

# NASA CONNECT

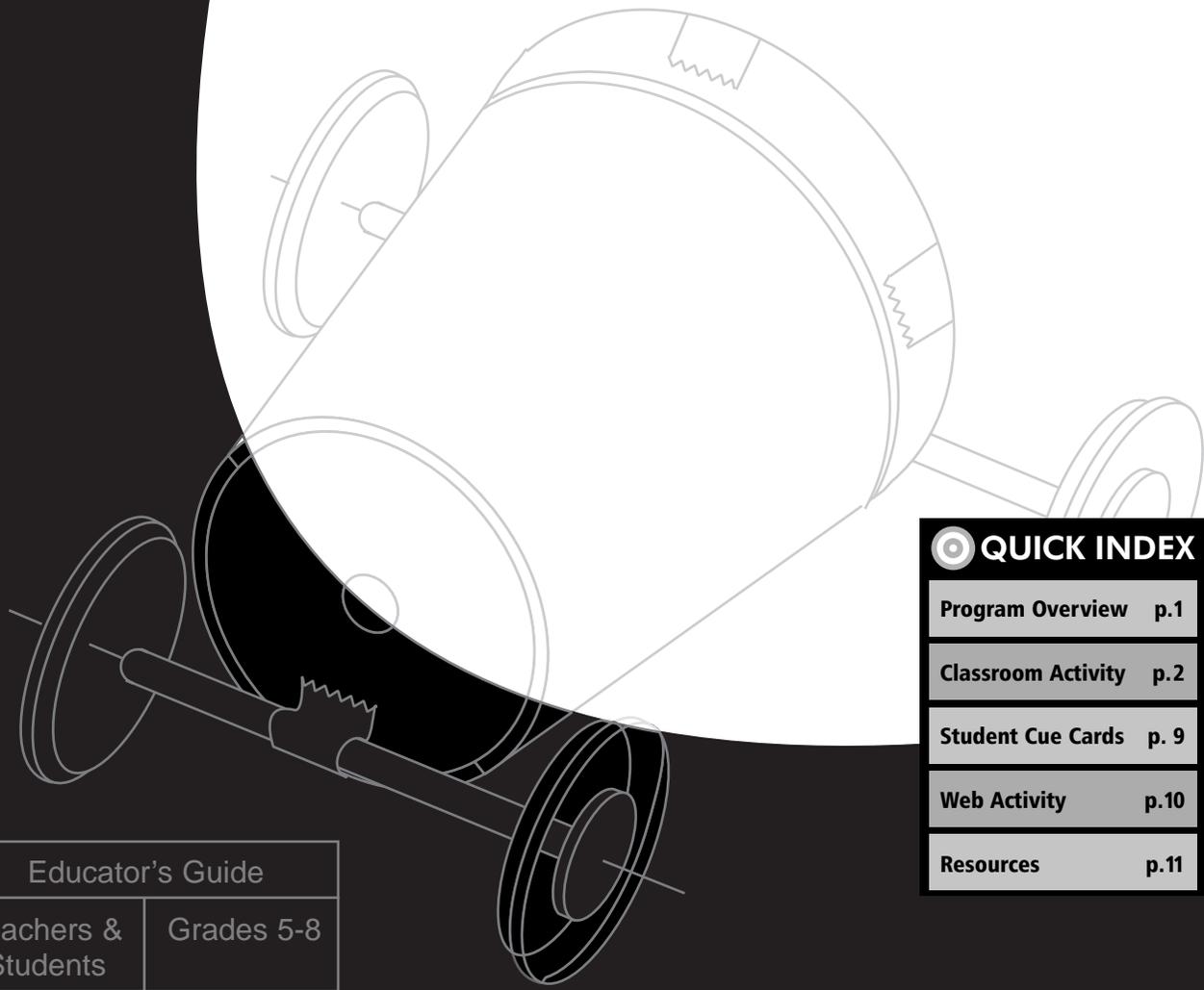
Program 1 in the 2000-2001 Series



## Measurement, Ratios, and Graphing:

3...2...1...Crash!

■ Program 1 Measurement, Ratios, and Graphing: 3...2...1...Crash!



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Teachers & Students	Grades 5-8

# PROGRAM OVERVIEW

## SUMMARY AND OBJECTIVES

In *Measurement, Ratios, and Graphing: 3...2...1...Crash!*, students will learn the history of the National Aeronautics and Space Administration (NASA) and discover how NASA Langley Research Center improves aircraft performance and safety by conducting extreme tests such as crashing planes, skidding tires, and blasting water. Students will observe NASA engineers using measurement, ratios, and graphing to make predictions and draw conclusions during their extreme tests. Students will learn how NASA researchers (1) measure and collect data, (2) develop ratios and graphs to analyze their data, (3) compare their results, and (4) predict possible solutions for their real-world problems.

## INTERACTIVE ACTIVITIES

To direct the instruction, questions are posed throughout the video by Norbert, the animated co-host of NASA CONNECT. Students are encouraged to think about answers to the questions and write their answers on the Student Cue Cards provided (p. 9). By answering the cue card questions, students will make the connection between the research conducted at NASA and the mathematics, science, and technology they learn in their classroom.

The hands-on classroom activity (p. 2), entitled the Effervescent Noncombustible Dragster (ENCD), is teacher-created and aligned with the national mathematics, science, and technology standards. Students will construct and test their own dragster, measure and collect data, and analyze the results just like NASA researchers.

ED.U.Tour, the on-line activity, (p. 10) allows students to tour the Aircraft Landing Dynamics Facility (ALDF) at NASA Langley Research Center. Interactive activities acquaint students with various mathematics and science concepts related to the research mission of the ALDF. ED.U.Tour is located in Norbert's lab at <http://connect.larc.nasa.gov/crash/lab.html>

## RESOURCES

Teacher and student resources (p.11) support, enhance, and extend the NASA CONNECT program. Books, periodicals, pamphlets, videotapes, and web sites provide teachers and students with background information and extensions. In addition to the resources listed in this lesson guide, the NASA CONNECT web site (<http://connect.larc.nasa.gov>) offers on-line resources for teachers, students, and parents. Teachers who would like to get the most from the NASA CONNECT web site can connect to Norbert's Lab and receive assistance from our "Lab Manager."

# THE CLASSROOM ACTIVITY

## BACKGROUND

The Effervescent Noncombustible Dragster (ENCD) activity is designed to visually simulate the research done at the NASA Langley Research Center's Aircraft Landing Dynamics Facility (ALDF). ALDF uses a high-pressure water-jet system to propel a test carriage along a track to test aircraft landing gear and runway surfaces. Background information on the statistics of ALDF can be obtained from the web site <http://sdb-www.larc.nasa.gov/SDB/ALDF.html>.

Students work in groups to construct a dragster and propulsion system using common household supplies. The objective of the activity is to examine various ratios of the propulsion mixture that result in the greatest distance the dragster travels. Through experimenting and predicting, students use measurement, ratios, and graphing to test their findings.

## NATIONAL STANDARDS

### MATHEMATICS STANDARDS

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- Understand patterns, relations, and functions.
- Represent and analyze mathematical situations and structures using algebraic symbols.
- Use mathematical models to represent and understand quantitative relationships.
- Analyze change in various contexts.
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.
- Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them.
- Select and use appropriate statistical methods to analyze data.
- Develop and evaluate inferences and predictions that are based on data.
- Apply and adapt a variety of appropriate strategies to solve problems.
- Solve problems that arise in mathematics and in other contexts.
- Monitor and reflect on the process of mathematical problem solving.
- Recognize reasoning and proof as fundamental aspects of mathematics.
- Make and investigate mathematical conjectures.
- Develop and evaluate mathematical arguments and proofs.
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others.
- Use the language of mathematical ideas precisely.
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole.
- Create and use representations to organize, record, and communicate mathematical ideas.
- Use representations to model and interpret physical, social, and mathematical phenomena.

## SCIENCE STANDARDS

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- Scientific inquiry
- Properties and changes of properties in matter
- Motion and forces
- Transfer of energy
- Abilities of technological design
- Understanding about science and technology

## TECHNOLOGY STANDARDS

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- Use technology tools to enhance learning, increase productivity, and promote creativity.
- Use technology tools to locate, evaluate, and collect information from a variety of sources.
- Use technology tools to process data and report results.

## INSTRUCTIONAL OBJECTIVES

Students will be able to

- construct an ENCD, a propulsion device, and test track using metric measurement.
- use measurement and ratios to perform experiments and predict outcomes of their trials.
- use graphing to organize their data, interpret, and analyze their results.

## VOCABULARY

**Axle** – a bar connected to the center of a circular object such as a wheel that allows or causes it to turn, especially one connecting two wheels of a vehicle.

**Circumference** – distance around a circle

**Propel** – to drive forward or onward by means of a force that causes motion

**Effervesce** – producing bubbles of gas in a liquid

**Noncombustible** – not capable of igniting and burning

## PREPARING FOR THE ACTIVITY



### MATERIALS

#### DRAGSTER

- 6 –8 oz **foam cup**
- foam **meat tray** (approx. 9 cm long and 7 cm wide)
- ballpoint **pen**
- tape** – a type that will stick to foam cups (duct tape works well)
- 3 **straws** – standard length
- 2 **wooden skewers**
- 4 round **film canister tops** or plastic milk carton tops

#### PROPULSION DEVICE

- shoe box** – bottom portion
- scissors**
- 1 **wooden skewer**
- Velcro®** – 5 cm long, 3 cm wide (adhesive back)
- film canister** – clear plastic with a lid that snaps inside the canister instead of outside the canister

#### TEST TRACK

- masking tape**
- meter stick**
- marker**

#### MATERIALS TO RUN THE TEST

- effervescent antacid tablets**
- graduated cylinder**
- paper towels**
- water** – room temperature for the mixture and additional water to rinse the canister after each use
- safety glasses** for students preparing the propulsion mixture

#### TIME

- Construction of dragster and propulsion device . . . . . 45 min
- Preparation of test track and running the experiment . . . . . 45 min
- Graphing and analyzing data . . . . . 45 min

#### ADVANCE PREPARATION

The film canister tops (milk carton tops) require a small pilot hole for the wooden skewer. The teacher should prepare these in advance for all groups. Use a small nail or sharp pen to puncture the center of the film canister or milk carton top. Test the hole to be sure that the top will fit securely onto the skewer. If the top turns freely on the skewer, the hole is too big.

Depending on the students, the teacher may choose to prepare the effervescent tablets in appropriate fractional sizes. Use the point of a sharp ink pen to score the top of the tablet by scratching a bisecting line across it. Break the tablet in half. Use the same process to create fourths by bisecting the half sections. The students will start the experiment with a half tablet, then through predicting, students will choose other fractional parts. It is recommended that you provide each group with at least a half tablet, 1 whole tablet, and 4 quarter sections. If you prepare the sections in advance, be sure to seal them tightly in a moisture proof container so they will not lose the effervescence prior to the experiment.

**Optional:** The teacher may choose to mark the exterior of the film canisters to indicate the 10 mL measure. Scratch the surface of the film canister or place tape at the appropriate location for 10 mL of water, thus enabling the students to pour the water directly into the canister without using the graduated cylinder during each trial.

Students may choose to decorate the constructed dragster.



## CAUTION

The combination of the effervescent tablet and water creates a reaction that pops the top off the film canister. The time it takes for the top to pop can be as little as 5 seconds and as long as 16 seconds. Remind students to follow the directions: fill the film canister with 10 mL of water and bend next to the shoe box with the film canister. While holding the canister near the Velcro® on the shoe box, drop the effervescent tablet into the water and **very quickly** snap the top on tightly and attach the canister to the Velcro® on the shoe box. Step away from the propulsion device.

**Students should wear safety glasses when preparing the mixture and film canister.** Be prepared to clean up water and tablet residue that spills onto the floor upon blast off. Rinse the canister after each use to remove remaining residue.

## THE ACTIVITY



### STEP 1: CONSTRUCT THE DRAGSTER

#### A. BACK OF THE DRAGSTER

1. Place the open end of the foam cup on a foam meat tray. Trace the circumference of the cup onto the foam meat tray and cut out the circle.
2. Tape the foam circle to the open end of the cup.

#### B. WHEEL BASE

1. Cut a straw 7cm long and tape the straw to the rim on the front end of the dragster (see figure 1).
2. Cut a second straw 13 cm long and tape the straw to the bottom of the back end of the cup so that the straws are parallel to each other and close to the rim at each end (see figure 2).
3. Thread a skewer through each straw and break off or cut the ends so that 2 to 3 cm of the skewer extend beyond the straw on each side.
4. Push a cap wheel onto the skewer on each side of the straw. Leave a small gap between each wheel and straw so the wheels are able to roll.
5. Tape a straw to the bottom of the cup, perpendicular to the other two straws (wheel axles). The straw should extend about 4 cm beyond the rear wheel axle (see figure 3).

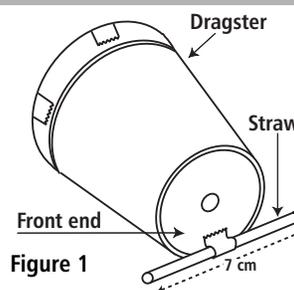


Figure 1

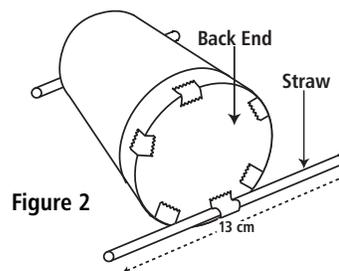


Figure 2

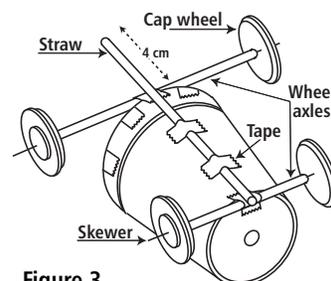


Figure 3

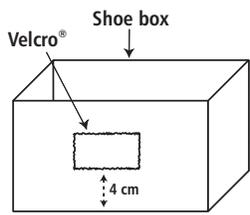


Figure 4

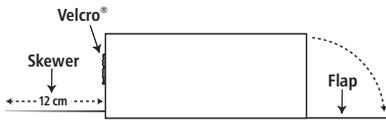


Figure 5

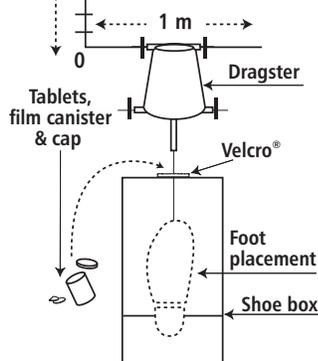
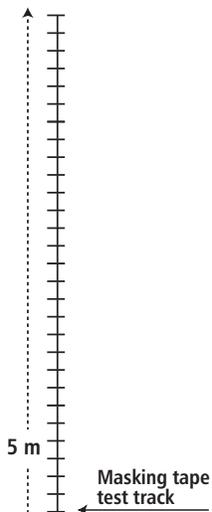


Figure 6

## STEP 2: CONSTRUCT THE PROPULSION DEVICE



1. Mark an "X" in the center of the end of the shoe box.
2. Glue a 5-cm section of Velcro® to the location of the "X" approximately 4 cm from the bottom of the shoe box (see figure 4).
3. Glue the opposing side of the Velcro® to the bottom of the film canister; trim as needed.
4. Cut the back seams of the shoe box, opposite the end where the Velcro® has been attached. Pull down the flap, created by cutting the seams, so that it is level with the bottom of the box.
5. Poke a skewer through the front end of the shoe box close to the bottom of the box and centered directly beneath the Velcro® strip. Extend the skewer through the hole 12 cm beyond the edge of the front of the box (see figure 5).



## STEP 3: PREPARE TEST TRACK

1. Cut two pieces of masking tape: one piece for the starting line (1 m long) and a second piece (5 m long) to measure the distance the dragster travels.
2. Place the masking tape at a right angle on the floor.
3. Mark the longest piece of tape in increments of decimeters (dm).



## STEP 4: TRIALS

### A. FIRST RATIO

1. Ratio of 1/2 of an effervescent tablet to 10 mL (approximately 2 tsp) water
2. Begin the trial by placing the dragster behind the starting line.
3. Align the shoe box behind the dragster. Slide the skewer, which is on the box, into the straw on the bottom of the dragster.
4. Adjust the dragster and shoe box behind the starting line so that the wheels of the dragster align with "zero" on the marked tape.
5. Place your foot into the shoe box to hold it in place during the test. Adjust the box and dragster as needed, so that the front wheels remain aligned with "zero" (see figure 6).
6. **Put on safety goggles.** Fill the film canister with 10 mL water and hold it near the front of the shoe box.
7. Drop the effervescent tablet into the canister and snap on the canister cap.
8. Quickly attach the canister to the Velcro® on the shoe box.
9. Position the dragster to rest against the film canister. **Stand back during blast off.**
10. After the dragster has stopped, place a ruler or straightedge perpendicular to the marked tape and next to the front wheels of the dragster.
11. Record the distance traveled on the Student Data Sheet (p. 8) for the ratio tested.
12. Rinse the canister with clean water and dry with a paper towel.
13. Repeat the trial using the same ratio.
14. Record the distance traveled.
15. Determine the average distance traveled of the two trials and enter your answer in the last column of the Student Data Sheet (p. 8).
16. Rinse and dry the canister to remove previous trial residue.

### B. SECOND RATIO

1. Predict a ratio of effervescent tablet to water that might yield a greater distance.
2. Follow the processes in Step 4-13, part A (p. 6) using your predicted ratio.
3. Record your findings on the Student Data Sheet (p. 8).
4. Determine the average of your two trials and record the answer on the Student Data Sheet (p. 8).
5. Rinse and dry the canister.

### C. THIRD RATIO

1. Based on the findings of the previous trials, predict another ratio that might yield the greatest distance.
2. Follow the process in Step 4-13, part A (p. 6), using the second predicted ratio.
3. Record your findings on the Student Data Sheet (p. 8).
4. Determine the average of your two trials and record the answer on the Student Data Sheet (p. 8).



## STEP 5: GRAPH THE RESULTS

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### DISCUSS THE CONSTRUCTION OF THE GRAPH

1. What are the independent and dependent variables?
2. What increments of measure should be used?
3. Construct the graph and plot the points.
4. Construct one graph for the entire class either on the chalkboard, the overhead, or on a large piece of paper taped to the wall.
5. Have each group plot its average distances for each ratio tested on the class graph. (Each group should plot at least three points. Use a different color for each group.)



## STEP 6: ANALYZE THE DATA

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### A. DISCUSS THE GRAPH OF THE RESULTS

1. What type graph was constructed? (scatter, line, bar?)
2. Are there different distance values plotted for the same ratio? Why?
3. Are there values that lie outside the groups of points? Why?

### B. MAKE PREDICTIONS

1. Based on the recorded data, what ratio produced the greatest distance?
2. What process would you use to find the maximum value of the distance? Is it possible to find the maximum value based on this experiment?
3. Test the predictions.
4. Discuss the outcomes.

## EXTENSIONS

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1. Construct the dragster from a soda can or plastic water or soda bottle (1/2 to 2L) and use vinegar and baking soda as a propulsion mixture. As before, change the ratio for optimum performance. Begin with the ratio of 200 mL vinegar to 16 g baking soda.
2. Construct an ENCD that is more aerodynamic by adding parts to the front, sides, and back. Compare the test results with the original dragster.
3. Analyze the graph of your test results. Do the results model a particular algebraic function; for example, parabolic, exponential, or linear? How can you test your hypothesis?

## STUDENT DATA SHEET

RATIO	DISTANCE 1	DISTANCE 2	AVERAGE DISTANCE

WORK AREA:

# STUDENT CUE CARDS

**Bob Daugherty, NASA Langley Research Center, Aircraft Landing Dynamics Facility**

1. How is the test set up to solve the problem? \_\_\_\_\_

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2. How are graphs used to find possible solutions? \_\_\_\_\_

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3. What visual method did NASA engineers use to represent their solution? \_\_\_\_\_

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**Lisa Jones, NASA Langley Research Center, Impact Dynamics Research Facility**

How is technology used to collect the mathematical data in crash tests? \_\_\_\_\_

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Why is area important in the results of the test? \_\_\_\_\_

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How are ratios used to find a solution? \_\_\_\_\_

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# THE WEB ACTIVITY

## PREPARING FOR THE ACTIVITY

### BACKGROUND

ED.U.Tour is a web-based tour of the Aircraft Landing Dynamics Facility (ALDF) at NASA Langley Research Center and includes activities that acquaint students with various mathematics and science concepts related to the research mission of the ALDF. For each of the four parts of the lab: Propulsion, Carriage, Track, Arrestment, there is a corresponding interactive lesson that presents some of the key science and mathematics principles associated with the ALDF system.



To access ED.U.Tour, visit Norbert's lab  
<http://connect.larc.nasa.gov/crash/norbert/lab.html>

From Norbert's lab, there is also a link to Career Corner featuring researchers and NASA CONNECT team members talking about their jobs at NASA and links to additional on-line resources. New this season is a section in the lab for teachers. The NASA CONNECT "Lab Manager" offers assistance to teachers who would like to get the most from the site.

## NATIONAL STANDARDS

### TECHNOLOGY STANDARDS

- Use technology tools to enhance learning, increase productivity, and promote creativity.

### SCIENCE STANDARDS

- Properties of objects and materials
- Motions and forces
- Abilities of technological design

### MATHEMATICS STANDARDS

- Understand patterns, relations, and functions.
- Use mathematical models to represent and understand quantitative relationships.
- Analyze change in various contexts.
- Understand measurable attributes of objects and the units, systems, and processes of measurement.
- Apply appropriate techniques, tools, and formulas to determine measurements.
- Develop and evaluate inferences and predictions that are based on data.
- Create and use representations to organize, record, and communicate mathematical ideas.
- Use representations to model and interpret physical, social, and mathematical phenomena.

## INSTRUCTIONAL OBJECTIVES

- Students will be able to calculate distance traveled, given visual representations, and relate their findings to NASA research.
- Students will be able to determine ratios, given visual representations, and predict outcomes based on their findings.

# RESOURCES

## BOOKS, PAMPHLETS, VIDEOTAPES AND PERIODICALS

NASA Facts: *Exploring NASA's Roots: The History of Langley Research Center*, NF167 April 1992

Davis, Stubbs, and Tanner: *Langley Aircraft Landing Dynamics Facility*, NASA RP-1189, October 1987

Buck, Rinder: *Flight of Passage: A Memoir*, Hyperion, June 1998 Reprint Edition

Bilstein, Roger E.: *Orders of Magnitude: A History of the NACA and NASA, 1915-1990 (NASA SP-4406)* 1989

Krause, Shari Stamford: *Aircraft Safety: Accident Investigations, Analyses, and Applications*. McGraw-Hill Companies, February 1996.

Rosenberg, Barry: Airbags for Aircraft, *Popular Mechanics*, 1/97, Volume 174, p. 60.

Skidding to Disaster, *Time*, 6/14/99, Volume 153, p. 58.

The Drop Test, *World of Wonder*, GRB Entertainment, Show 403 (Call 1-818-728-7600 for video information)

## WEB SITES

NASA's homepage with links for students <http://www.nasa.gov>

NASA Langley Research Center's homepage <http://www.larc.nasa.gov>

NASA Langley's Structural and Dynamics Branch homepage with links to the Aircraft Landing and Dynamics Facility (ALDF) and the Impact Dynamics Research Facility (IDRF) <http://SDB-www.larc.nasa.gov/SDB/SDB.html>

Overview of NASA Langley's Impact Dynamics Landing Facility (IDRF)  
<http://oea.larc.nasa.gov/tour/impact1.html>

Overview of NASA Langley's Aircraft Landing Dynamics Facility (ALDF)  
<http://oea.larc.nasa.gov/tour/ALDF1.html>

National Highway Traffic Safety Administration homepage  
<http://www.nhtsa.dot.gov/>

Description of how the shuttle lands at Kennedy Space Center  
<http://www-pao.ksc.nasa.gov/kscpao/nasafact/landing.htm>

An article about NASA Langley's IDRF  
[http://www.knowledgerevolution.com/press/stories/ss\\_nasa.html](http://www.knowledgerevolution.com/press/stories/ss_nasa.html)