

Flight Test Project Activity Planner for Teachers

Takeoff Distance

Introduction

This project allows students to conduct aircraft flight testing in a similar manner done at flight test centers at Edwards Air Force Base. Conducting these flight tests using a flight simulator and analyzing data allows students to visualize basic physics concepts within the context of aerospace. Students will assess the expected outcome, plan and conduct a test, collect and analyze data to determine if their hypothesis are proven correct or not. Students will conduct takeoff testing by varying airplane gross weight and seeing the effects on runway takeoff distance.

Grade Level

This project can support a wide range of student levels and abilities starting in junior high. After this basic activity, extensions are provided for in depth exploration into areas such as kinematics, aerodynamics and weather for high school students. Using a flight simulation software that appears to be a video game appeals to students while the fidelity of the simulation with its data recording capability lends itself to being a very functional engineering and student learning tool. Students from junior high through high school can benefit.

Supplies Needed

- Obtain Xplane version 9 demo for free at <http://www.x-plane.com/desktop/try-it/older/> Depending on internet connection it will take a while time to download. This free demo version will stop running after 10 minutes and requires a program restart, but it runs long enough to conduct this activity. Version 9 is recommended to be run on older, less powerful laptops. Cost to purchase Xplane Fly to Learn is approximately \$24 which eliminates the 10 minute restriction and can be found at <http://flytolearn.com/> and includes further teacher resources at <http://flytolearn.com/resources/>.
- Laptop (PC) or desktop computer with mouse.
- Excel spreadsheet software or graph paper to plot the data or DatPlot (<http://www.datplot.com/>)

Duration

Depending on the depth of study, this initial activity can be completed in a minimum of three 55 minute lab sessions as in the suggested outline (not including the time to load the software) and can be expanded with further exploration. Extensions of the project will take approximately two to three sessions each.

Outline

First class Project introduction, teacher demo, test plan review and time for student independent exploration and checkout.
Second class Actual student flight testing and data collection
Third class Data review and plot generation to draw conclusions from the testing and comparing results within class.

Initial Thinking

Initially have students think about the effects of the total weight of the airplane (gross weight) has on the takeoff and the runway distance needed for takeoff. Would it have any effect? Think about different sizes of birds and how long it takes for some to take flight. What are some similarities of small and large birds in flight that could be useful for an airplane? Have students develop a hypothesis about what the outcome might be.

Test Plan

Develop a test plan matrix that details what test conditions to fly to include items to adjust called variables. Students will also record test data within the same table. Use the following as an example for the Boeing 777 airplane. (Note you will repeat the same test condition three times and get an average of the takeoff distance from Xplane. This will average out some of the data scatter due to inconsistencies in performing the test). Use a constant flap setting of 15 and vary the Gross Weights 350,000, 500,000 and 625,000 lbs. (To change Gross Weight, go to Airplane menu then Fuel Payload and adjust fuel weight until you get the total gross weight you want).

Test Plan Matrix

Cond/Trial	Flaps	Gross Weight	T/O Distance (ft)	Average Distance
1.1	15	350,000 lbs		
1.2	15	350,000 lbs		
1.3	15	350,000 lbs		
2.1	15	500,000 lbs		
2.2	15	500,000 lbs		
2.3	15	500,000 lbs		
3.1	15	625,000 lbs		
3.2	15	625,000 lbs		
3.3	15	625,000 lbs		

Test Procedure

You will use the following test procedure to start the simulation, record the data, configure the airplane, conduct the takeoff and recover the data.

- Start Xplane
- Select an airplane from the menu. Suggest a 'heavy metal' airplane like a B777 to better demonstrate the differences in takeoff distance.
- Use the default airport runway and location
- Set up data collection
 - Select Settings, Data Input & Output, Data Set.
 - Check middle two boxes for the following data sets: 1, 3, 20, 21, 66 (time, speeds, altitude, gear loads, etc)
- Get ready for Takeoff
 - Set Takeoff parameters of Flaps and Gross Weight per test plan matrix (add Flaps with '1', remove with '2').
 - Add full thrust, (F2)
 - Release Brakes (B)
 - Use mouse and click in the pilot window to get a control box. Use the mouse to move the airplane surfaces up/down; left/right.
 - At about 100 knots airspeed, pull back on the elevator by moving the mouse directly down until the airplane takes off. Keep your pitch attitude below 15 degrees so you don't stall the plane and fall..
 - After reaching about 200 feet above the ground, pause the simulation (P).
- Data Recovery
 - Go to Data Input & Output, then Data View
 - To unclutter the screen, deselect (uncheck) all parameters except Vtrue mph, Alt ft agl, Distance nm, ft and all Gear loads. This will leave you with just a few parameters to view.
 - Slide your cursor to the far left to the start of the test, as you move the cursor slowly you will see time (seconds) increase (on the bottom) and start to see the velocity increase as well. Keep moving to the right until you see all off the landing gear loads go down to zero. This means the aircraft has left the ground or taken off. Place the cursor there and read off the distance the aircraft has traveled. Record this value in your test matrix.
 - After recovering the test data, go to Location and reset the simulation to the same airport and do the next test condition or trial.
 - After all the trials are done, average the three trials together and place that value in the test matrix column.
 - Move to the next condition and change the airplane configuration and repeat the testing until the test matrix is filled.

Data Analysis

Data Results

- Using Excel, or manually on graph paper, plot each of the distance values against takeoff distance (Distance on Y axis, gross weight on X axis).
- Alternatively, use the takeoff start and stop times along with the basic kinematic equations of speed, time and distance to determine distance.

Conclusions

- Look at the data. Can you see a pattern of takeoff distance? How is it related to the variable of gross weight? Can you make some inferences? Does your test data support your hypothesis of what you might have thought it to be? Can you make any predictions for values in between? You should see that increasing gross weight will increase takeoff distance.

Questions/Comments?

Contact Dan Hrehov at danhrehov@outlook.com. Dan has over 35 years as a flight test engineer, has a Master's in Teaching degree and holds a Washington State Teachers certificate for secondary education with a physics endorsement.

<https://www.linkedin.com/in/danhrehov/>