LDSD
Low Density Supersonic Decelerator

For the Teacher

Challenge
Design and test a drag device to slow a spacecraft and protect its cargo, as well as calculate the surface area and measure the mass of spacecraft.

Materials
Items required for activity:

- Scissors
- Rulers
- Clear tape
- Digital scale or balance
- Stopwatch
- Thin string such as embroidery thread or fishing line
- Small sealable plastic storage bag—at least one for each team
- Washers or marbles to serve as mass in the spacecraft
- Hole reinforcements or stickers and hole punch
- Cardstock or old file folders for spacecraft template
- Template for spacecraft (see attached)—one for each team
- Tall ladder or overhang above a stairway or common area

This activity uses the design of the surface area as the variable, not the material of the drag device. Below are listed some possible materials to use to make the drag devices. Students may select a combination of materials. Choose and provide only a few for students to select from:

- Plastic trash/grocery bags
- Wrapping paper/tissue paper/plastic tablecloths

Pre-Activity Set-up
Pre-determine where the students will drop test drag devices. To get accurate data, drops should be at least 2 meters high, measured from the bottom of the craft to the ground. It is best to have a stairwell overhang or balcony.

Use materials like washers, marbles, etc., and put inside the plastic bag, inside the capsule. Each team's cargo and spacecraft should have the same mass of 20–30 grams.

The challenge includes the requirement that students must have at least five angled edges. This requirement is to create a more dynamic calculation of surface area and to encourage designs beyond a simple round shape. A simple round or pentagon shape will work, but five angled edges should encourage multiple parachutes, adding streamers, etc. Students could research ahead of time various geometries of parachute designs to provide them some ideas for different shapes.

For the Teacher

Motivate

- This activity has an introduction video for students to watch that introduces the challenge. It can be found at: *http://www.youtube.com/watch?v=RmhSb34PlZQ*
- For this activity, the spacecraft will be represented by the paper template, and equipment is represented by the weights in the sealable storage bag.
- Ask students in what ways they could slow down or decelerate the spacecraft. Possible answers might include engines, parachutes, drag devices, and streamers. NASA has created various designs over the years to slow down spacecrafts; two examples are the Apollo and Orion capsules. Have students research other shapes used in hang gliding, military parachutes, etc. to gathersome geometric shape ideas.
- Discuss the Low Density Supersonic Decelerator Program (see *Background*) and how engineers are working to develop various size drag devices for future spacecraft.
- Videos and more information about Low Density Supersonic Decelerator are available at *http://www.nasa.gov/mission_pages/tdm/ldsd/index.html*. A video about landing on Mars is available at *http://www.jpl.nasa.gov/video/index.php?id=1090*
- Challenge the students to design a drag device system that will slow the spacecraft during a drop from at least 2 meters high. The cargo (weighted plastic bag), the spacecraft (using the attached template), and the drag device design cannot exceed a total mass of 50 grams. The drag device aspect must have at least five angled edges.

Ask

- Help students answer any questions they have about the challenge.
- Explain calculations necessary for determining surface area and surface area of unusual shapes. The Internet can provide formulas for unusual shapes.

Imagine

- Brainstorm ideas about what shapes will work best to slow the spacecraft down.
- Be sure all students are communicating and collaborating and that all suggestions and ideas are documented.

Plan

- All drawings should be approved before building begins.

Create

- A template is provided in the student section to make a spacecraft.

Experiment

- Students will follow the directions and answer questions on the *Experiment and Record* and the *Quality Assurance* sheets.
- Younger students should measure the amount of time it takes for the drag device to fall. They can also calculate the speed of the drop.

Improve

- After completing the first round of testing, students will make modifications to their designs to try to increase the amount of time it takes for their spacecraft to drop (increasing drag). Document the redesigns and test results, calculating the surface area and making sure the mass remains under 50 grams.

Challenge Closure

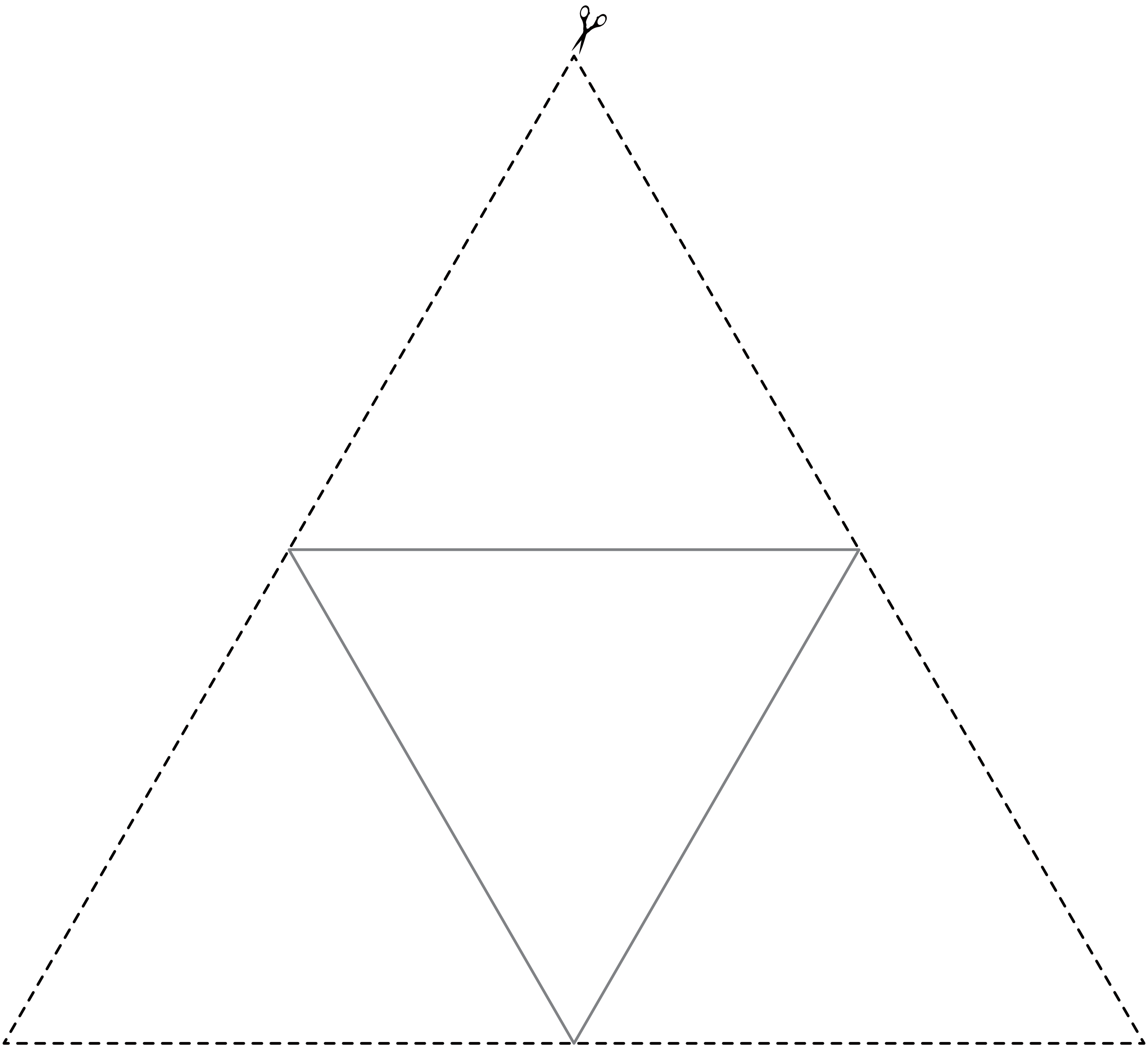
Engage the students in a discussion by reviewing all of the data and posing the following questions:

- Which drag device design characteristics provided the most reliable results?
- Which design had the slowest descent (longest drop time)?
- What was discovered about the relationship between surface area and drop time (or speed)?
- What information could engineers working on this project learn from your team's results?
- What other tests and calculations could you do before making your recommendations to the engineering team? (Test different materials or shapes, create and test for possible anomalies, determine maximum load the drag device can slow etc.)
- What do you think would be the best way to present your results?

Template

For the Teacher

Cut out the larger triangle and fold on inner lines to create a pyramid shape. Put weights inside the pyramid shape and tape up sides.



Background

As NASA plans new robotic missions and human expeditions to Mars, it becomes important for the spacecraft to carry heavier and larger payloads to accommodate extended stays on the Martian surface. NASA has been using its current parachute-based deceleration system since the Viking Program, which put two landers on Mars in 1977. The current technology will not sufficiently slow the larger, heavier landers from the supersonic speeds of atmospheric entry to land safely on the surface.

NASA is currently designing three new decelerators as part of the Low Density Supersonic Decelerator (LDSD) Technology Demonstration Missions. The first two designs are Supersonic Inflatable Aerodynamic Decelerators (SIAD)—large, durable, balloon-like pressure vessels that inflate around the entry vehicle and will slow down the capsule. One has a 6-meter-diameter size and the other has an 8-meter-diameter size. The third is a 30-meter-diameter parachute that will further slow the entry vehicle. All three devices will be the largest of their kind ever flown.

To learn more about the Low Density Supersonic Decelerator see *http://www.youtube.com/watch?v=1G9QPsTjP0Q* and *http://www.nasa.gov/mission_pages/tdm/ldsd/index.html*

Data from the MEDLI mission and from MISSE-X will play a key role in the LDSD designs. If your class has already completed these challenges, think back to some of the lessons learned in those activities and apply that knowledge to today's challenge.

The Challenge

Design a drag device to slow the weighted spacecraft when it is dropped from a specified height (at least 2 meters). Data gathered in this challenge include surface area, mass, and descent time. Redesign to improve your drag device drop performance. The design constraints:

- Use only materials provided to you to create the drag device.
- The overall mass of your drag device cannot exceed 50 grams.
- Drag devices must have at least five separate angled edges (rounded edges are allowed, but one big circle is not allowed).
- Test drops must be from at least 2 meters.
- Must use the template provided for you to build a cargo capsule.

Reminder For All Challenges

- Be sure to document all design and test results.
- Make any necessary design changes to improve your results and retest. Document the modifications and results.
- Complete all conclusion questions.

Our Team's Plan

LDSD

ASK

Today you will design a drag device that will slow down the descent of a space capsule.
What questions do you have about today's challenge?

IMAGINE

What will the general shape of your drag device be?
What features will you include?

PLAN

Draw and label your drag device:

Be sure to include measurements!

Write a hypothesis that describes how the surface area of the drag device will affect the time it takes for the payload to drop.

Experiment & Record

Team Name ____________________

1. Record the mass and surface area in the table below.
2. Record the drop height: ________________________________
3. Drop drag device attached to cargo while timing descent. After each drop, note any damage to the drag device or capsule. Each device should be dropped three times and the results averaged together. Calculate the speed. Record results in the table below.

	Mass (grams)	Surface Area (cm^2)		Time (sec)	Speed (cm/sec)	Note any damage after each drop
Design One			Drop #1			
			Drop #2			
			Drop #3			
			Average			
Redesign			Drop #1			
			Drop #2			
			Drop #3			
			Average			

Experiment & Record

Team Name ____________________

4. Plot results on a scatter graph. The surface area (the independent variable) is plotted on the X axis, and the time or speed it takes for the capsule to drop (the dependent variable) is plotted on the Y axis. Label graph appropriately.

5. Improve the design of your drag device and repeat the testing. Record your results for the redesign and plot results on the graph above in a different color.

6. For evaluation, exchange your drag device with another team's and complete the *Quality Assurance* page.

Experiment & Record

Challenge Closure

1. Which drag device design characteristics provided the most reliable results and why?

2. Which design had the slowest descent (longest drop time)?

3. What was discovered about the relationship between surface area and drop time (or speed)?

4. What information could engineers working on this project learn from your team's results?

5. What other testing and calculations could you do before making your recommendations to the engineering team?

6. What do you think would be the best way to present your results?

Quality Assurance

LDSD

Each team is to review another team's design and model, then answer the following questions.

Team Name	Yes	No	Notes
Was the drag device securely attached to the capsule?			
Was the mass of the entire drag device below 50 grams?			
Did the team correctly collect, calculate, and record data?			
Did the team have a successful drag device (no broken materials)?			

List the specific strengths of the design.

List the specific weaknesses of the design.

Inspected by: ______________________________

Signature: ______________________________

More Fun With Engineering

Activity One:

On a playground or large outdoor area, measure out the diameters of the three decelerators that NASA is currently designing as part of LDSD: 6 meters, 8 meters, and 30 meters.

Activity Two:

Atmospheric Conditions

Today, you were able to simulate a landing in your classroom. The entry NASA is preparing for will be on to Mars or another planetary body. Since NASA engineers have little experience landing massive spacecrafts on Mars, they must make predictions of what it will be like. Then, they will attempt to simulate those entry conditions on Earth.

The Mars Science Laboratory Entry Descent and Landing Instrument (MEDLI) sensors captured detailed data about the atmospheric conditions when the Mars Science Laboratory (also known as Curiosity) landed in August 2012. This information will help engineers get as close to the conditions of Mars during their simulated Low Density Supersonic Decelerator (LDSD) entries on Earth.

Very soon, engineers will be testing the LDSD designs at supersonic speeds in Earth's stratosphere. Based on the new data, they will make even more precise predictions of what they can expect on an entry to Mars.

Research what is known about the atmospheric conditions on Earth and Mars, then answer the following questions.
http://quest.nasa.gov/aero/planetary/mars.html
http://www.nasa.gov/offices/marsplanning/faqs/index.html

1. What weather and environmental conditions do you think they should try to simulate on Earth ahead of time?
2. Which conditions would have the largest effect on the design?
3. Based on the designs you did today, how would your overall design concept perform on the entry phase to Earth? To Mars?