Experimental Design Assignment - 2020

Objectives
To provide hands on insight into how experimental design can be used to systematically improve design quality, but also to illustrate the practicalities of experimental design analysis and the difficulties it might entail.

General Information
The assignment may be performed in groups of 2-3 students. You will be constructing a helicopter using experimental design methodology. Each group will document its findings in one well-written technical report. The reports will be graded Pass or Fail. A Pass grade on this assignment is required to pass the course. A Fail grade means the report needs to be revised or rewritten. Important grading criteria are analytical correctness, structure and clarity in communication.

The Assignment
Your job as a group is to improve the design of a paper model helicopter so it will stay airborne as long as possible when dropped from a specified height. A blueprint of the existing design is handed out on a separate paper. The result parameter you should measure is the flying time when the helicopter is dropped from a specified height, for example 3 meter. The exact height is up to you to decide but it must be kept constant in all your experiments. Possible design changes to the helicopter are: the length and breadth of the rotor, the length and breadth of the body of the craft etc. (See Figure 1).

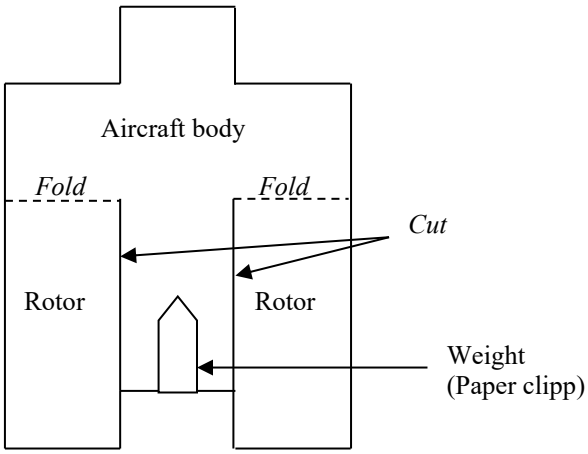

Figure 1. The model helicopter

How to proceed
The first step is to identify through brainstorming which factors you believe will influence the flying capability of the helicopter. To avoid having to many factors to work with in the

experimental phase you probably also need to prioritize which factors you think are the most important. The second step is to plan the experiment, in case you have many plausible factors this could involve choosing a reduced factorial experiment as a means to determine which factors to study in detail in a following complete 2^k factorial experiment. The next step is to determine the factor levels, i.e., which values will the high (+) and low (–) levels represent. These choices will affect the results; a smart selection will render better outcomes. There are no obvious rules on how to make these decisions, both too large and too narrow intervals might render the experiment useless. However, a good starting point is the existing design, which is known to work reasonably well.

After the initial experiment the results should be analyzed (for example using a normal plot) to determine which factors have significant effects and are worth studying further. Deciding which factors that are active (cause significant effects) is a delicate balance act between extremes, to classify a factor as active when it's not and not picking a factor as active when it is. If the results seem counter intuitive it could be a consequence of badly chosen factor levels and it's recommended to redo the experiment with revised factor levels. Even if the results do not stand out as peculiar it could be useful to redo the experiment with revised factor levels at least for those variables that appear to be relevant. On the other hand, there is a rule of thumb saying that about 25% of the resources should be spent on the first round of experiments the rest should be devoted to further in depth experimental studies and verification, so do not overdo it.

It is worth noting that the process is iterative to its nature, continuous refinement and improvement based on new information is the name of the game. (See Figure 2).

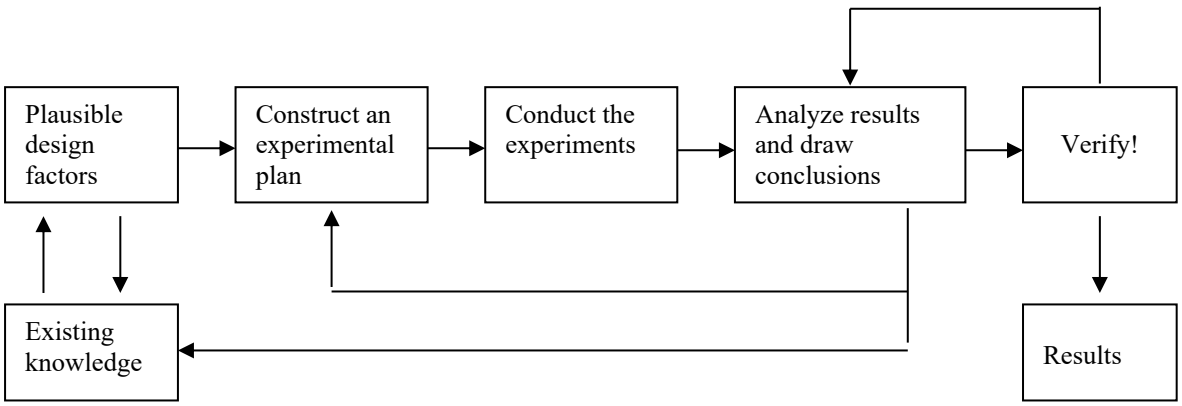

Figure 2. The experimental design work process

A suitable work plan can also be described in terms of a number of questions in the following way:

- What do we already know and which information is sought? (What factors/variables might affect the flying time in any significant way?)

- How should we conduct the investigation? What experimental plan should we use?
- How are we going to analyze and interpret the experimental results?
- Can we trust the results; do we need to redo the experiment with other factor levels to be sure which factors are active?
- Does the result confirm our beliefs and assumptions? What are the contradictions? How can they be explained? Do we need more experiments?
- Is the problem solved? What is our solution/conclusion?

Guidance
Choose a considerable drop height, say around 3 meters, to get better precision in your results. It takes some time before the helicopter starts spinning and this will have significant effect on the flying time. Observe the model during the experiments to see if it behaves strangely, pulls to the side etc.

Using the weight (with or without paperclip) as a design factor is not recommended, models without weight becomes instable and with too many paperclips it becomes too heavy. Furthermore, it is not advisable to fold angles on the rotors or other parts of the model since it is very difficult to fold different models the same. You must be able to keep the chosen design factors constant.

To reduce the variability due to external factors, it is recommended that every experiment be replicated several times. This also enables you to estimate the variability in individual results.

Limitations
You are only allowed to use the material provided to you by the instructor. Furthermore, the model must not require more material than one sheet of paper can cover, the paperclip excluded.

One final, quite obvious, limitation is that experiments are expensive to conduct do not go overboard with regards to the number of experiments performed.

Reporting instructions
Each group should produce a well-written and well-structured computer typed report (OBS! One report per group!). The report should explain the problem, your approach to solve it, your findings, results and conclusions. Given the nature of the assignment, it is particularly important you show and motivate each step in your analysis; don't just provide an answer or a number that appears to be taken out of the blue. Each report should clearly state the name of all the group members. The report should be handed in in paper format ***at the latest June 5, 1pm.***

Good luck with the experiments (and have fun)! /Fredrik