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Design and Manufacture of a Rotorcraft for Military Applications

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1. Project Evaluation

1.1 Project Success

This project involved four objectives – to design a rotorcraft meeting specific requirements, to design the manufacturing processes used in creating that rotorcraft, to build a prototype, and to state the protocols for the operation and assembly of the rotorcraft. Project success can be evaluated by assessing each of these objectives individually.

The rotorcraft designed by this team was originally expected to fit in a military backpack, carry a payload of at least fifty pounds, be made with commercial off the shelf components, be able to travel up to a mile, and be easy to maintain and use in the field. The rotorcraft very barely does not fit in a standard military backpack, but an extension or a flap could be built for the backpack to ensure fit. The payload requirement was reduced to thirty pounds, and the designed rotorcraft is expected to be able to carry that payload. The rotorcraft is made with commercial off the shelf components with the exception of the hinge plates and base plates, which can be easily created in a machine shop. Without flight testing, the team cannot verify the distance that the rotorcraft can travel. The rotorcraft is built to be easy to set up in the field and can be assembled or disassembled in a maintenance shop with relative ease. Overall, the team succeeded in designing a rotorcraft meeting the expectations of the stakeholders.

The team successfully designed the manufacturing processes used in creating the rotorcraft. In particular, these processes are the VARTM process for creating the base plates, manufacturing the hinge plates, and assembling the rotorcraft.

The team did not successfully build and test a prototype of the rotorcraft as designed. Ultimately, the speed controls, motors, batteries, and propellers were not tested and attached to the rotorcraft frame before the deadline. However, all the necessary components have been purchased and the prototype could be built with additional time on the part of the team members that understand electrical assembly and design.

The team did successfully describe the protocols for assembly of the rotorcraft in previous progress reports. The team also described how the user would set up the rotorcraft for flight in the field.

Of four objectives, the team successfully completed three objectives. The unsuccessful objective is building the prototype, which could be done with more time. However, as of right now the project cannot be described as successful, due to the lack of a fully assembled prototype.

The project assumptions establish the operation limits for the rotorcraft. If these assumptions are not valid (for example, excessive wind velocity, unstable ground, user travel distance, et cetera), then the results obtained above may be invalidated. Other assumptions deal with simplifying calculations (that the net torque is zero, that the current is constant, that the batteries discharge at full capacity for the entire flight, et cetera) and the possible effects of each of these assumptions are described in detail above. Any failure on the part of an invalid assumption should be considered a failure on the part of the rotorcraft operation, not on the part of the design or of this project.

The rotorcraft designed in this project is not necessarily the optimal design for these requirements. There is room for future projects and future improvements in many areas of this design, including the rotorcraft configuration, selected components, and stricter adherence to a reasonable budget.

1.2 Lessons Learned

The team started the design and manufacturing of the rotorcraft in Fall 2014, following the DMADV Six-Sigma process. The team has completed the project during Spring 2015. However, the team has encountered some issues resulting on delays affecting the critical path, miss allocation of budget, and miss communication between team members, advisors, and sponsor.

This section is intended to explain the reason of the issues encountered and how the team could have avoided them. One of the biggest problems was the ordering of parts. Many components are required to build the rotorcraft; the team first placed and ordered the components on December 2015 expecting the orders to be delivered on February 2015. However, the motors and batteries ordered had to be cancelled because the order would take around three to four months to be delivered and the team did not want to take the risk of not completing the rotorcraft, therefore, the team had to order new motors and batteries. Also, only APC 18”x10” clockwise propellers were available, and the rotorcraft requires four clockwise and four counter clockwise propellers in order to provide the necessary thrust forces. Similarly, five carbon fiber tubes were ordered to build the arms when only two were necessary. Therefore, the APC 18”x10” propellers, three carbon fiber tubes, and epoxy resin and poly vinyl alcohol that were provided by the HPMI where returned.

Another issue encountered was that the team did not take into consideration **all** the components required to build the rotorcraft. For example: the motor mounts, screws, RC controller, battery charger, and pins were not considered on the initial design, which result on the team purchasing those components because the waiting time was too long. Likewise, some components were not compatible with each other or the team had to improvise during the manufacture of the rotorcraft because some of the ideas proposed on the original design could not be accomplished. For example: the Zinger Wood propellers did not fit on the motor shaft and had to be drilled on the machine shop, and the team could not find hinges to connect the arms to the base plate, therefore, an aluminum sheet was cut using the water jet to produce the arm holders.

Further, the team experienced some problems with communication and organization. The team is conformed by eight people from three different engineering disciplines and different schedules, which made it difficult to coordinate meetings and work efficiently. Unfortunately, not all team members delivered the same performance, which resulted on a defective motor dropped from the third to the first floor, a damaged ESC due to incorrect wire connection, and delayed on the final assembly of the rotorcraft. The team did not personally meet the sponsor, but the team’s advisors were available whenever needed.

The issues explained above could have been avoided if the team had apply the following recommendations:

- Order parts ahead of time
- Call manufacturers before placing the orders and confirm availability
- Call manufacturers to confirm components can be delivered on time
- Take into consideration and evaluate minor details of the design
- Check specifications for each individual component
- Check compatibility of components
- Take into consideration machine shop time

- Implement better organization
- Better team, sponsor, and advisor communication
- Hold each individual accountable for their role

Some recommendations for future teams revisiting this project would be to research for a more optimal method of attachment, like a hook that can release the payload when needed. Also, seek help and advice from knowledgeable people at the beginning stages of the project in order to minimize risks that appear at the building of the prototype stage.