Remote Control Helicopter

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Concept Generation and Selection

Document

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Introduction

In this document, we will be giving a brief overview of the project in which we have been tasked with completing, which is the scaling of a remote controlled helicopter. We will also be discussing the testing done on the helicopter, as well as the design solutions that we have come up with for problems noted during our testing. Lastly, we will review our Gantt chart and give an update as to where our team is at and what is coming in the near future.

Problem Description

Our client is Dr. Kosaraju, an instructor at Northern Arizona University. He has given our team the task of purchasing and scaling a remote controlled helicopter. For this task he requested a helicopter whose length is approximately 10 inches. Our ultimate task is to successfully scale this helicopter by 1.5. In the process of scaling, we will be analyzing the design of the helicopter itself to see what could be changed to help better the performance of the helicopter.

Testing

Before our team took apart the helicopter, we decided to test different aspects of the aircraft. We wanted to measure the lift, lift without lights, mass, the battery life, and the dimensions. First, we measured the mass and found it to be just over 0.3lb. To measure the lift we slowly added weights to the helicopter until it could not lift anymore. During this process it was noted that without the lights turned on, on the aircraft, the helicopter had more power allocated to the lift. A graph of the lift of the helicopter without lights can be seen in Figure 1, and the table of values for that plot can be seen in Table 1.The battery life varies from around 6-10 minutes. This varies depending on if there is a load. Lastly, the dimensions are the following: length is 13.39 inches, width is 2.36 inches, and the height is 5.9 inches.

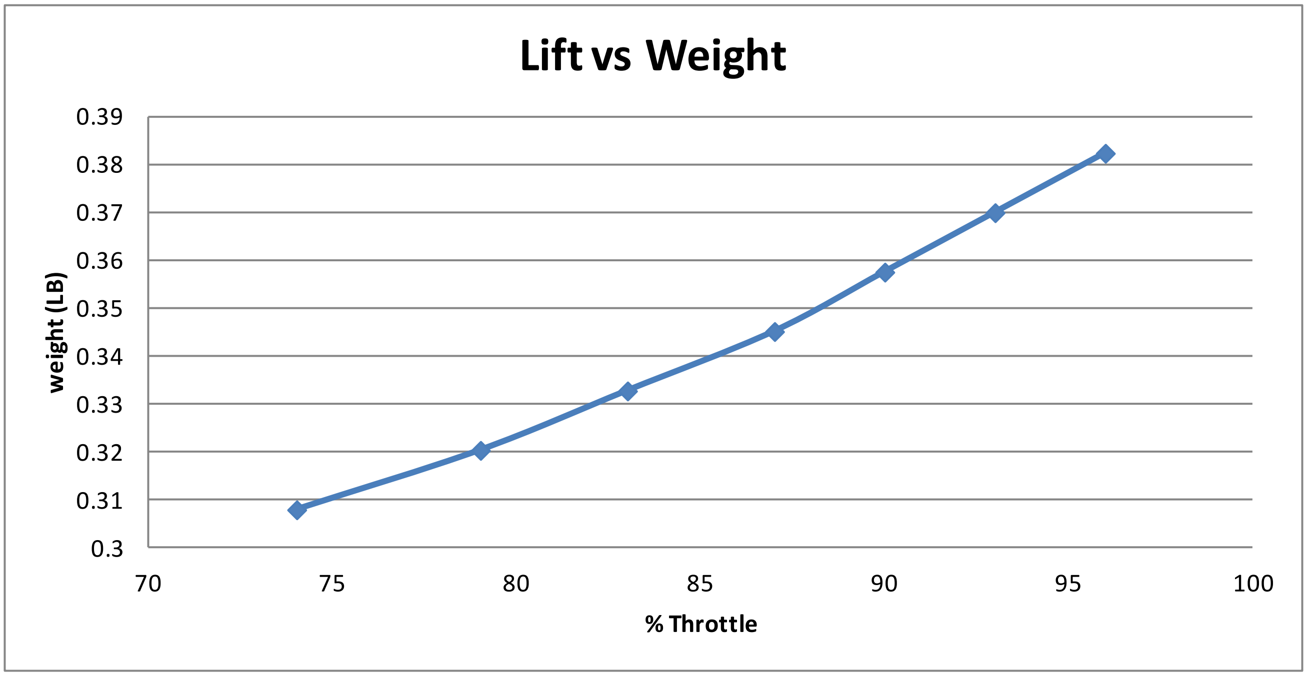

Figure 1

Table 1: Data from lift testing

Object	% Thottle	Weight (lb)
just helicopter	74	0.307853503
1 pencil	79	0.320265533
2 pencil	83	0.332677563
3 pencil	87	0.345089593
4 pencil	90	0.357501623
5 pencil	93	0.369913653
6 pencil	96	0.382325683

Design Ideas

Since our project is composed of many different subsections, we have divided the helicopter up in to five different subsections for design improvement. Those subsections are: blade durability, longer battery life, increase in lift, improved landing gear, and a live feed video camera. In these subsections we have at least three ideas to improve the design of the helicopter.

Blade Durability

In the testing of the helicopter we quickly realized that there is a major flaw in the durability of the blades. It appears as though the blades from the upper level hit the blades on the lower level, once the throttle has been engaged and disengaged. With this realization we have come up with three ideas on how to improve upon this design. The first idea is to increase the height of the top rotor blades, which creates a bigger gap and thus gets rid of contact all together. The foreseen problem with this is that it may decrease the lift capabilities of the helicopter. The second design idea to reduce blade contact is to use a stronger more durable material that can absorb the damage without yielding any plastic deformation. This does not get rid of the blade contact, but rather is a way to prepare for it to hopefully allow for a longer blade life. The last idea for blade contact is to make the blades more rigid. On the original helicopter, the upper blades are able to swivel freely in either direction for a range of about 180 degrees. If the blades were made more rigid, in that they cannot swivel this range, then it is believed that this will eliminate the blade contact. Our decision matrix for this design can be seen in Table 2. We graded each category based upon ease of design, safety, cost, and estimated life. It can be seen through the table that the best design for the blade contact is making the blades more rigid.

Table 2: Blade contact decision matrix

Blade Contact:	Column1	Column2	Column3	Column4	Colu
Category	Ease of Design	Safety	Cost	Estimated Life	Total
Raised Upper Rotor	3	5	8	7	5.8
Durable Blade Material	7	5	4	6	5.5
Rigid Blade Design	8	5	8	8	7.1
Weight (%)	20	30	20	30	

Battery Pack

Another drawback of the small-scale helicopter that became apparent during testing is its poor battery life. During testing, the average time that the helicopter could remain in flight on a single charge did not exceed 8 minutes; for the enlarged helicopter, the flight time should be at least doubled.

The first decision to be made is regarding the type of battery to be used. One needs not to look far before concluding that a lithium polymer (or LiPo) battery is the optimal battery for the situation. Although lithium polymer batteries come at a relatively high cost, the benefits of LiPo batteries justify their cost. Lithium polymer batteries have both a higher capacity and power output than alternative battery types, but they also weigh much less [3].

After determining that a lithium polymer battery will be utilized in the enlarged helicopter, the configuration of the lithium polymer battery pack must be chosen. The options for different LiPo battery pack configurations are: a single LiPo cell, multiple LiPo cells in parallel, multiple LiPo cells in series, and multiple LiPo cells in both series and parallel. Each configuration has its own criteria in which it excels and falls short. The criterion for selecting a lithium polymer battery configuration is defined as follows:

- Voltage- the voltage supplied by the configuration. A higher voltage results in many benefits and is assigned a weight of 25%; it allows for a more consistent power to be delivered throughout the flight, which allows for better control in addition allowing for a higher power output resulting in a larger lift force [1].
- Capacity- the amount of power that can be supplied by the configuration on a single charge. A larger battery capacity results in a longer flight time for the helicopter and is assigned a weight of 30%.

- Weight- the total weight of the components making up the battery configuration. The batteries weight directly affects the lift force that can be generated by the helicopter and is assigned a weight of 25%.
- Lifespan- the number of cycles the battery configuration can be charged and depleted is given a weight of 10%. The battery will see relatively few cycles over the duration of this project so the lifespan is not of utmost importance.
- Cost- the total cost associated with the battery configuration. All costs associated with the helicopter must be justified; however, keeping the cost extremely low is not a big need for the customer and therefore receives a weight of 10%.

The above criterion were analyzed for all four battery configurations and combined in Table 3, the decision matrix used to determine which battery configuration fit best. Each criterion was assigned a weight based on its importance; values were then assigned for each configuration, based on how well the configuration fulfills the needs of the battery.

Table 4. Decision matrix used to determine battery pack configuration.

Battery	Column1	Column2	Column3	Column4	Column5	Column6
	Voltage	Capacity	Weight	Lifespan	Cost	Total
Single LiPo	5	5	9	3	9	6.2
LiPos in Parallel	5	10	6	6	6	6.95
LiPos in Series	10	5	6	6	6	6.7
Parallel+Series	10	10	3	9	3	7.45
Weight (%)	25	30	25	10	10	

The voltage value assigned to each configuration was assigned keeping in mind that in series, voltages add, and while in parallel, amperages add. For both the single LiPo cell and LiPo cells in parallel, the voltages do not add so a smaller voltage results. For the LiPo cells in series, however, the voltages do add and a larger voltage results. The same larger voltage results from the LiPo cells oriented in both series and parallel.

The capacity of a battery pack increases when in parallel [7]. For this reason, the single LiPo and the LiPo cells in series are assigned smaller values, and the LiPo cells in parallel received a higher value; the configuration including cells in parallel and series has the same potential for increased capacity and receives this same higher value.

The weight values assigned to each configuration based not only on fact that a larger number of LiPo cells results in a larger weight, but that a larger current requires thicker connections. The single lithium polymer cell is the lightest weight. Next to that is the series configuration, which has more cells, but a small current. After comes the parallel configuration, which has more cells in addition to a large current. The heaviest of the configuration takes advantage of connections in parallel and series and has the most cells in addition to a large current.

The lifespan of the battery configuration increases with the number of cells used in the configuration. This is because when multiple cells are utilized in a battery configuration, they share the load that would put a single cell above its discharge rating, resulting in a much shorter lifespan.

The last criterion used in the decision matrix is the cost; as more cells and connecting components are utilized in the battery pack, the cost increases. For that reason, the cost value decreases from the simplest (the single LiPo cell) to the most complicated (the LiPo cells in parallel and series).

After deciding the values for each criterion as described above, the weight was applied to each value and totaled up. The battery configuration resulting with the highest total score and the configuration that will be utilized in the enlarged helicopter is the lithium polymer cells configured in both parallel and series. Figure 2 shows the battery configuration that utilizes lithium polymer cells in both parallel and series.

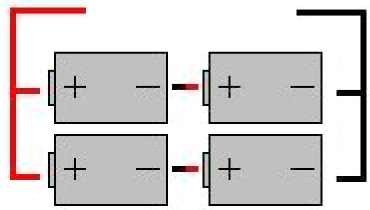

Figure 2: Configuration with lithium polymer cells in parallel and series.

Landing Gear

The landing gear includes wheels, but in some cases, helicopters are equipped with skis for snow or water terrains. In our case of a vertical take-off and landing aircraft such as the helicopter, the wheels are replaced with skid designs to improve landing and taking off. Choice of landing gears depends upon numerous factors and one should not automatically assume that each landing gear design is necessarily the best. There are several design requirements which affect our decision on selecting the right landing gear design. These include: helicopter weight, take-off/landing, stability on ground, landing impact, and cost. In order to choose the right design, the candidate must decide which design suits them best.

In the design process, the team came up with four possible designs to use which are flatted skis and rounded skis which are both large and small. The idea of the first design is to make the skis large and flat. This will help stabilize the helicopter when lifting off the ground. The second idea is small and flat skis. By making the skis much smaller and flat this would allow the helicopter to land much faster and also to allow more lift. The third idea is making a smaller landing gear rounded. Lastly, the final idea is to make a large and rounded landing gear. Based on the comparison of the designs, the results can be seen below in Table 4.

Table 4: Landing gear decision matrix

Landing Gear:	Column1	Column	Column3	Column4	Colu	Colum
Category	Weight	Landing	Ground Stability	Landing Impact	Cost	Total
Larger Landing Gear (Flat)	7	5	7	7	5	6.4
Smaller Landing Gear (Flat)	1	1	4	6	7	3.2
Smaller Landing Gear (Rounded)	1	2	4	8	7	3.8
Larger Landing Gear (Rounded)	7	8	7	9	5	7.4
Weight (%)	30	20	20	20	10	

Lift

One of the tests we ran on our helicopter was to determine how much weight our helicopter could lift as you can see in Figure 1. The helicopter could not carry as much weight as we will need when we enlarge the final design. After figuring this out we chose three different solutions to increase the overall lift of the helicopter. The first idea we had was to get larger motors which would be able to spin the rotors at a larger rpm. This idea has a large draw back though these larger motors would increase the weight and this would decrease the extra weight we could lift. The second idea is to gear the motors in a way that would increase the rpm of the rotors. After reading parts of Principles of Helicopter Aerodynamics by J. Gordon Leishman [2], we decided our third idea. We could lengthen the blades to increase the overall lift. After making these three ideas we made a decision matrix as you can see in Table 5. Idea three, lengthening the blades, will be our solution to gain more lift.

Table 5: Lift decision matrix

Lift	Columr	Column2	Colum	Colun	Column5	Colu
Category	ease of design	Minimize Cost	Safety	Weight	Minimize Power	Total
Larger Motors	6	4	7	3	3	4.55
gear ratio	7	6	7	7	7	6.85
Longer Blades	8	9	3	8	8	7.15
Weight (%)	20	15	20	25	20	

Improved Camera

One of the requirements for this helicopter is that it must have the capability to give live feed video. As we thought about this requirement we found three different cameras that would work to meet this requirement. The first camera that we looked at is GoPros HERO3 White Edition. This camera has its own power source so it would not be taking power from the helicopter and it is durable. The down side is it is heavy with regards to the helicopter and its lifting capabilities and it is fairly expensive. The second idea is a wireless hidden camera this camera also will also have its own power source and it is the least expensive of all the cameras. The largest down side to this camera is not as durable as the other choices. Our final idea was to take a live feed camera off of another helicopter. The down side to this camera is it will have to use the helicopters battery. After researching these three ideas we made a decision matrix as you can see in Table 6.

Table 6: Camera decision matrix

Improved Camera Capability	Colu	Column2	Column3	Column4	Column5	Col
	Weight	Minimize Helicopter Power Usage	Minimize Cost	Durability	Ease of Use	Total
Go Pro	4	10	2	10	8	7
Spycam	7	10	9	3	8	7.55
Wi-spi camera	9	3	4	9	8	6.8
Weight (%)	30	25	10	15	20	

Gantt Chart

In the project planning, we have met and are on task with our schedule. There were no changes to the Gantt chart based on the given tasks listed below. The deconstruction process was met during the time period. During the deconstruction process, the team reversed engineered each individual part and was given a part to design in CAD. Analyzing then took place in order to create each individual CAD drawings. In the next few weeks, the team is going to: reassemble the helicopter in SolidWorks, design the scaled up parts, brainstorm the design improvements, analyze each individual part design, and lastly send in the final proposal designs. If any changes do occur in the coming days, the team will meet up and change the Gantt chart accordingly.

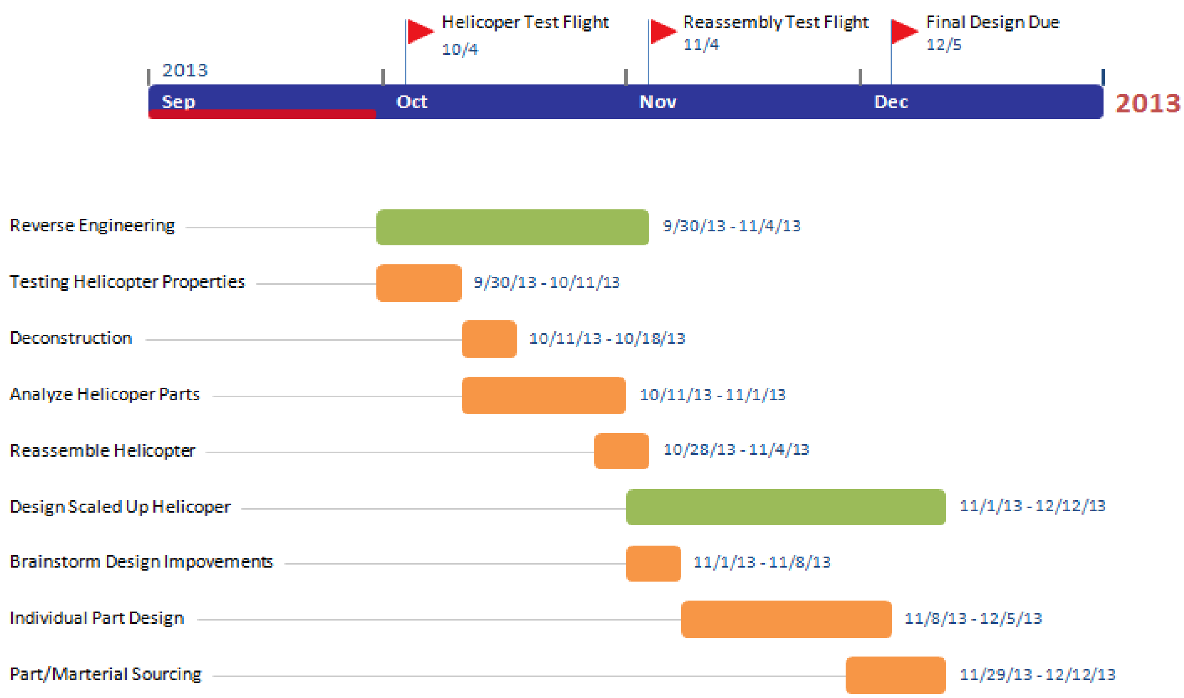

Figure 3: Project Plan

Conclusion

In conclusion, our team discussed what the main problem is with the helicopter and what needs to be resolved in the designs. We tested and analyzed what the lift capacity is by analyzing all the data into a lift versus weight graph. The team found out that the maximum lift capacity that the helicopter can lift is approximately six mechanical pencils, roughly .38 lbs. After collecting all the data needed for the helicopter, it was then taken apart and modeled in CAD. Designs were then discussed by selecting which concept design was better through decision making. The first design is the major flaws in the blade designs. As a team, we quickly knew that the blades were not durable from the chips within the blades. We also discussed the battery pack life design. There were two main battery packs and we choose to design ours in both parallel and series. The third design was its lifting capabilities. The team discussed how to improve the lift capabilities by increasing the rotor length size. In addition, landing gear designs were discussed as the forth design in order to provide a safe landing and take-off. The team thought that having a larger skid rack would help provide the helicopter for a softer landing. The final design concept was improving camera capabilities. This allowed the team to figure out how much of a range our helicopter can fly with live feed streaming. Lastly, our project plan is to continue working on CAD drawings and also to upscale the parts into a final design. Thus far, we have successfully followed our Gantt chart and plan to continue progress according to the schedule.

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