Teacher FAQ's for the Flight Test Project Rev A

The following set of FAQs are what typically a teacher might ask of this project. If these don't address your questions, please contact Dan Hrehov at danhrehov@outlook.com.

1. **What is the Flight Test Project?**

   The flight test project uses the exciting field of aerospace and flight testing as a way to enthuse students about learning math and science principles. Students will explore the physics of flight through the study of aeronautical engineering and flight test by means of current industry practices using an engineering grade, desktop flight simulator. They will learn the forces of flight and how airplanes fly. Students will conduct airplane takeoff testing, varying variables such as flap setting and gross weight and then use kinematic equations to calculate runway takeoff distance, comparing their results with the simulator's values. They will make an assessment of the expected outcome, plan and conduct a test, collect and analyze data to determine if their hypothesis is proven correct or not. Conducting these flight tests using a flight simulator and analyzing data, allows students to visualize basic physics concepts within the context of aerospace and that is done in a similar manner at typical flight test centers such as Edwards Air Force Base.

2. **What math levels are required?**

   For the middle school version, nothing more than solving distance equations using a given formula. For high school students, basic algebra skills are needed to be able to solve for a single variable in an equation and also be able to calculate the slope of a line.

3. **What is the grade level?**

   This project can support a wide range of student levels and abilities starting in junior high on up to 9^{th} and 10^{th} grade. Introducing Newton's laws, the Lift equation, velocity and distance equations will require some understanding of basic algebra concepts.

4. **Are there Common Core Standards associated with this project, and if so, what are they?**

   Yes. Both Next Generation Science Standards, NGSS, for science and Common Core Math standards adopted by Washington State are addressed in this project. Here are some specific standards that are at least partially addressed.

   Science

   - MS-PS2 Motion and Stability: Forces and Interactions
     - MS-PS2-1. Apply Newton's Third Law to design a solution to a problem involving the motion of two colliding objects.
     - MS-PS2-2. Plan an investigation to provide evidence that the change in an object's motion depends on the sum of the forces on the object and the mass of the object.

- MS-ETS1 Engineering Design
    - MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.
- HS-PS2 Motion and Stability: Forces and Interactions
    - HS-PS2-1. Analyze data to support the claim that Newton's second law of motion describes the mathematical relationship among the net force on a macroscopic object, its mass, and its acceleration.
- HS-ETS1 Engineering Design
    - HS-ETS1-2. Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering.

Math

- Ratios and Proportional Relationships 7.RP
- Expressions and Equations 7.EE
- Expressions and Equations 8.EE
- Functions 8.F
- Creating Equations A-CED

5. **What is the duration of this project?**

The basic four session schedule, primarily suited for junior high students is listed below. These would be block periods that would include both direct instruction and lab work to conduct the testing.

1. Project introduction
2. Teacher led demonstration of Xplane
3. Students conduct their own flight tests, collect and and compile data
4. Project debrief/reflection.

For a more in-depth study of additional concepts, ten sessions as described below, would be as an example of a suitable class schedule. These also would be block periods that would include both direct instruction and lab work to conduct the testing and perform the analysis.

1. Introduction to project and to flight testing
2. Anatomy of an airplane
3. Flight Instruments
4. Force and Airplane Forces
5. Lift and Lift Equation
6. Anatomy of a Takeoff
7. Velocity

8. Distance
9. Test Results
10. Project debrief/reflection

6. **Is there assistance available to help with lesson planning?**

   Yes, contact Dan Hrehov at danhrehov@outlook.com with your specific request. Powerpoint slides can be made available as well.

7. **How much does it cost?**

   Nothing, except for the computer/mouse, all of the software can be downloaded for free.

   - Xplane version 9 demo for free at http://www.x-plane.com/desktop/try-it/older / Depending on internet connection it will take some 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 some testing. Version 9 is recommended if it is to be run on older, less powerful laptops, but still has all the functionality required.
   - Alternatively, there is a commercial course called Fly to Learn that includes v9 Xplane software, lesson plans and other resources for both teachers and students to conduct the basic testing. The cost to purchase Xplane Fly to Learn is approximately $24 per computer which eliminates the 10 minute restriction and can be found at http://flytolearn.com/ . (Note: There are loaner copies of the 'Fly to Learn' software that can be borrowed. Additionally, classroom scholarships can be made available as well. Send you written request to SFTE.)

8. **Are there extensions to this project that advanced students could try?**

   After the initial testing of various airplane gross weights, extensions in the areas of exploring effects of temperature, altitude, wind, thrust and flaps on airplane takeoff performance can also be done. More advanced extensions are available.

9. **What are the math connections to this project?**

   The connection to math concepts is important for several reasons, not only just for practice but primarily in the use of validating the test results against the theory. Manipulating one variable in a three variable equation such as the distance equation using average velocity, is something junior high students can understand. Here are some other specific examples;

   - The concept of velocity is introduced and used as an important factor in determining takeoff distance and also in its effects on lift in the lift equation.
   - The conversion of units, specifically miles per hour => feet per second is required to obtain the runway distance in the correct units of feet.

- Unit conversion can also be used as an opportunity to introduce students to dimensional analysis whereby doing the units conversion longhand, carrying all the units along with the numeric values in the equations and canceling 'like' units is a method to independently verify correct units at the end.
- Distance calculations can be made using average velocity where velocity can be assumed to be linear; distance equals average velocity multiplied by time: $D = V_{ave} * t$ where $V_{ave} = (V_f + V_i)/2$.
- Distance can also be arrived at by using acceleration: distance $D = ½at^2$, where acceleration is determined by: acceleration = $\Delta v/\Delta t$. Coupling this with another useful concept that the slope of the velocity plot equates to acceleration is another method to reinforce linear equation concepts.
- Introducing the lift equation, $L = \frac{1}{2}\rho S V^2 C_L$, is important in understanding the parameters that affect lift. For example, knowing that the lift generated by the wing must equal the weight of the airplane, will illustrate to students the need to increase some other variable in the equation to produce the extra needed lift. For example, increasing either velocity, wing area or the Coefficient of Lift, C_L, will increase lift. Adding flaps will increase both wing area, S, and C_L. Advanced students can explore how air density affects lift by testing airport temperature or airport elevation. Other factors such as headwinds and thrust settings have a direct relationship to runway distance and test results can readily illustrate that.

10. What are some good online resources for reference?

- X-plane Web site: http://www.x-plane.com/desktop/home/
- Fly To Learn website http://flytolearn.com/
- DatPlot web site: http://www.datplot.com/
- *NASA Beginners Guide to Aeronautics* page https://www.grc.nasa.gov/WWW/k-12/airplane/index.html
- *NASA What is Aeronautics* page https://www.grc.nasa.gov/WWW/k-12/UEET/StudentSite/aeronautics.html

11. What is SFTE?

The Society of Flight Test Engineers (SFTE) is an international professional engineering society, based in Lancaster, CA, supporting the worldwide aerospace flight testing community. Visit http://www.sfte.org/ or call (661) 949-2095 (SFTE Headquarters 44814 N. Elm Avenue, Lancaster, CA 93534) for further information about the Society. There are several local chapters around the country usually situated in communities with an aerospace industry presence.