Discussion Guide

Slide 1 Arrange students in small groups of 3-5 and identify a designated work area. Allow students time to choose a team name. The deploy area should already be established. (See Challenge Checklist for details.)

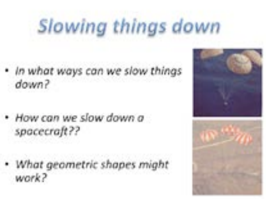
Slide 2 This one minute video explains some of the challenges of landing on Mars. After watching the video clip, remind students this challenge is not about the landing– but about slowing down the spacecraft as it descends through the Martian atmosphere.
This video clip can be downloaded or bookmarked in advance and saved to your computer.

Slide 3 Why does landing matter if NASA has successfully done it before? Because each time we go there, we attempt to bring along more and better equipment, so we can learn new things.
Take a look at this Mars Rover family portrait. These rovers landed on Mars in 1997, 2004, and 2012. What do you notice about them? (*They are successively bigger and more complex!)*

- Each landing requires more equipment
- More weight is carried
- Improved landing options are needed

Slide 4 This video features Chris Tanner, a mechanical engineer at the Jet Propulsion Laboratory in Pasadena, CA who describes the current effort to develop the next generation of landing systems.
This video clip can be downloaded or bookmarked in advance and saved to your computer.

Slide 5 Pass out the student pages. Review the highlights of the video and discuss how engineers are working to develop various sized drag devices for future spacecraft. Have students read the *Low Density Supersonic Decelerator* section on the first page of the student pages. (*Student pages begin on page 6 of the educator guide*.)



Slide 6 Ask students in what ways they can slow things down? How do you slow down a spacecraft? Possible answers might include engines, parachutes, drag devices, and streamers.
NASA has created various designs over the years to slow down spacecraft. The Apollo and Orion capsules (pictured) are two examples.
Students can also research other geometric shapes used in hang gliding, military parachutes, etc. for ideas.

Slide 7 Review the challenge. Show them the *Spacecraft Template (Page 14 of the educator guide)* and distribute to each group.

Do not show students an example of a previously built parachute as they will have a tendency to copy your example!

Slide 8 Explain that you will be following the engineering design process to complete the challenge. *For additional videos and activities about the engineering design process, return to the challenge Web site.*

The next 10 slides follow the student pages will keep you and your students moving through the activity. (*Student pages begin on page 6 of the educator guide*.)

Ask

What questions do you have about today's challenge?

Slide 9 Allow students ask any clarifying questions they have about the challenge. Remember that no building or materials distribution should occur during this section.

Potential questions could be:
What type of materials can we use? Give students a "tour" of all the materials available for building their drag devices, but do not tell them what each material is for.
Where is our deploy site? Tour the deploy area and review how the timing will take place. Do not show them an example of a previously built parachute or a test drop. Wait until after they have built their drag devices.
What does "5 angled edges" mean? This means they can't have a simple circular design. It must have at least 5 edges. They all do not have to be on the same piece of material, the drag device could have multiple pieces of different materials.
How do I calculate surface area? Students can trace the outline of their drag device onto 1cm graph paper and divide the shape into squares, triangles, rectangles, etc. to count the number of squares inside.

Imagine

What shape will you use for your drag device?

Will you include any special features?

Everyone will use the same spacecraft template.

Slide 10 Students will collaborate with their team to generate a list of preliminary design ideas. Allow the students plenty of time to work in their small groups and **imagine** what their drag device should look like. This is a paper and pencil activity. They should not be cutting or building anything yet! Encourage team members to listen to each other and write down as many ideas and variations as they can think of. All ideas are valid and should be documented. They might need to come back to this list for new ideas after testing. These ideas might help lead others in the group to the idea that will work best.

Discuss the questions as either a whole group or as teams.
Take photos and/or videos of students as they work to capture their creative processes.

Plan

1. Draw your design on paper, including measurements.
2. Calculate mass and surface area of your drag device.
3. Instructor must approve drawing before building begins.

Slide 11 Students will draw out their drag device, including measurements. Use graph paper, if needed. Require as much detail from them as you believe they can provide.

All drawings should be approved by you before building begins. Students should take photos of drawings as they are approved, or when they believe they have made important design decisions and changes.

Create

Begin building!

Be respectful of supplies.

Slide 12 Students will begin building their drag devices and should take care not to waste supplies. If appropriate for your students, give each type of material a value and require each team to keep track of their "spending" to keep their project on a budget. Students can do preliminary drops from raised arm heights during the CREATE phase. The official drops will take place in the EXPERIMENT phase.

Students should be reminded to take photos as they work and bring their designs to life. They should also keep track of any questions they might like to ask a NASA engineer about their design or the design process.

Slide 13 Before moving to the deploy area, have students calculate the surface area and mass of their drag devices and record it in their data sheets.
Review safety rules and procedure for how each group will perform their drop, then proceed to the Drop Area.

As students bring their devices to the Drop Area, remind them to create a video of the test, and that they should begin the video with a brief description of the variable(s) they are testing. They can use the video for their submission, but videos can also be used as data to review design effectiveness, just like the engineers at NASA.

Slide 14 Measure the amount of time it takes for the drag device to fall, and the speed of the drop can also be calculated. *(This chart can be found on Page 9 of the Educator Guide.)*

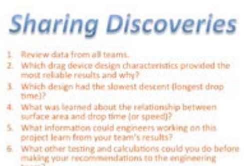
Slide 15 After first round testing is complete, students should complete the scatter graph, and then begin making improvements and modifications.

The surface area (the independent variable) is plotted on the X axis, and the time it takes for the egg to drop (the dependent variable) is plotted on the Y axis. *(This graph can be found on Page 10 of the Educator Guide)*

Slide 16 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 second round of designs and test results, calculating the surface area and making sure the mass remains under 50 grams. Help students think of questions they could ask a subject matter expert about the challenge.

Slide 17 Students will exchange designs to be evaluated. They will evaluate information from the student data sheets and interviews with one another, but not from retesting the drop. *(This form can be found on Page 11 of the Educator Guide)*

Slide 18 *(These questions can be found on Page 11 of the Educator Guide)*



Slide 19 It is important for the students to share what they learned. Be sure to leave enough time for them to answer as a team or as a class discussion. *(These questions can be found on Page 11 of the Educator Guide)*