XB-70 VALKYRIE—ENGINEERING TEAMS / PART I

Students will learn about the development of the XB-70 Valkyrie research aircraft, and they will also learn about some of the incredible features of this airplane. They will get a feel for the engineering mindset required to design/troubleshoot airplanes.

LESSON PLAN

Learning Objectives

The students will

- Learn about the development of the XB-70 Valkyrie
- Learn about the key features of this amazing aircraft
- Learn about the dynamics of working within a cooperative learning team, while assisting their team with specific engineering design concepts/troubleshooting
- Learn to solve problems while working within a group
- Learn about the global history surrounding the creation of the XB-70 Valkyrie
- Learn about how the XB-70 really works (including solving the same problems that confronted engineers during its actual 'blueprint' stages)
- Learn to effectively brainstorm within a group, and to come up with logical, functional solutions

Introduction/Background

The Cold War was a climate of distrust and political unrest between the United States and the Soviet Union after World War II had ended. The XB-70 program commenced in 1955, when the U. S. Air Force saw the need for a high-altitude, long-range, supersonic bomber. This requirement came about when the Air Force realized that bombers could have performance similar to that of fighters, and could therefore, be much more efficacious (technological breakthroughs in the 1950s and 1960s made this type of high performance possible). This aircraft would be capable of carrying a reasonable number of bombs to the Soviet Union from the continental United States, and it would be a replacement for the subsonic B-52 "Stratofortress." In 1957, the Air Force issued new requirements for the potential bomber: cruising speed of Mach 3.0 to Mach 3.2, altitudes of between 70,000 and 75,000 feet, range of up to 10, 500 miles and a gross weight not to exceed 490,000 pounds. There was even interest in the employment of nuclear-powered bombers, but that idea was eventually dropped. North American Aviation's design for the XB-70 (and potentially for the B-70 Valkyrie Bomber) was accepted and a development contract was awarded in early 1958. The first flight was planned for December 1961, and a fully-operational 'wing' of 30 aircraft was to be ready by August 1964. Two prototype aircraft were built: No. 1 XB-70A and No. 2 XB-70 (both received the "X" experimental designation).

Grade Level: 5—8
National Science Education Standards:
Science as Inquiry, Science and Technology and History and Nature of Science

National Standards for History:
Chronological Thinking and Historical Comprehension

National Standards for Mathematics:
Problem Solving and Communication

Technology Education Standards (ITEA):
Understanding/appreciating engineering design

Materials Required:

- Magic board and markers
- Laptop, monitor, digital projector
- Demo items/teacher addendum items as listed within the lesson plan

Resources:

- General Information:

http://www.nationalmuseum.af.mil/factsheets/factsheet.asp?id=14209 and http://www.nationalmuseum.af.mil.factsheets/factsheet.asp?id=592 and http://www.unrealaircraft.com/classics/xb70.php and http://www.aircraftinformation.info/art_xb-70.htm and http://en.wikipedia.org/wiki/North American XB-70 Valkyrie and http://www.nasa.gov/centers/dryden/news/FactSheets/FS-084-DFRC.html and http://www.boeing.com/boeing/history/bna/xb70.page and http://xb70.interceptor.com/ and http://www.wired.com/dangerroom/2010/12/meet-the-xb-70-valkyrie-almost-the-world%E and http://www.aerospaceweb.org/design/waverider/design.shtml and http://www.sr-71.org/aircraft/xb-70.php and http://aar.faculty.asu.edu/research/hypersonic/hyper_challenges.html and http://www.barnesand noble.com/w/compression-lift-gerd-numitor/1111622613

The XB-70Valkyrie didn't look like a plane that was developed in the 1950s and 1960s. Rather, the huge delta wings, forward-placed canards and long, sleek shape seemed to place the impressive aircraft in the 1980s or 1990s! North American Aviation engineers created a brilliant design plan which would help the aircraft reach Mach 3 speeds. The main idea centered around a concept now known as "compression lift" (details will be covered within the lesson plan's "procedures" section). Another situation/problem/scenario (that will also be covered in detail in "procedures" coincided with the aircraft's 'three-times-the-speed-of-sound' velocity. The build-up of heat due to the plane skin's friction with the air during sustained supersonic flight had to be addressed! The two prototype Valkyries were tested extensively throughout the 1960s. However, other new technologies invalided the original reason for their existence. By the time it was deemed operational, fighter interceptors were no longer the key threat to strategic bombers. Ballistic missiles had become efficacious enough to shoot down high-flying aircraft. Additionally, the Pentagon no longer needed long-range bombers to deliver nuclear weapons, because military leaders could rely upon Intercontinental Ballistic Missiles (ICBMs) for strategic deterrence.

Procedures:

NOTE: Teachers may use as much of the information contained within the "Intro/Background" section as they deem appropriate for their students; similarly, teachers may wish to pick and choose items within this "Procedures" section. Teachers may wish to divide the class into four, five or six teams of five students each prior to commencing this lesson plan.

- Write (on board) the things that will be covered/discussed/reviewed in class, including: historical aspects of the XB-70, unique features of the Valkyrie, engineering team challenges/solutions and actual photos of one of the world's most exotic airplanes.
- Hook: Hold up (or show on overhead) a photo of an actual XB-70 Valkyrie found on page 5 (Teacher Addendum). Show the class a cardstock facsimile of the aircraft's wing design and underside that you have copied from page 4 (Teacher Addendum) and tell students that this is a 2-dimensional representation/model of the delta wings and underside of the airplane. Ask them to imagine/visualize that the cone-shaped portion of the underside is raised, so as to form a box shape under the wings. Show them how the air intake/engine 'box' is configured in the photo; for 3-D effect, cut out a piece of Styrofoam (5.25" x 1.5") and glue it to your model.
- **Special Note:** National Science Academic Standards/Science As Inquiry/Evidence, Models And Explanation: models (either 2 or 3 dimensional) correspond to real objects and have explanatory power. They help both scientists and students understand how things work!
- Have the wing tips of your cardstock model already folded down before class (to break the fibers in the cardstock paper) but put them back into a flat, 0 degree configuration during the 'hook' step above.
- Pass out cardstock underside/delta wing models to each engineering team. Tell students that the XB-70 has six, large jet engines to supply power, and they are aligned across the back portion of the huge delta wing. However, those powerful engines don't need as much fuel to get the giant aircraft up to a speed that is three times the speed of sound (and to keep it cruising at Mach 3) as one might think.
- Prior to the next step, you may wish to review the meaning of the four aerodynamic forces of flight, namely, thrust, drag, weight and lift (these forces are covered in another lesson plan on our website: Airlift Mission: The Basic Science of Flight—Lesson Plan 'B').
- Hold your model up again and slowly raise it higher—tell teams that this is a hint as to what problem they will be trying to solve! Questions: how can we increase the plane's lift, and decrease both its drag and fuel usage?
- Make sure each team has plenty of paper and pencils, and have teams brainstorm about ideas that could help add to the airplane's lift force (help support the aircraft's weight) decrease the plane's drag force (less friction and air resistance) and also save fuel. Encourage members to discuss ideas within their team and write them down—emphasize that no idea is too wild and no idea is foolish (they may even wish to redesign the plane)!
- Call on each team to give one or two of their ideas—write the ideas on the board.
- Lead a class discussion to assess the functionality/practicality of each idea—allow each team time to defend their ideas. Tell them that their ideas and their defense of same are great!
- Tell the class that one idea the North American Aviation engineers came up with is now called "compression lift." As the XB-70 flew at supersonic speeds, shockwaves (composed of high pressure air) were generated off the nose and other sharp points/leading edges of the airplane. The Valkyrie's huge, folded wing tips formed a 'tunnel' beneath the fuselage and captured/channeled/focused the shockwaves to create more lift and more fuel economy. In other words, the body of the aircraft generated a downward force on the fluid it was passing through (air) and that fluid generated an upward force on the plane's specially-designed underside.

Procedures (continued)

- Tell students that this is a demonstration of Newton's Third Law of Motion—ask them if someone can recite that law (for every action, there is an equal but opposite reaction). In this exemplar, the 'action' is the plane's downward force on the fluid, and the 'reaction' is the fluid's upward force on the plane!
- Show your model with the wing tips bent down about 65 degrees (tell students this is for speeds from Mach 2 to Mach 3). Tell teams the 0 degree/flat position is for take-offs and subsonic flight; the 25-30 degree angle is for speeds up to Mach 2.
- Tell students that the downturned wing tips added 'vertical surface area' to the airplane, which added to its stability at very high speeds. Add this information for students in higher grades: the downturned wing tips also helped to keep the aircraft level and its nose down (with increasing supersonic speeds) by offsetting the usual rearward (aft) movement of the center of pressure (also known as the center of lift or average lift point) away from the plane's center of gravity (a point at which the aircraft could be suspended and seem perfectly balanced). Additionally, the downturned wing tips altered wing geometry and actually decreased drag.
- Tell the students that cooperative learning and working within the framework of a team are very important skills that will be helpful to them as future students and in their adult lives as well.
- Congratulate all the teams for their contributions to this aerospace engineering challenge!
- You may wish to tell teams that they will be enjoying another engineering challenge when you cover XB-70 Valkyrie—Engineering Teams / Part II.

Assessment/Evaluation

The students should be evaluated on their class participation and contributions, listening skills and their ability to follow verbal instructions, especially when they are working as cooperative learning members of an XB-70 engineering team!

Extension

Students may wish to do further research on terms such as supersonic and hypersonic flight, center of pressure and center of gravity. You may also wish to give them scheduled class time (at a later date) to share their findings with the entire class!

TEACHER ADDENDUM
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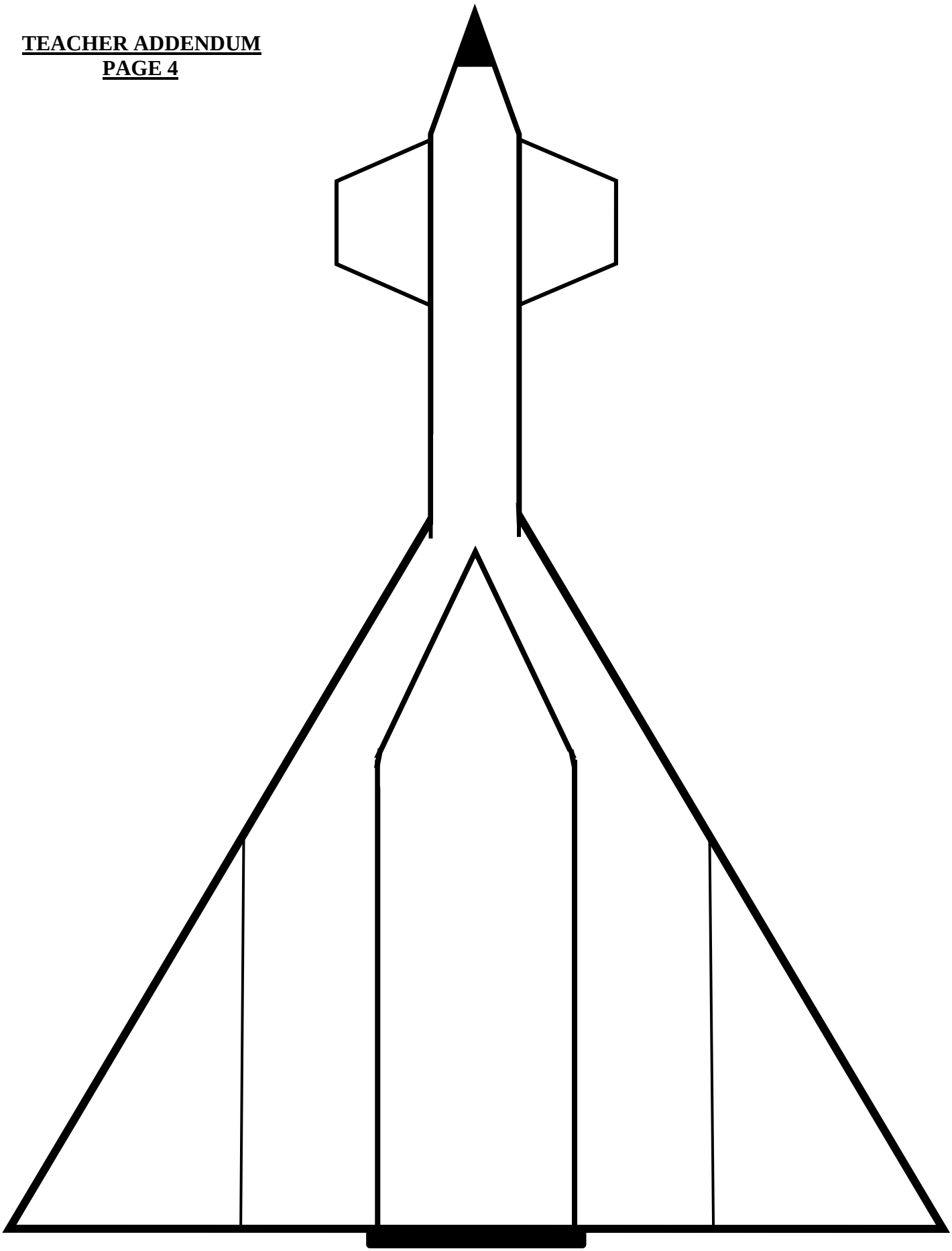

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