Ground Effect Vehicles Research Project Midterm Report

Society of Physics Students Towson University Chapter

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Introduction

During the course of research on ground effect aircraft we have collected a great deal of interesting data. From this data we have been able to assert specific conclusions about the design of such craft and their application. Already we have completed two out the three experiments that we planned to execute.

Within the coming months we will conduct further research into wing design for ground effect vehicles. Based on the data we have gained through this project we will produce a working model of such a vehicle. This will prove our research beyond a reasonable doubt and allow issues in construction and use of such vehicles to be explored.

Test 1

Test 1 Overview

Test one allowed us to analyze the basic airfoil that allowed the greatest lift to be achieved. The airfoil, which is the side view of a wing usually tear dropped in shape, was very interesting to collect data on.

Test Procedure

We tested each airfoil with the same amount of surface area. Each wing was six inches in length, ¾ of an inch in height and 6 inches in width. By keeping these parameters consistent in each wing we tested, everything other than the airfoil was constant. This allowed us to specifically look at which airfoil produced the greatest lift. Four wings were tested. Two of the wings are asymmetrical so they will be tested both forwards and backwards to see if this has any effect on design.

Test 1-A

Test 1-A Reversed

Test 1-B

Test 1-C

Test 1-D

Test 1-D Reversed

We originally tested these wings and kept only one trial run. Due to necessity of providing ample data to support our conclusions we retested each wing design three more times and kept that trial data. Both trials produced similar results.

The surface area of the wings will be constant so that deviations in weight and can be attributed in design problems.

Two Force meters were used in this experiment. One was attached to the wing so that lift could be directly measurement. The second force meter was positioned facing opposite of the direction of the wind. By attaching a large piece of balsa wood perpendicular to the wind direction we could directly measure the force of the wind by how much it pushed against the balsa wood.

Prediction

Based on the background research done to investigate what we should expect in conducting our own research we believe that Test 1-A work the best. This design exploits Bernoulli's principle the greatest out of any of the designs that we are testing. We are not sure whether this design we will the best forward or backwards or if that will have any effect on the deficiency of the wing. Most probably the design will work better forwards rather than backwards since that is how most plans are designed in general, with the apex of the wing forwards.

Data

Test 1-A

	Thrust Force	Lift Force
Trial 1	1.01 Newtons	1.29 Newtons
Trial 2	.81 Newtons	1.47 Newtons
Trial 3	.83 Newtons	1.79 Newtons
Trial 4	.89 Newtons	1.45 Newtons
Avg.	.885 Newtons	1.5 Newtons

Lift Force / Thrust Force = 1.5 Newtons / .885 Newtons = 1.695 Newtons

Test 1-A Reversed

	Thrust Force	Lift Force
Trial 1	1.26 Newtons	3.29 Newtons
Trial 2	1.24 Newtons	3.15 Newtons
Trial 3	1.24 Newtons	3.1 Newtons
Avg.	1.247 Newtons	3.18 Newtons

Lift Force / Thrust Force = 3.18 Newtons / 1.247 Newtons= 2.55 Newtons

Test 1-B

	Thrust Force	Lift Force
Trial 1	1.03 Newtons	2.09 Newtons
Trial 2	1.03 Newtons	2.12 Newtons
Trial 3	1.02 Newtons	1.84 Newtons
Avg.	1.027 Newtons	2.017 Newtons

Lift Force / Thrust Force = 2.017 Newtons / 1.027 Newtons= 1.964 Newtons

Test 1-C

	Thrust Force	Lift Force
Trial 1	1.19 Newtons	1.75 Newtons
Trial 2	1.25 Newtons	2.26 Newtons
Trial 3	1.21 Newtons	2.31 Newtons
Avg.	1.216 Newtons	2.106 Newtons

Lift Force / Thrust Force = 2.106 Newtons / 1.216 Newtons= 1.73 Newtons

Test 1-D

	Thrust Force	Lift Force
Trial 1	1.3 Newtons	1.8 Newtons
Trial 2	1.31Newtons	2.42 Newtons
Trial 3	1.31Newtons	2.24 Newtons
Avg.	1.303 Newtons	2.153 Newtons

Lift Force / Thrust Force = 2.153 Newtons / 1.303 Newtons= 1.652 Newtons

Test 1-D Reversed

	Thrust Force	Lift Force
Trial 1	1.42 Newtons	2.27 Newtons
Trial 2	1.43 Newtons	2.59 Newtons
Trial 3	1.43 Newtons	2.77 Newtons
Avg.	1.427 Newtons	2.543 Newtons

Lift Force / Thrust Force = 2.543 Newtons / 1.427 Newtons= 1.782 Newtons

Note: We choose 10 seconds to 40 seconds as our time interval in order to prevent take off and landing data from varying our results. The interval we chose is away from these points because take off force ends before 10 seconds and landing starts at 50 seconds. The course of the whole test is over 60 seconds.

We took the absolute value of the magnitude and used it in our data in order to make the data easier to read for the viewer. Lift is negative with respect to our measuring device because the wing is pulling up rather than pushing down. The Magnitude is the point of concern. However a change in the direction of force (a change in sign value) will be noted.

Conclusion Test 1

The airfoil that produced the greatest amount of lift was surprisingly Wing Design 1-A Reversed. This is very peculiar because most airplanes have the opposite setup in normal flight. During our background investigation of what other groups believe affects planes it was disputed by NASA that Bernoulli's effect was not the leading cause of lift. Bernoulli states that because the air traveling over the longer wing top has to move faster in order to keep up with the air moving on the bottom the wing lifts upward because of the greater pressure beneath it. However our findings show that the wing with the greater difference in pressure had the greater amount of lift. The surface area below the wing was consistent for all tested designs. So the theory that Newton's law being the greatest component of lift is not true. This may only be true for ground effect aircraft and may not prove NASA wrong.

Test 2

Test 2 Overview

The purpose of this test is to compare several general wing positions and analyze which works best in ground effect.

Test Procedure

Test 2-A

Test 2-B

Test 2-C

The surface area of the wings will be constant so that deviations in weight and can be attributed in design problems.

The three tests above allow a general view of what wing positioning produces the greatest lift. If we had found that two of the tests produce similar amount of lift that was greater than the other then we could continue researching wing designs that combined aspects of both designs. If only one of the tests works the best than no further research of this part of design warrants further investigation.

Two Force meters were used in this experiment. One was attached to the wing so that lift could be directly measurement. The second force meter was positioned facing opposite of the direction of the wind. By attaching a large piece of balsa wood perpendicular to the wind direction we could directly measure the force of the wind by how much it pushed against the balsa wood.

Prediction

The hypothesis made for this test was that Test 2-B would produce the greatest lift. The downward angle of the wings seems to allow for more force to be trapped underneath the wing allowing for greater lift. It was also presented in our background research that the downward angle of the wings worked best for ground effect aircraft.

Data

Test 2-A

Purpose

Test 2-A was based on the information from internet sources that stated flat box like wings work well. We tested this to see if the statements made were true and to compare the results of this test to the other test designs.

We ran three tests to validate our data and produce a viable conclusion.

Average Lift Values

	Thrust Force	Lift Force
Trial 1	.81 Newtons	7.67 Newtons
Trial 2	.82 Newtons	7.89 Newtons
Trial 3	.76 Newtons	8.49 Newtons
Avg.	.796 Newtons	8.016 Newtons

We took the absolute value of the magnitude and used it in our data in order to make the data easier to read for the viewer. Lift is negative with respect to our measuring device because the wing is pulling up rather than pushing down. The Magnitude is the point of concern. However a change in the direction of force (a change in sign value) will be noted.

For all three runs the average total value of lift for this design between 10 seconds and 40 seconds was 8.016 Newtons for .796 Newtons of thrust.

Lift / Thrust Ratio = 8.016 Newtons / .796 Newtons = 10.07 Newtons

Note: We choose 10 seconds to 40 seconds as our time interval in order to prevent take off and landing data from varying our results. The interval we chose is away from these points because take off force ends before 10 seconds and landing starts at 50 seconds. The course of the whole test is over 60 seconds.

Test 2-B

Purpose

The purpose of this test was to see if angling the wings downward towards the ground would increase or decrease lift.

We ran three tests to validate our data and produce a viable conclusion.

Average Lift Values

	Thrust Force	Lift Force
Trial 1	.68 Newtons	6.17 Newtons
Trial 2	.79 Newtons	7.99 Newtons
Trial 3	.81 Newtons	6.92 Newtons
Avg.	.76 Newtons	7.026 Newtons

We took the absolute value of the magnitude and used it in our data in order to make the data easier to read for the viewer. Lift is negative with respect to our measuring device because the wing is pulling up rather than pushing down. The Magnitude is the point of concern. However a change in the direction of force (a change in sign value) will be noted.

For all three runs the average total value of lift for this design between 10 seconds and 40 seconds was 7.026 Newtons for .76 Newtons of thrust.

Lift / Thrust Ratio = 7.026 Newtons / .76 Newtons = 9.24 Newtons

Note: We choose 10 seconds to 40 seconds as our time interval in order to prevent take off and landing data from varying our results. The interval we chose is away from these points because take off force ends before 10 seconds and landing starts at 50 seconds. The course of the whole test is over 60 seconds.

Test 2-C

Purpose

This test was used in order to determine if positioning the wings upwards away from the ground affected the lift of the wing.

We ran three tests to validate our data and produce a viable conclusion.

Average Lift Values

	Thrust Force	Lift Force
Trial 1	1.06 Newtons	7.63 Newtons
Trial 2	.96 Newtons	8.18 Newtons
Trial 3	.91 Newtons	7.13 Newtons
Avg.	.976 Newtons	7.646 Newtons

We took the absolute value of the magnitude and used it in our data in order to make the data easier to read for the viewer. Lift is negative with respect to our measuring device because the wing is pulling up rather than pushing down. The Magnitude is the point of concern. However a change in the direction of force (a change in sign value) will be noted.

For all three runs the average total value of lift for this design between 10 seconds and 40 seconds was 7.646 Newtons for .976 Newtons of thrust.

Lift / Thrust Ratio = 7.646 Newtons / .976 Newtons = 7.83 Newtons

Note: We choose 10 seconds to 40 seconds as our time interval in order to prevent take off and landing data from varying our results. The interval we chose is away from these points because take off force ends before 10 seconds and landing starts at 50 seconds. The course of the whole test is over 60 seconds.

Conclusion Test 2

From our data collected in this test, Test 2-A produced the greatest lift. This was contradictory to both our hypothesis and the statements made by groups have built such vehicles. This is quite extraordinary because it allows us to theorize why this happened. It seems that as the wing positioning is shifted up or down with respect to a completely horizontal wing design, the normal force produce by lift changes. When you angle the wings upwards away form the ground not only does the normal change but more force is lost and is not captured in ground effect.