Engineering Design Process Applied to Top Gun: Airbus Aerospace Engineering Project

**Goal:** To design a paper airplane that can travel the straight and fast as well as travel a long distance while carrying a load.

**Research:** Use technology and media to research the role of fighter jets and cargo planes, and identify types of planes that have been designed to solve problems faced by both planes.

*Note that the research can be teacher-driven using slides and videos.*

**Develop:** Using research, brainstorm multiple solutions to creating an airplane prototype that would fly straight and fast as well as travel a long distance while carrying a load.

**Choose:** Choose one plane design per objective to build, test and evaluate.

**Create:** Build an airplane prototype that maximizes speed as well as carries a cargo load a long distance.

**Test and Evaluate:** Test airplane designs, gather data, and evaluate results.

**Communicate:** Analyze data and discuss with the team what changes could be made to the plane prototypes. Share your design with the class, why you chose the design, and how it performed under the given conditions.

**Redesign:** Develop a redesign plan using data from first trial to create, test and evaluate an improved prototype of an airplane.

**Note:** The Engineering Design Process (EDP) fits seamlessly with the 5-E model. For the purpose of focusing teachers on engineering, the EDP headings are used in this lesson.
### Engineering Design Challenge

**Project Title:** TOP GUN

**Project Sources:**

- Top Gun Over Moscow. PBS  
- Take Off with Paper Airplanes  
- How Planes Fly  
  [http://www.youtube.com/watch?v=ocni_Whz5EA](http://www.youtube.com/watch?v=ocni_Whz5EA)  
  [http://www.youtube.com/watch?v=5ltjFEei3AI](http://www.youtube.com/watch?v=5ltjFEei3AI)
- Loading Cargo  
  [http://www.youtube.com/watch?v=j9W8eOxYyT4](http://www.youtube.com/watch?v=j9W8eOxYyT4)
- FedEx  
  [http://www.youtube.com/watch?v=A5ZtK1r7Ovc](http://www.youtube.com/watch?v=A5ZtK1r7Ovc)
- AIRBUS  

**Project Submitter:** K. Elizabeth Hammonds

**Grade Level/Subject:** Mobile County Public School System; Mathematics, Grade 8, 3rd Quarter

**Engineering Challenge:** Planes are often designed for specific purposes, such as flying short distances at high speeds or to carry heavy cargo loads long distances. In an effort to enhance safety, fighter jets have increasingly been modified to fly straighter and faster. At the same time, cargo planes have been continuously modified to carry increasingly heavy cargo loads. Plane manufacturers work closely with scientists and aerospace engineering teams to research and improve an airplane’s design and performance. As a result of this collaboration, fighter jets and cargo planes are becoming more sophisticated.
**Lesson Description:** Through this hands-on experience and challenge, students will apply the Engineering Design Process (EDP) to solve a real-world problem. Students will work in teams to develop a plan to create and build a prototype (model) of an airplane that flies straight and fast as well as an airplane that effectively carries cargo a long distance. Teams will apply their mathematical knowledge of Symmetry, Reflection, Lines of Symmetry and Reflection, and area, as well as their understanding of Newton’s Laws of Motion to create their design. Students will graph the reflection of an airplane wing on a coordinate plane to show that the two wing shapes are congruent. Engineering teams will communicate their findings by analyzing data collected to identify the next steps required for the redesign of their prototypes and share what was learned.

**Time Required:** 2 50-minute class period

### Educational Content Standards

#### Engineering Standard:

8.1 Describe the steps of the Engineering Design Process (EDP).

#### Real World Connection:

Engineers apply the EDP to design technologies to meet human needs. Airbus USA is building an airplane manufacturing plant located in Mobile, Alabama.

#### MCPSS Mathematics to support the engineering challenge:

16. Verify experimentally the properties of rotations, reflections, and translations. [8-G1]
17. Understand that a two-dimensional figure is congruent to another if the second can be obtained from the first by a sequence of rotations, reflections, and translations. [8-G2]
18. Describe the effect of dilations, translations, rotations, and reflections on two-dimensional figures using coordinates. [8-G3]

#### MCPSS Science to support the engineering challenge:

7.1 Recognize applications of Newton’s Three Laws of Motion.

#### Learning Objectives to support the engineering challenge:

- Describe the steps of the engineering design process used to research, design, and test a model of an airplane that will fly straight and fast as well as fly a long distance while carrying a load.
- Describe constraints, relationships and goals as applied to the engineering design challenge.
- Students will complete data chart of their results, and then analyze and interpret them.
- Students will collaborate on ways to improve their design – by changing the shape and/or material.
### Materials required:

**For each teacher:**
- Engineering Design Process Poster
- 1 Computer and Projector (or Smart Board)
- Chart Paper
- PPT. titled *TOP Gun*
- Stopwatch (1 for each testing area)
- Model airplanes/gliders

**For each team of three students:**
- 2 sheets of copy paper (8 ½” x 11”)
- 1 Manila Folder (or 8 ½” x 11” cardstock)
- 5 paper Clips
- 2 Scissors
- 1 Roll of Masking Tape
- 2 Sheets of Construction Paper (8 ½” x 11”)
- 1 Meter Stick or Measuring Tape
- 3 index cards

### Reproducible Materials:
- Copies of SH: 1, Research Data (1 for each team)
- Copies of SH: 2. Cargo Data (1 for each team)
- Copies of SH: 3, Technical Drawing (one per student)
- Copies of Research: What Makes Paper Airplanes Fly? (class set; one per student)

### Teacher Preparation: Day 1
- Make 2-3 different paper airplane designs, using different types of paper, for students to look at before they begin their designs.
- Preview lesson.
- Review PowerPoint.
- Prepare to have students working in teams of 3.
- Prepare to have teams of 3 pair up to form teams of 6 for research.
- Preview student handouts.
- Gather all materials for Day 1.
- Make copies of SH: 1, Research Data. (1 for each team)
- Make copies of Research: What Makes Paper Airplanes Fly?. (class set; one per student)
- Prepare an area for testing airplanes. Place two strips of tape, 4 meters in length, parallel to each other, one - two meters apart. This will serve as the flight path.
### Teacher Preparation: Day 2
- Preview lesson.
- Review PowerPoint.
- Prepare to have students working in teams of 3 (combining with another team to make a 6 member team for some activities).
- Preview student handouts.
- Gather all materials for Day 2.
- Make copies of SH: SH: 2. Cargo Data. (1 for each team)
- Make copies of SH: 3, Technical Drawing. (one per student)

### Prerequisite knowledge:
**Before this lesson students should:**
- Have prior knowledge of data charts, recording and analyzing data.
- Know how to measure distances with a yard stick or a measuring tape.
- Have basic knowledge of Newton’s Laws of Motion.
- Have basic understanding of transformations (rotations, translations, and reflections).
- Have experience graphing points on a coordinate plane.

### Science objectives:
- Students will apply Newton’s Three Laws of Motion to solve the design challenge.
- Students should conclude that a paper plane made of heavier material will resist wind draft (forces) and will fly in a straighter path.
- Students should conclude that the wider the plane’s body, the more surface area it has to stay aloft (counter acting forces).
- Students should conclude that the load is kept near the center of the plane to remain balanced.

### Math Objectives:
- Students use their understanding of symmetry, lines of symmetry, reflection, and lines of reflection to design a paper airplane that can fly the straightest and fastest as well as design an airplane to fly the longest distance while carrying a load.
- Students should recognize that the paper airplane must have strong line symmetry in order to balance the airplane to fly straight.
- Students should be able to conclude that planes must have a strong line of reflection and recognize the planes halves need to be mirror images of each other in order to fly straight and reliable long distances.
- Students will understand that the longer or shorter wing dimensions affect the plane’s flight.
- Students apply mathematical knowledge of symmetry, reflection, and area to solve a design challenge.
DAY ONE

Crash Test!
Grade 8, Math, Q 3

Engineering Connection:
Engineering is the process used to design technology to meet a human need. Many of today’s jobs require employees to work in teams. Engineers have been continuously redesigning airplanes to meet increased needs in countries, companies, and individuals.

DEFINE THE PROBLEM AND RESEARCH

Bell Ringer: Display Slide # 2. As students enter the classroom have them complete the Bell Ringer in their notebooks.

List two reasons why engineering companies might require their workers to work in teams.

After about a minute allow some students to share their responses. Student responses should indicate that they are aware of the following ideas:

- Each member of a team brings his or her own special skills, abilities, knowledge, and ideas to the mix.
- The best teams often accomplish more than individuals do.
- Teams have been shown to improve communication within a company.
- Working in teams give workers a greater sense of job satisfaction.

Introduce the challenge: Explain that for this challenge, students will work together as engineering design teams of three. Refer to the Engineering Design Process poster and remind students that they will be using these steps to solve a design challenge related to aerospace engineering. Point out that this is important because of the growing aerospace business and industry in the Mobile area.

Display Slide # 3. Say:

Airplanes are designed differently based on how they will be used. What are some types of airplanes and their uses? (Let students share some ideas about different types of airplanes and their function, for example, cargo planes, crop dusters, passenger planes and jet fighters.)
Explain that some aerospace engineers work on making planes safer. Others work on designing planes that perform better. For example, in an effort to enhance the national security of some countries, aerospace engineers have been modifying fighter jets to fly faster in a straight flight path. Plane manufacturers work closely with scientists and aerospace engineering teams to research and improve the airplane’s design and performance. As a result of this collaboration, all planes have become more sophisticated over the recent years.

Tell students that for this challenge, they will be working on improving the design of paper airplanes to meet specific criteria, or performance standards. In order to do that they will need some background information. Ask:

**What step of the engineering process should we work on first?** (Define the Problem)

First, students need to make sure they understand the problem.

**Launch the challenge:** Tell students that their challenge is to design a better paper airplane.

Ask:

**What are some features that are important for paper airplanes to be successful?** (They need to be able to fly fast and straight.)

Display **Slide # 4**.

**Design Challenge:** Design a paper airplane prototype that goes straight with a high average velocity.

Explain that they will be working in teams to design the straightest and fastest paper airplane. Later they will learn about another feature that the planes will need. There are certain standards, or criteria, that the paper planes must meet to be successful. Display **Slide # 4** and go over the criteria:

**Criteria**

**Paper airplanes must:**

- Travel straight and fast.
- Be launched from the same height, with the same force and trajectory each time.
- Travel at least 4 meters.

Engineers also have limits when they are designing technologies like airplanes. Display **Slide # 5**. The limits, or constraints, for this design are:
Constraints:

- You may only use the materials given.
- You will have 20 minutes to complete your designs and build the prototypes.

RESEARCH

Refer to the EDP poster and ask what needs to be done next. (Research) Ask:

What do you need to know more about before you begin designing your planes? (Answers may include: What are some design features that help paper airplanes go faster and/or straighter?, What are the forces that help airplanes stay in the air?, How do forces work to keep paper planes from flying straight and fast?)

Display Slide # 6 and tell students that this video will help them understand how planes fly so that they have a basic understanding of the forces that work for and against planes while in flight.

The Aerodynamics of Flight

http://www.youtube.com/watch?v=5ltjFEei3AI

After the video, Ask:

How does a plane fly? What keeps the plane in the air? (Make sure students are using the terms like weight, drag, lift and thrust correctly.)

Then give students time to think about how the information in the video might apply to their paper airplanes. After a minute or two, have students share their ideas with their team members.

Next, display Slide # 7 and show the video of the evolution of fighter jets so that students can get a visual idea of how they might build their prototype.

History of Fighter Jets (pictures)

http://www.youtube.com/watch?v=CDRi7lpc-Go

After the video, ask students what they noticed about the planes? What similarities and differences did they notice in the different generations of fighter jets? Did one fighter jet stand out?
Tell students that looking at real airplanes should help them better understand how airplanes work, but that it might also be good to read about paper airplanes and see some model airplanes. Hold up some model airplanes. Then, pass them around so that students can look at the various features. Ask some students to share some similarities and differences in each model. Record answers on the board. Explain to students that their prototype does not have to look exactly like any one of the models. The models are to help them get an idea of how to begin designing a paper plane. 

Distribute the handout: Research: “What Makes Paper Airplanes Fly?”, one to each student. Allow time for students to read the handout and discuss, in their teams, how the information will help them design their planes.

**DEVELOP AND CHOOSE**

Call team’s attention back to the EDP and explain that they are going to be working on the Develop step of the EDP. They will work as a team to generate several ideas for creating their paper airplane. They will choose one of those ideas to create a paper airplane to test and evaluate. Then, they will use the data they get from their tests as research to help them create another prototype paper airplane.

First, each team of 3 will need to pair with another team to form a six-member team.

One 3-member team, or triad, will work on plans for a plane designed to go the straightest. The other triad will focus on a plane designed to go the fastest. They will have 10 minutes to develop and test their ideas. After the 10 minutes the whole team of six will have 7 minutes to combine their ideas and create one prototype to fit both parts of the criteria, straight and fast. Display Slide # 8 and Distribute SH: 1, Research Data and make sure students understand how to complete the handout to record the data collected from their research.

**Teacher Note:** Students may have difficulty calculating the area of the wing surface because of the irregular shape. Explain that they only need a good approximation of the area of the wing surface. Encourage students to work as a team to develop efficient strategies for estimating the area. Strategies might include: a) tracing the wing on cm grid paper and counting the number of squares covered by the wing, b) dividing the wing into smaller sections of shapes that they can calculate the formula for, c) determining the shape their wing most closely resembles and using a formula to calculate the area of that shape and adjust.
Develop, Choose and Create:

Display Slide #9, with the criteria, for teams to refer to as they design their planes. Monitor students as they work and assist students with any needs or issues that arise. Their ideas and designs should be student/team lead. While in the research step of the design process, you may decide to provide a template for students who are having trouble getting started.

Test and Evaluate:

To test their prototypes, teams should take their planes to a designated flight path. One member will be responsible for “launching” the plane. Stress to students that how the plane is released will have an effect on the flight path. For more accurate and consistent results the same person should launch each time.

Another team member should be the timer and be responsible for timing the flight from the launch to the point when it crosses the 4 meter mark on the path. The other team member is responsible for observing what happens to the plane during the flight and completing the research data chart. Teams may test and redesign as many times as possible in the given time period. They should record all test results on their chart. Students should evaluate their design based on the criteria given per each design, not other groups.

COMMUNICATE AND REFLECT

Have each team share their final design characteristics, flight time, and approximate area of wing surface with the class.

Record the data on the board. Have the students make conjectures about which plane shapes, sizes and materials best met the criteria. Display Slide #10. Ask:

Do the planes which meet the design criteria have any similarities? Major differences?

Allow the students to share ideas. Chart the similarities and differences on the board.

What do you notice about materials of the planes that best meet the design criteria?
Students should conclude that paper planes made of heavier material will resist wind draft (forces) and will fly in a straighter path.

*What do you notice about the shape and size of the planes that meet the design criteria the best? (Encourage students to notice the symmetry of the plane.)*

- Students should conclude that the wider the planes body, the more wing area it has to stay aloft (counter acting forces).
- Students should conclude that the paper airplane must have strong line symmetry in order to balance the airplane to fly straight.
- Students should be able to conclude that planes must have a strong line of reflection and recognize the planes halves need to be mirror images of each other in order to fly straight and reliable long distances.
- Students should realize that the longer or shorter wing dimensions affect the plane’s flight. Students should conclude that the wider the planes body, the more surface the wings have, helping it to stay aloft (counter acting forces).

Stress the idea that the designs must have a strong line of symmetry in order to balance the airplane to fly straight and for long distances. Ask some students to explain how they made sure their planes were symmetrical. Help them to see that reflecting one side of the plane over the center line of the plane can help them determine if in fact the two sides are symmetrical, and therefore congruent.

**Wrap-up**

Display **Slide #11** and instruct students to follow the directions on the slide.

**Answer the following question on an index card:**

*If you could change one thing about your design what would it be and why?*

Collect index cards as students leave and look over them before the next lesson.
DAY TWO

Top Gun
Grade 8, Math, Q 3

Have bell ringer displayed on board when students arrive for class.

Bell Ringer: Slide #12: Have students answer the following questions on an index card:

What is the most challenging part of working in teams to design your airplanes?

What is an advantage of working in teams to complete the design challenge?

Collect the cards and refer to them as you monitor the teams working on their challenge.

Introduce the next part of the challenge: Explain to students that in this lesson they will continue to work together as engineering design teams on a new airplane design challenge.

Explain that engineers are modifying cargo planes to carry increasingly heavy cargo loads. Commercial planes, like those being designed and built by Airbus, need to carry more and more passenger cargo. Commercial mailing companies such as FedEx are continuously improving the amount of cargo each flight can carry. While carrying heavier loads these planes still need to be able to fly straight and fast. Plane manufacturers work closely with scientists and aerospace engineering teams to research and improve the airplane’s design and performance. As a result of this collaboration, cargo planes are becoming more sophisticated.

Ask:

Why do you think it is important for cargo planes to carry as much cargo as possible?
(Possible answers may include responses like being able to save money if they can get more weight on each flight because they can make fewer flights.)

Tell students that one thing engineers must consider when designing cargo planes is the how weight will be distributed on the plane, in other words, how to load the cargo and how to keep it from shifting.
Continue Research:

Remind students that they are still in the research phase of the engineering design process.
Display Slide # 13. Say:

**We are about to watch a short video clip to give us an idea of how exactly one company loads their cargo planes.**

Video clip(s) and Resources:

http://www.youtube.com/watch?v=j9W8eOxYyT4

Launch the challenge- Tell students they have a new criterion to meet. They will design an airplane prototype that maximizes speed and straight flight and carry a load.

Display Slide # 14 and explain that these are the new criteria.

Criteria:

**Paper airplanes must:**

- Travel straight and fast.
- Be launched from the same height, with the same force and trajectory each time.
- Travel at least 4 meters.
- Carry a load.

Remind students of the constraints.

Constraints:

- Students may only use the materials given.
- They will have 20 minutes to complete their designs, build and test their prototypes.

Display Slide # 15. Students will use paper clips as the load. Ask students what they think might happen when they add weight to their paper airplanes. After a few students share their responses ask them to talk in their teams about what they will need to think about when adding weight.

Remind students to use what they learned from the previous lesson about design features that make the paper airplanes fly straighter and faster. As students begin making their prototypes, have the following FEDEX video playing in the background:

http://www.youtube.com/watch?v=A5ZtK1r70vc
Brainstorming and Prototypes - Distribute SH: 2, Cargo Data. Remind students to record their test results on the handout. Their ideas and designs should be student/team lead. Students will use the same flight paths used in the previous lesson.

After 20 minutes, allow each team to share their test results and plane designs with the class. Ask:

What do you notice about where the most successful planes placed their cargo? Students should conclude that the load should be kept near the center of the plane to maintain.

COMMUNICATE AND REFLECT:

Explain that after engineers design new technologies, they need to be able to communicate with others about their designs. One way to do that is with drawings. Remind students it is important for the paper airplanes to be symmetrical. The wings on both sides of the plane need to be congruent. Distribute SH: 3, Technical Drawing, showing a sketch of one side of a paper plane on a coordinate plane. Ask students to talk in their teams about how they might draw the other half of the plane so that it is congruent to the half that is shown. Help students understand that they could reflect the drawing over the y-axis.

Monitor as students complete the airplane drawings:

Have students use ordered pairs to label the points on the drawing. Let students work in teams to reflect the drawing over the y-axis and label the points on the reflection. (Each student should complete their own handout.) Monitor as students work to make sure their reflections are accurate and have been labeled correctly. Provide assistance as needed.

Wrap-up:

Display Slide # 16 and write their response on an index card.

List 3 things you learned about designing paper airplanes.

Collect the handouts and index cards as students leave class.

PROJECT CLOSURE:

Tell students that Mobile already has several companies that design, build and repair airplanes. ST Aerospace and AIRBUS are two of those companies. Engineers at Airbus in Mobile design interiors of airplanes. What are some things that an engineer might need to think about while designing the plane’s interior? Allow all student responses.

Show a short video from AIRBUS MOBILE and the future of planes.

As you design and test different features, record your results on the chart below. Record the sketch, purpose for each design feature, area of wing surface, and the result of your team’s test trials. When you have your optimal design, complete the section below the chart.

Success Rating Scale: 0 – Did not meet criteria; 1 – Met some criteria; 2 – Met most criteria; 3 – Met all criteria; 4 – Exceeded all criteria

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Purpose for Design Features</th>
<th>Result of Test Trials</th>
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<tbody>
<tr>
<td>EX: Pointed nose produces less air resistance</td>
<td>Straight Flight: YES or NO Flight Time: _________ Seconds Average Velocity: m/sec</td>
<td>Area of wing surface = Overall Success Rating:</td>
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**Optimal Design:** (Draw a sketch of your design on the back of this handout.)

Flight Time: Overall Success Rating: 
Velocity: m/sec =
Area of Wing 1 surface + Area of Wing 2 surface = __________ Total area of wing surface 

SH: 1
Engineering Design Challenge: TOP GUN
Student Handout #2: Day 2, Cargo

Design a cargo loading plan. Test your plane with the cargo and record results on the chart, including a sketch of cargo placement and the reason for your design. When you have your optimal design, complete the section below the chart.

Success Rating Scale: 0 – Did not meet criteria; 1 – Met some criteria; 2 – Met most criteria; 3 – Met all criteria; 4 – Exceeded all criteria

<table>
<thead>
<tr>
<th>Sketch</th>
<th>Reason for Location of Cargo</th>
<th>Result of Test Trials</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EX: Cargo loaded on back of plane for stability</td>
<td>Straight Flight: YES or NO Flight Time: ________ Seconds Average Velocity: m/sec Area of wing surface = Overall Success Rating:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Straight Flight: YES or NO Flight Time: ________ Seconds Average Velocity: m/sec Area of wing surface = Overall Success Rating:</td>
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<td>Straight Flight: YES or NO Flight Time: ________ Seconds Average Velocity: m/sec Area of wing surface = Overall Success Rating:</td>
</tr>
</tbody>
</table>

Optimal Design:

Flight Time: Overall Success Rating: 

Velocity: m/sec =

Describe placement of cargo:
Use ordered pairs to label the points indicated on the drawing. Then, reflect the image over the y-axis to complete the technical drawing of the paper airplane wing design. Label the points on the reflection.
What Makes Paper Airplanes Fly?

Aerodynamics
What makes a paper airplane fly? Air — the stuff that's all around you. Hold your hand in front of your body with your palm facing sideways so that your thumb is on top and your pinkie is facing the floor. Swing your hand back and forth. Do you feel the air? Now turn your palm so it is parallel to the ground and swing it back and forth again, like you're slicing it through the air. You can still feel the air, but your hand is able to move through it more smoothly than when your hand was turned up at a right angle. How easily an airplane moves through the air, or its aerodynamics, is the first consideration in making an airplane fly for a long distance.

Drag & Gravity
Planes that push a lot of air, like your hand did when it was facing the side, are said to have a lot of "drag." Or resistance, to moving through the air. If you want your plane to fly as far as possible, you want a plane with as little drag as possible. A second force that planes need to overcome is "gravity." You need to keep your plane's weight to a minimum to help flight against gravity's pull to the ground.

Thrust & Lift
"Thrust" and "lift" are two other forces that help your plane make a long flight. Thrust is the forward movement of the plane. The initial thrust comes from the muscles of the "pilot" as the paper airplane is launched. After this, paper airplanes are really gliders, converting altitude to forward motion.

Lift comes when the air below the airplane wing is pushing up harder than the air above it is pushing down. It is this difference in pressure that enables the plane to fly. Pressure can be reduced on a wing's surface by making the air move over it more quickly. The wings of a plane are curved so that the air moves more quickly over the top of the wing, resulting in an upward push, or lift, on the wing.

The Four Forces in Balance
Long flights come when these four forces — drag, gravity, thrust, and lift — are balanced. Some planes (like darts) are meant to be thrown with a lot of force. Because darts don't have a lot of drag and lift, they depend on extra thrust to overcome gravity. Long distance flyers are often built with this same design. Planes that are built to spend a long time in the air usually have a lot of lift but little thrust. These planes fly a slow and gentle flight.

Back to Paper Airplane Contest
Top Gun

Bell Ringer

*List two reasons why engineering companies might require their workers to work in teams.

Airplanes!!!!

*Airplanes are designed differently based on how they will be used. What are some types of airplanes and their uses?

Criteria

Paper airplanes must:

* Travel straight and fast.
* Be launched from the same height, with the same force and trajectory each time.
* Travel at least 4 meters.
Evolution of Fighter Jets

http://www.youtube.com/watch?v=CDRi7ipc-Go

*What similarities and differences did you notice in the different generations of fighter jets?

Sketch | Purpose for Design | Features |
--- | --- | ---
 | StraightFlight: 100m or not | Straight Flight: 100m or not |
 | Flight Time: 100m or not | Flight Time: 100m or not |
 | Size of wing surface: | Size of wing surface: |
 | Overall success Rate: | Overall success Rate: |
 | | | 
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Criteria

Paper airplanes must:

* Travel straight and fast.
* Be launched from the same height, with the same force and trajectory each time.
* Travel at least 4 meters.

* Do the planes which meet the design criteria have any similarities?
* What do you notice about the material of the planes that meet the design criteria the best?
* What do you notice about the shape and size of the planes that meet the design criteria the best?

Answer the following question on an index card:

* If you could change one thing about your design what would it be and why?

Bell Ringer

* What is the most challenging part of working in teams to design your airplanes?
* What is an advantage of working in teams to complete the design challenge?
Paper airplanes must:

* Travel straight and fast.
* Be launched from the same height, with the same force and trajectory each time.
* Travel at least 4 meters.
* Carry a load.

List 3 things you learned about designing paper airplanes.