14

Looking at previous concepts of lifting the fix aircraft to a desired altitude, the team found that it would be easier to use a parachute system. The parachute system can be folded up into a control box that is lifted by a propeller. When the parachute and the control box reached the desired altitude the propeller will separate and open the parachute system that will be controlled with control box. With having the control box attached to the parachute the path of the oscillation created by the parachute can be controlled remotely.

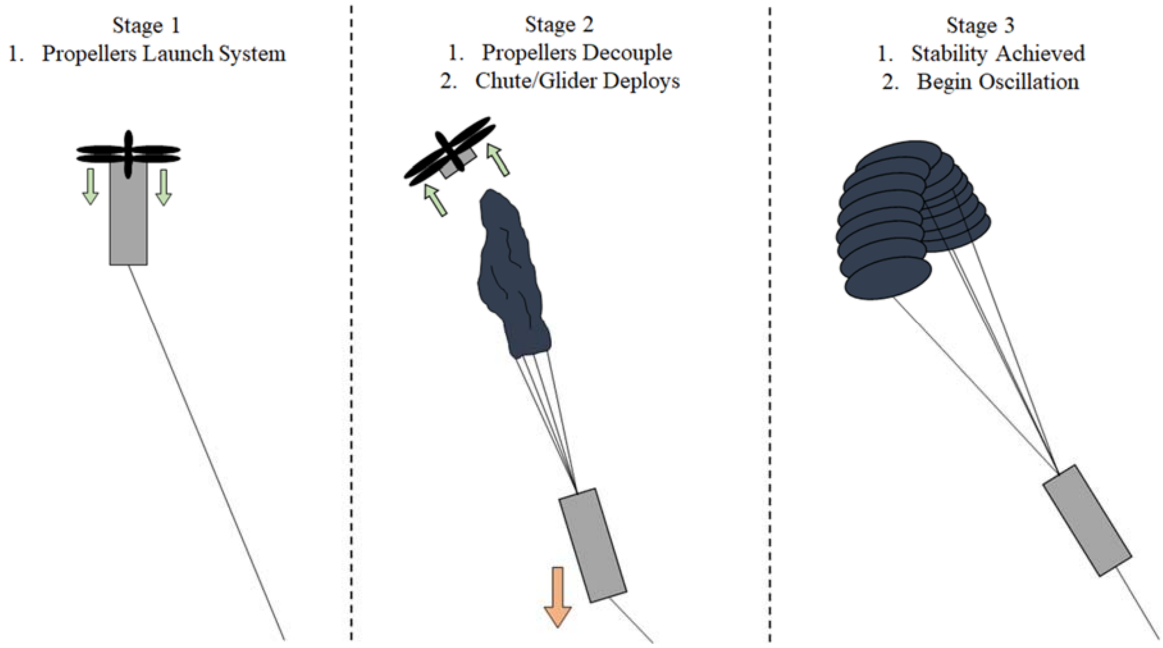

Figure 19. Propeller Launched Chute System Basic Schematic.

Concept 15

Like the previous concept, concept 15 focuses on how to launch the aircraft by using a propeller that lifts it to a secure height. When reaching the desired altitude, the propellers stop, and the wings expand. The autonomous features will turn on the propellers and direct the aircraft to the assigned path that creates the fastest motion for the ground system to generate the most power. A benefit of having the propeller attach to the aircraft is that when the wind is not strong enough to keep the aircraft lifted in the desired altitude, the autonomous part of the aircraft could softly land the craft versus letting the glider fall down uncontrollably, or the craft could push to a higher altitude to reach stronger winds. The propellers could also be flipped as a generator to provide power to maintain the onboard system.

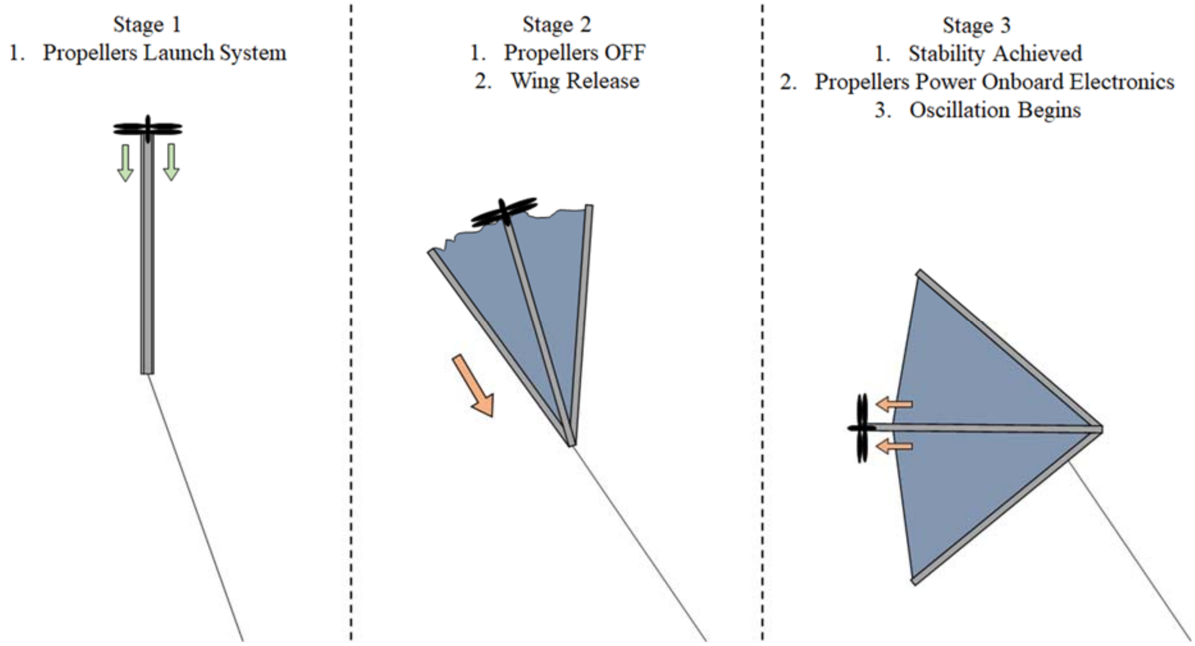

Figure 20. Fixed Propeller Launched, Winged System Basic Schematic.

1.6 Concept Ranking

The team utilized the Pugh Matrix Method as a tool for comparing design ideas against design criteria. By doing so we were able to determine which designs were better than others by ranking the overall designs numerically. This method also allows for certain design criteria to be weighted more highly than others, creating a more accurate evaluation of the design ideas.

To create a reliable Pugh Matrix, evaluations were conducted of all the general variables that affect the power generation and the airfoil. To ensure that the project achieves its best design, these variables must be optimized to provide the highest efficiency at the best cost. To account for this, certain variables are weighted more than others. The priority of the variables was determined by the project scope, customer needs, and functions of the systems. The variables with the greatest influence include size, safety, reliability, efficiency and cost.