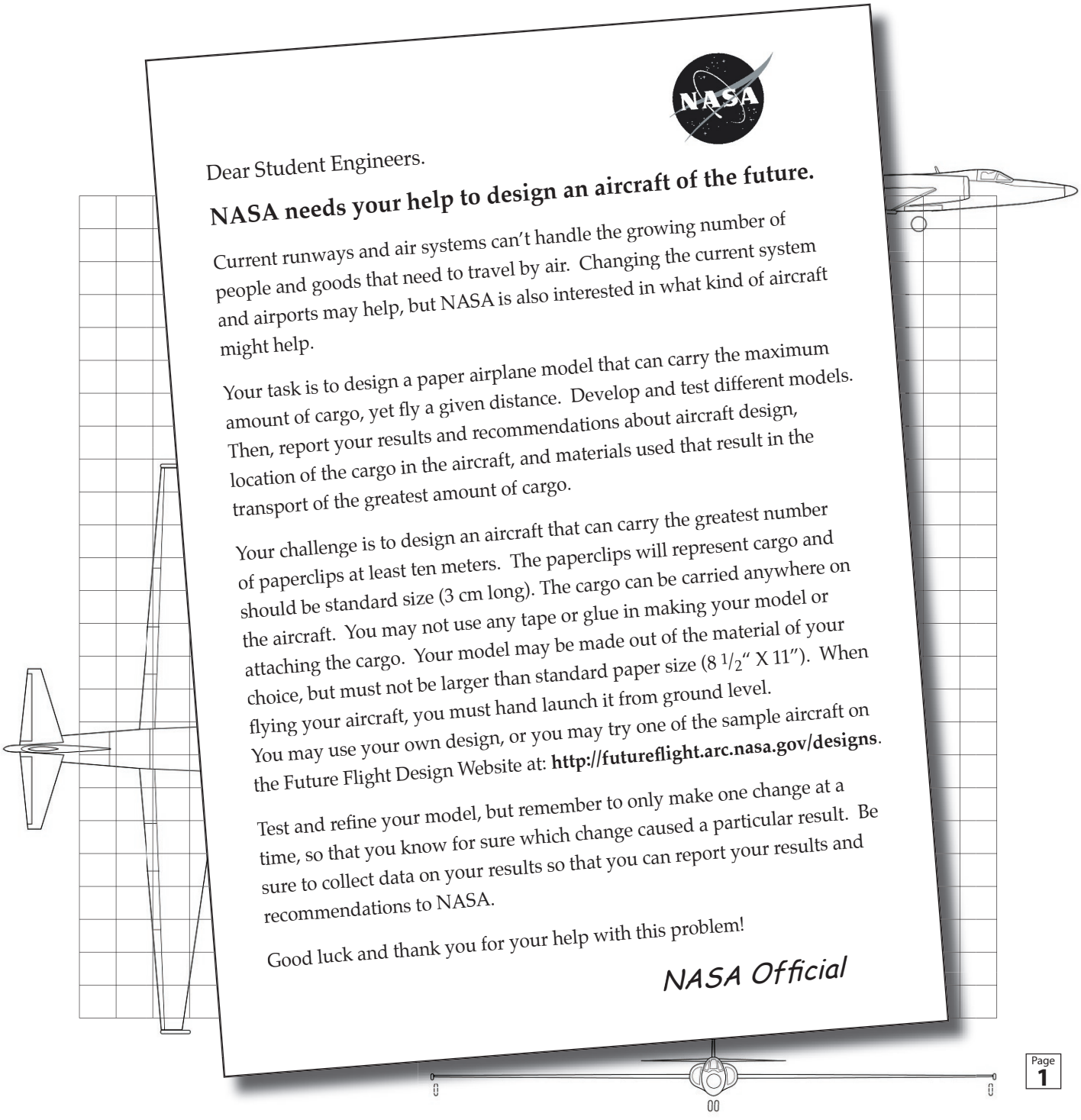
Designing an Aircraft
Using The
5 Steps of the Engineering Design Process



Dear Student Engineers.

NASA needs your help to design an aircraft of the future.

Current runways and air systems can't handle the growing number of people and goods that need to travel by air. Changing the current system and airports may help, but NASA is also interested in what kind of aircraft might help.

Your task is to design a paper airplane model that can carry the maximum amount of cargo, yet fly a given distance. Develop and test different models. Then, report your results and recommendations about aircraft design, location of the cargo in the aircraft, and materials used that result in the transport of the greatest amount of cargo.

Your challenge is to design an aircraft that can carry the greatest number of paperclips at least ten meters. The paperclips will represent cargo and should be standard size (3 cm long). The cargo can be carried anywhere on the aircraft. You may not use any tape or glue in making your model or attaching the cargo. Your model may be made out of the material of your choice, but must not be larger than standard paper size (8 $^1/_2$" X 11"). When flying your aircraft, you must hand launch it from ground level. You may use your own design, or you may try one of the sample aircraft on the Future Flight Design Website at: **http://futureflight.arc.nasa.gov/designs**.

Test and refine your model, but remember to only make one change at a time, so that you know for sure which change caused a particular result. Be sure to collect data on your results so that you can report your results and recommendations to NASA.

Good luck and thank you for your help with this problem!

NASA Official

Step 1 Define the Problem

Engineers begin by understanding the problem and outlining the requirements that must be met.

List the *criteria* and *constraints* for your aircraft. List both the things that your design will need to be able to do (criteria) and the things that will limit your design (constraints). An example of criteria is the amount of cargo the aircraft must carry or how far it must fly before refueling. Examples of constraints are the limits in size or cost.

Criteria (standards or requirements)	**Constraints** (limits to design)

Step 2 Generate Ideas

Engineers then brainstorm solutions and create a basic design followed by a detailed design.

Consider three things: *shape*, *materials,* and *location of the cargo*. List at least three different factors for each one that you can test and compare. Examples describing your aircraft's shape might be: sleek, blunt, many-folds, large wings, etc.

	Factor 1	**Factor 2**	**Factor 3**
Aircraft Shape			
Materials			
Location of Cargo			

This is also a good time to learn more about flight, lift, propulsion, and fuselage parts and the effects of changes to each. To learn more about this, visit the Future Flight Design labs at: **http://futureflight.arc.nasa.gov/map.html**

Step 3 Select a Solution

In this phase, engineers select the solution that best meets the criteria and constraints.

Circle one factor from each row above (in Step 2). Combine the three factors to develop an aircraft that will carry the most cargo for the longest distance. Why do you think this aircraft will be able to meet the requirements? Describe what the aircraft will look like and how the cargo will be carried.

Step 4 Test and Refine

Next, engineers do many tests of their solutions. They make changes and test again until they have their best solution.

1. Select a material for the aircraft that you described in Step 3.
2. Fold your airplane while taking into consideration the factors you selected in Step 3.
   (You may use an original design for the folding or begin with and modify the sample designs from NASA.)
3. Distribute the cargo (paper clips) in the manner that you identified in Step 3.
4. Test fly your aircraft three times to get a consistent result.
5. Record the results of your three flights, including load carried and distance flown, in the chart below.
6. Make one change at a time and test each change at least three times.

		Description	Flight Test 1	Flight Test 2	Flight Test 3
Design 1	Aircraft Shape				
	Material				
	Location of Cargo				
Design 2	Aircraft Shape				
	Material				
	Location of Cargo				
Design 3	Aircraft Shape				
	Material				
	Location of Cargo				

Step 5 Present the Results

Finally, engineers present their solution to others to receive feedback for further improvements of their design and to see if their solution is accepted for use.

Share your results with the class. What can you learn from others' results to improve your own aircraft?

On a separate sheet of paper, write a letter to NASA reporting your results and recommendations for the type of aircraft that will carry the cargo and fly the required distance. Explain the process you used to find this solution and what makes it the best. In building a life-size version of this aircraft, what recommendations would you make for the shape selection, materials used, and cargo placement? Why?

NASA thanks you for your help! If you are interested in tackling some more flight problems, visit:
http://futureflight.arc.nasa.gov

Teacher Notes

Future Flight Design (http://futureflight.arc.nasa.gov) is a Web-based interactive, problem-based learning environment where students in grades 5-8 learn about forces of flight and engineering design, as they design air transportation and aircraft systems of the future. The site includes two problem-based learning scenarios in which students are asked to 1.) Develop a futuristic air transportation system through a research-based problem and 2.) Design a new aircraft using online interactive multimedia. Accompanying educator guides, student logs and career fact sheets are available as PDFs. All activities are aligned to the national education standards.

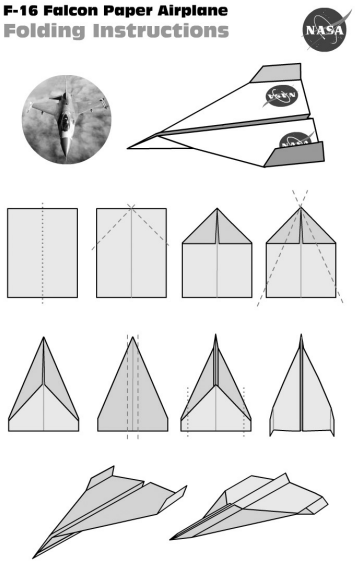
The problem included on this poster is a third bonus problem-based learning scenario that will engage your students in the theme of the Web site and introduce them to the engineering design process.

Suggestions when using the activities included on this poster:

- You may want to have students work in pairs or teams of three on this problem.
- Step 2: Students may either draw or describe the shape of different aircraft. Suggested paper airplane models can be found on the Web site at: http://futureflight.arc.nasa.gov/designs
- Step 4: Be sure to discuss with students why it is important to make only one change (variable) at a time to be sure of the change that resulted in a given result.
- Step 4: You may want to have teams specialize by focusing on different areas and sharing results back with the class. One group may only focus on changing aircraft design, while another focuses on different materials.
- Extensions: Have students come up with other challenges to design for, such as designing an aircraft that can go the maximum distance carrying ten paperclips.

Sample Aircraft

Students can use their own design or try one of the NASA designs from the Future Flight Design Website!



http://futureflight.arc.nasa.gov/designs

Answer Key

Step 1

Criteria: 1.) must fly 10 meters when hand-launched at ground level, 2.) must carry the greatest number of standard 3cm paperclips, 3.) cargo must be attached to the aircraft.
Constraints: 1.) must not use tape or glue and 2.) material size must not exceed 8 $^1/_2$" X 11".

Step 2

Answers will vary. Materials might include typing paper, construction paper, card stock, aluminum foil, etc. Cargo location could be spread out throughout the aircraft body and wings, primarily at the front, center or back of the aircraft.

Step 3

Answers will vary. (Example: The design is sleek, lightweight, and the weight is balanced.)

Step 4

Answers will vary. We were able to transport 10 to 25 paperclips 10 meters using standard typing paper and paper clips that were evenly distributed from right to left.

Step 5

Answers will vary. Some conclusions students may arrive at include: 1.) Stronger, lighter materials are best for building aircraft. 2.) Wider aircraft can carry more cargo than sleeker aircraft. 3.) When cargo is distributed throughout the aircraft (balanced), the aircraft flies better. 4.) The aircraft that flew best tend to be symmetrical, well-creased, and flat on top. 5.) Launching can affect results. Sleeker aircraft need to be thrown harder, while wider craft need to be thrown slower. Launching at an angle can also affect the resulting distance.

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Thank you.