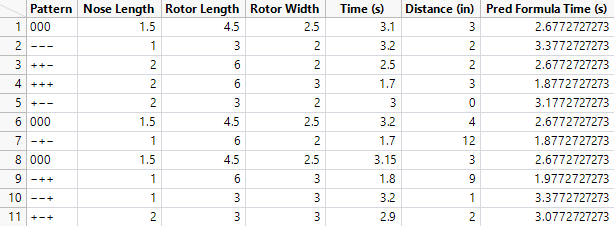
Paper Helicopter Group 25 Project for MATH 740/840

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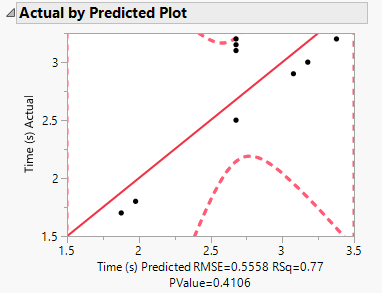
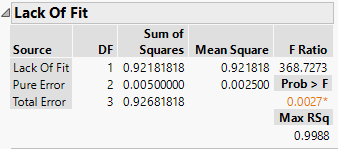
# Introduction

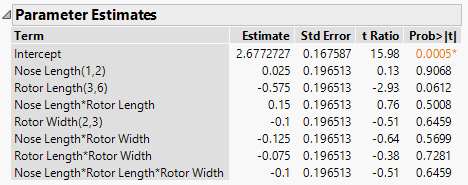
The purpose of this project is to determine the effect certain dimensions of a paper helicopter have on the overall flight time, and in relation its descent speed. A full factorial experiment was used with a high and low dimension was used for nose length, rotor length and rotor width while all other dimensions were held constant. 3 additional center point paper helicopter tests were also conducted. The varying dimensions were 1”/2”, 3”/6”, and 2”/3”, respectively. A total of 11 helicopters were created initially, with each copter getting dropped twice with an average taken between them for it actual drop time used for further analysis. The table below illustrates these helicopter dimensions and test results used for analysis

Table - Experimental set-up and dimensions with flight time and distance away experimental data



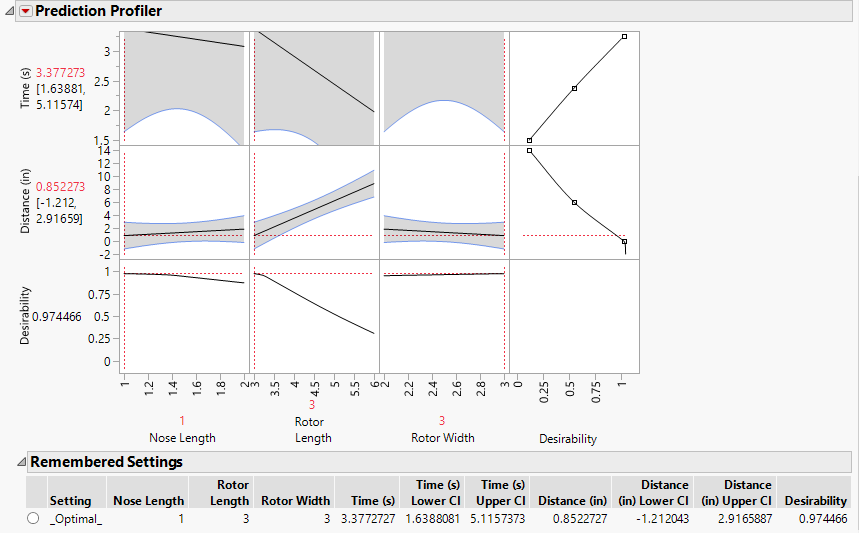
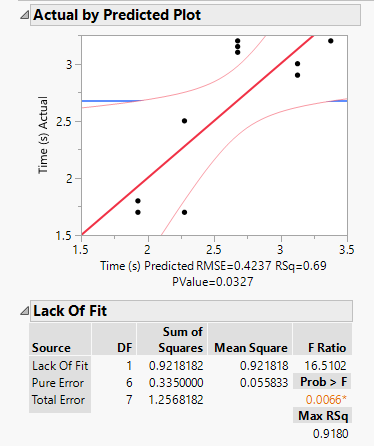
# Analysis of the Experimental Results

When doing a full-factorial analysis, we can begin to understand what affects the output of flight time, and what factors do not. JMP also can pinpoint the interactions of the different dimensions, lending a hand to find the best dimensions to increase flight time, making the helicopter descend at the slowest speed. The following figures (1 and 2) show the curvature in the relationship of the output to the varying factors as JMP tries to make a prediction line given the data. With a RSq value of 0.77, we can start to trust that there is a relationship on the factors changing and the output time to landing. The lack of fit table prints a total error of 0.928 seconds, with the main source being the Lack of Fit error, meaning there is some discrepancy in the data collection and how there aren’t very clear trends on the affect each dimension has on the fall time.

Using the parameter estimates, we can begin to determine what factors affect the flight time. There is one major parameter that changes the flight time significantly, which is the rotor length, having a prob value of 0.0612. and the next being the NoseLength\*RotorLength relationship with a prob value of .5008. Both have estimated effects of -0.575 and 0.15 seconds, respectively. By having nose length play a part on the parameter effects as a pair but not its individual dimension, we must keep it in the analysis as its combined affect plays a role in determining flight time. Therefore, the final model includes the Rotor length and nose length, with rotor width not playing a role in overall flight time. The predicted times based on the Prediction Formula of JMP is within Table 1 above.

# Optimizing Helicopter Performance

Once the initial analysis of the important varying parameters was complete, we could begin to pay attention to the parameters that mattered. Deleting the rotor width option, it narrowed in our important parameters and focusing on the optimization of these parameters in terms of flight time and minimizing the distance away it landed from the vertical landing surface. It converged on a nose length of 1 inch, a rotor length of 3 inches, and a rotor width of 3 inches printing an expected time of 3.37 seconds and 0.85 inches from the pad. It hasn’t maximized the time completely, but it optimized to also consider the importance of minimizing the distance away from the release vertical to the landing location.



# Validating the Results

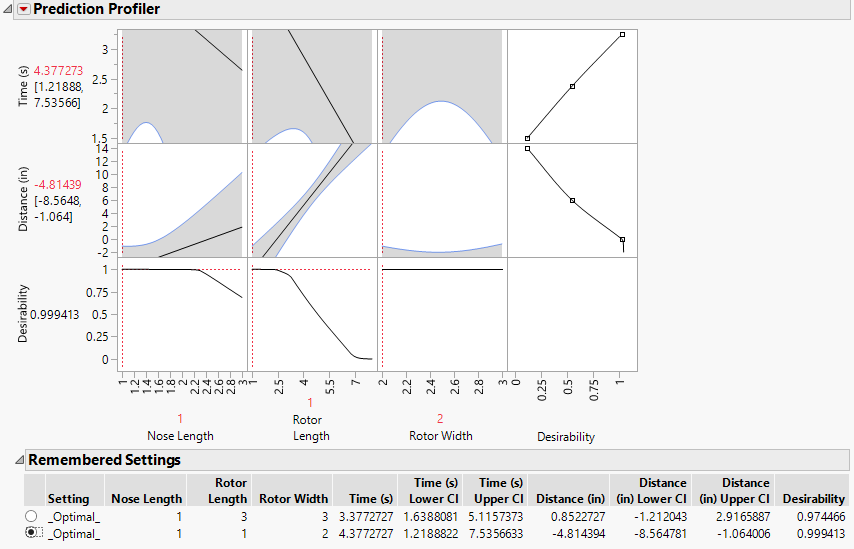
With the final optimized dimensions determined above, it seems it matches a current helicopter already constructed. Three more of that version was created again and drop tested in the same way.

|  |  |
| --- | --- |
| Drop Time (s) | Accuracy (in) |
| 3.5 | 2 |
| 3.1 | 0 |
| 3.0 | 4 |
| **3.2 Average** | **2 Average** |

From the table above, it is clear that the optimization assisted in finding the desirable dimensions for the paper helicopter with increasing flight time (decreasing drop rate) while also minimizing the distance away it falls from the vertical axis of the drop location. As the tests we done indoors without drift, each drop was very repeatable as each drop can be maintained the same each time. A greater amount of tests, more rigorous paper helicopter construction and a larger range of dimensions could help with more verification on the ‘best’ design to maximize flight time and minimize the amount of drift, but increasing the resources needed to come to that answer.

# Projected Potential Improvement

The figure below is performing the optimization with bounds extending past the experimental box, outputting a potential drop time of 4.37 seconds while allowing a drift of 4.8 inches.



Two paper helicopters were made, each with the dimensions of the second remembered settings. The drop time was measured to be 4.10 seconds and a drift of 4 inches, detailing that although extended past what we can usually trust, it still does a reasonable job in predicting the flight time of the helicopter and the total drift.