Engineers in the Classroom

Since the very beginning, the U.S. space program has generated innovations benefiting humans in amazingly diverse and sometimes unexpected ways. From America's first space flight in 1961, when Alan Shepard Jr. flew above the Earth for 14.8 minutes, to the *Apollo 11* moon landing, to the first flight of space shuttle *Columbia* in 1981, to the 1998 launch of the first International Space Station module, to the Mars exploration rovers in 2004, the U.S. has pioneered incredible discoveries as a result of its passion and drive to explore.

These achievements would not have been possible without the contributions of engineers in many different disciplines. While aerospace engineers design and develop the spacecraft, mechanical engineers design the machines that make the components of those spacecraft—including the engines. Software engineers create the computer systems that control the craft, and systems engineers ensure that all components of each spacecraft work together.

This classroom poster guide is designed to assist you while engaging students during space exploration discussions and activities, such as Lockheed Martin's **Space Day**. The contents will help students learn about the accomplishments and discoveries made possible by the U.S. space program, encourage students to imagine what might be achieved in the future, and spark interest in students, leading them to a possible career in engineering.

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ENGINEERS IN THE CLASSROOM™

National Science Education Standards

This program addresses the following National Science Education Standards.

Science and Technology

Students should develop understandings about science and technology:

- Scientists in different disciplines ask different questions, use different methods of investigation, and accept different types of evidence to support their explanations. Many scientific investigations require the contributions of individuals from different disciplines, including engineering.
- Science often advances with the introduction of new technologies. Solving technological problems often results in new scientific knowledge. New technologies often extend the current levels of scientific understanding and introduce new areas of research.
- Creativity, imagination, and a good knowledge base are all required in the work of science and engineering.

History and Nature of Science

Students should develop understandings of science as human endeavor:

- Individuals and teams have contributed and will continue to contribute to the scientific enterprise. Doing science or engineering can be as simple as an individual conducting field studies or as complex as hundreds of people working on a major scientific question or technological problem. Pursuing science as a career or as a hobby can be both fascinating and intellectually rewarding.
- Scientists are influenced by societal, cultural, and personal beliefs and ways of viewing the world. Science is not separate from society but rather science is a part of society.

Activities and Grade Level

This guide can be used with middle school and/or high school students and adapted as needed. The activities are meant to build on one another as they generate student awareness of the history, achievements, and technological advancements that have resulted from the U.S. space program and the important contributions that engineers, of various disciplines, have made to that program.

Presentation Tips

You will need to make copies of the presenter and teacher background material as well as the activity masters and review everything with the teacher before asking him or her to display the poster in the classroom for student reference. Activities two and three are intended for the teacher to use as a classroom follow-up to your presentation.

Activity 1: Space Flight: Past, Present and Future

Goal: To provide students with an overview of the U.S. space program to date, and to engage them in considering what future space explorations may discover

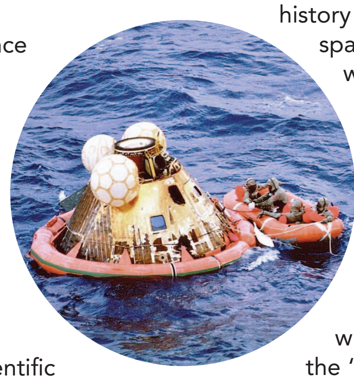
Time Required: Approximately 45 minutes

Objectives

Students will:

- Learn about the past and present—and consider the future—of the U.S. space program
- Consider how various engineering disciplines have contributed, and will continue to contribute, to space exploration and discovery

First make sure that the poster is displayed for reference, then distribute the activity sheets to students.



In Part 1 of the activity, provide a brief overview of the history and major milestones of the U.S. space program. Tell students that, while the U.S. program is currently in a strategic planning stage since the final flight of the space shuttle *Atlantis*, the international space program continues. For example, U.S. astronauts now fly on Russian spacecraft to reach the International Space Station—a surprising development, since it was our rivalry with the Russians that led to the launch of the “space race” itself in 1957.

As you talk, look for opportunities to point out how engineers from various disciplines might have contributed to the program. Conclude by pointing to the phrase “And next…?” on the poster, and pose some questions to prompt students to think about the future of space flight. For example: “We’ve been to the moon; we’ve explored Mars; we’ve orbited Saturn. What do you think is/should be next? Or have we done all we need to do?”

Next, administer the quiz to the entire class, calling on volunteers for the answers, or have students work independently, then review the answers with the class. ***Answers:*** 1-B; 2-A; 3-B; 4-A; 5-B; 6-B; 7-A; 8-all 3 are correct; 9-B; 10-A.

Before beginning Part 2, divide students into “engineering teams” of 5-6 each. Allow a few minutes for teams to brainstorm about the future of U.S. space endeavors and to list their top three ideas on the activity sheet, then ask teams to share their ideas. Provide time at the end of class to field any questions students might have—about the space program or about your personal experiences as a Lockheed Martin engineer. If you wish to extend your interaction with the class and review the vision statements created by students in Activity 3 that relate to your presentation in this activity, arrange that with the teacher before you leave.

Activity 2: The Space Shuttle: Payloads Paid Off (Teacher Follow-Up)

Goal: To provide students with information about some of the payloads the U.S. space shuttle has carried into orbit, and to experiment with how different weight payloads can affect a balloon rocket

Time Required: Approximately 45 minutes

Objectives

Students will:

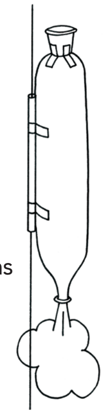
- Learn about some of the payloads carried by various U.S. space shuttles and do research to expand on that list, including experiments conducted by students like themselves
- Experiment with the effect of different weight payloads on a simple balloon rocket

This activity, intended as a teacher follow-up to the material presented by the engineer in Activity 1, may also be done by the presenter if desired. Begin by talking about the space shuttle, the world's first reusable spacecraft. The first shuttle, *Columbia*, took flight with a crew of two in April 1981. Thirty years and 135 missions later, *Atlantis* made the final shuttle flight in July 2011. The shuttle's original purpose was to launch satellites, carry scientific experiments—including a number of student experiments—and carry out military missions, many of which were, and remain, classified. Later flights focused on the International Space Station. Each shuttle consisted of three components: the orbiter, the rocket boosters, and the fuel tank.

In Part 1, review with students the list of shuttle payloads on the sheet. Divide the class into small teams and allow several days for additional research before teams reach consensus on their choice of additions to the list, which should include at least one additional student experiment. Provide class time for discussion.

In Part 2, have students work in teams of 3-4 to experiment with the weight and positioning of payloads on their balloon rockets. You will need the following:

What You Will Need



- Several large, long balloons per team
- String, minimum of 1mm in width
- One plastic drinking straw per team
- Two small paper cups per team
- A large supply of paper clips
- One roll of tape per team
- One clothespin per team
- One or more small kitchen-type scales for use by all teams

Teacher preparation: Cut one length of string per team, long enough to reach from the ceiling to the floor or to a desktop. Thread the string through a straw and tie one end of each string to a paper clip. Use a marking pen to measure off metric units on the string to help students determine the distance their rockets will travel. Next, hook the clip to a ceiling light or a ceiling tile brace, and tape the other end of the string to the floor or desktop, making the string taut. Space the strings throughout the classroom so that each team has room to work comfortably.

Student directions: Blow up a balloon, twist the opening, and hold it shut with the clothespin. Tape the paper cup (the payload bay) to any location on the balloon. Tape the balloon to the straw, with the closed end facing the ceiling and the clothespin end facing the floor. Launch the rocket by removing the clothespin, untwisting the end, and letting go.

Review the description of staging on the activity master. The first balloon rocket launch should have no payload (paper clips) in the payload bay. One team member should launch the balloon; one or two students should act as spotters to determine the height the balloon reaches; and one student should record the flight data on the activity sheet. For ensuing launches, students should experiment with different weight payloads and different positions for the payload bay. They also might experiment with the rocket design by adding a second balloon to the configuration. One team member should make a sketch of the payload bay position/rocket configuration on the reverse of the sheet each time a change is made. Have students share their results, discuss how well different design elements worked, and consider what adjustments they think would help their rocket lift even heavier payloads.

Activity 3: The Space Shuttle: A Living Legacy (Teacher Follow-Up)

Goal: To help students appreciate the technological innovations generated as a result of the U.S. space program
Time Required: Approximately 45 minutes

Objectives

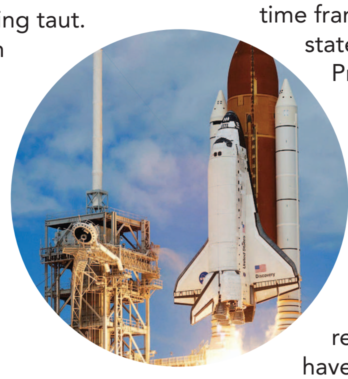
Students will:

- Learn how the many discoveries and innovations occurring as a result of the space program in general and, specifically, the U.S. space shuttle program, have helped humans in a variety of ways
- Develop a "vision statement" as they consider the future of space flight and where they think it might take humans

In Part 1 of the activity, discuss the innovations listed on the sheet. Have students first work independently to identify additional examples and then work in teams to develop their Top 10 lists. Provide time for teams to present their lists and for the class as a whole to agree on a Top 10 class list. Have each team choose one innovation from that list, do some research to learn more about it, and report back to the class as a whole before taking a class vote as to the one innovation they think had the greatest impact on life as we know it (including the innovations already listed on the sheet).

In Part 2, lead a class discussion about what students have learned during this unit on space—including contributions made by engineers from different disciplines. Remind students that, in Activity 1, they began to think about the "what next" of the U.S. space program. To conclude the unit, have students work with their team to develop and refine a "vision statement" that conveys their ideas about where space endeavors will take humans in the next 10 years.

Explain that a vision statement is a brief description of what individuals or organizations would like to achieve in a given time frame. An excellent, and relevant, vision statement can be found in the words spoken by President John F. Kennedy on May 25, 1961: "I believe that this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to the Earth." Once each team has developed its statement, members should identify the engineering disciplines that they think will play a role in making that vision a reality. Remind students that many disciplines have contributed, and will contribute in the future, toward achieving goals in space. If you have made arrangements with your Lockheed Martin presenter, share copies of the team vision statements with him or her for feedback to the class.



Presenter/Teacher Resources

- This link (**www.nasa.gov/50th/50th_magazine/benefits.html**) cites numerous technological advances that resulted from the space program.
- This link (**www.nasa.gov/audience/foreducators/eleven-more.html**) discusses a number of student experiments carried on the final flight of *Atlantis* in July 2011.
- For a comprehensive overview of space shuttle era facts, go to **www.nasa.gov/pdf/566250main_2011.07.05%20SHUTTLE%20ERA%20FACTS.pdf**

Space Flight: Past, Present and Future

Goal: To provide students with an overview of the U.S. space program to date, and to engage them in considering what future space explorations may discover

Introduction: From America's first space flight in 1961 to the Mars exploration rovers in 2004, the U.S. space program has pioneered discoveries that have generated innovations benefiting humans in amazingly diverse and sometimes unexpected ways. These achievements would not have been possible without the contributions of engineers in many different disciplines.

In this activity, you will test your knowledge of some of the milestones in space and, with your team, begin to build a vision for the future of space exploration.

Instructions: After taking the quiz, brainstorm with your team about your vision for the future of space flight. List your ideas for the top 3 future space flight endeavors, along with the engineering disciplines you think will be involved.

Part 1. Circle the letter or letters that correctly complete(s) each statement.

1. In a speech on May 25, 1961, President John F. Kennedy said the nation should commit itself to:
A. Putting a satellite in space.
B. Landing a man on the moon.
C. Beating the Russians in the space race.

2. On June 2, 1966, *Surveyor 1* became the first American spacecraft to:
A. Soft-land on the moon.
B. Carry a scientific experiment.
C. Take photos of the Earth from space.

3. The Apollo-Soyuz Test Project in July 1975 was a joint project between the U.S. and the Soviet Union. It was designed to test the compatibility of:
A. U.S. and Soviet communication systems.
B. The docking systems of the two spacecraft.
C. The U.S. and Soviet space programs.

4. One of the first space shuttles, *Enterprise*, was named for:
A. A spacecraft featured in the "Star Trek" TV series.
B. An important nuclear submarine.
C. A positive character trait.

5. The tragic explosion on January 28, 1986, of the space shuttle *Challenger* resulted in the death of the entire seven-member crew, which included:
A. Senator John Glenn.
B. Christa McAuliffe, the first teacher to go into space.
C. The most ethnically diverse crew in space shuttle history.

6. The goal of the *Magellan* mission, which began in May 1989, was to:
A. Prove that flight to the edge of the solar system was possible.
B. Map the surface of the planet Venus.
C. Determine if there was water on Mars.

7. In December 1993, astronauts piloted the space shuttle *Endeavor* on a highly successful mission to:
A. Repair the Hubble space telescope.
B. Launch a new communications satellite.
C. Orbit the moon.

8. The February 1995 flight of the space shuttle *Discovery* was significant because it:
A. Featured a flyby of the Russian space station *Mir*.
B. Was the first time a woman pilot, Eileen Collins, flew the space shuttle.
C. Carried the first Russian to be launched aboard a U.S. spacecraft.

9. In January 2004, the twin rovers, *Spirit* and *Opportunity*, landed on:
A. Neptune. B. Mars. C. The moon.

10. In April 2012, a final milestone for the space shuttle program occurred when *Discovery* was:
A. Put on display at the National Air and Space Museum's Udvar-Hazy Center.
B. Sold on Ebay.
C. Purchased by billionaire adventurer and space travel enthusiast Richard Branson.

Part 2. Write your team's top 3 ideas about the future of space endeavors below, along with the engineering disciplines that you think might help to make them a reality.

1. Idea: ______________________________

Disciplines: ______________________________

2. Idea: ______________________________

Disciplines: ______________________________

3. Idea: ______________________________

Disciplines: ______________________________

Engineering Disciplines

Aerospace	Mechanical	Software
Electrical	Nuclear	Systems

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The Space Shuttle: Payloads Paid Off

Goal: To provide students with information about some of the **payloads** the U.S. space shuttle has carried into orbit, and to experiment with how different weight payloads can affect a balloon rocket

Introduction: The space shuttles carried more than a crew of astronauts. They also carried payloads, including satellites to be launched from orbit, as well as experiments—some of which were devised by students like you!

In this activity, you will learn about some of the payloads that the space shuttles carried, and you will consider how the weight of those payloads might have affected the shuttle rocket at liftoff by conducting your own simulated rocket launch.

Instructions: Review the information below. Research to learn more about space shuttle payloads—including some that were designed by students—then conduct your own payload weight experiments.

Some Space Shuttle Payloads

Space Shuttle Columbia, March 1982 (Flight No. STS-3)
This shuttle flight carried the first student experiment. Common houseflies, velvetbean caterpillar moths, and worker honeybees were observed for about 25 minutes in a zero-G environment to compare their flight responses, since each has a somewhat different flight-control mechanism.

Space Shuttle Discovery, April 1990 (Flight No. STS-31)
This shuttle carried and launched the Hubble space telescope into orbit.

Space Shuttle Columbia, October 1995 (Flight No. STS-73)
Five small potatoes were grown while in orbit to test the Astroculture plant growth facility. The success of this experiment showed that edible foods could be grown in space.

Space Shuttle Endeavor, February 2000 (Flight No. STS-99)
The experiments on board this flight included a student experiment, EarthKAM, which took more than 2,700 digital photos through an overhead flight-deck window.

Space Shuttle Atlantis, June 2010 (Flight No. STS-132)
This flight delivered a Russian-built mini-research module nearly 20 feet long and weighing more than 17,700 pounds to the International Space Station.

Key Term

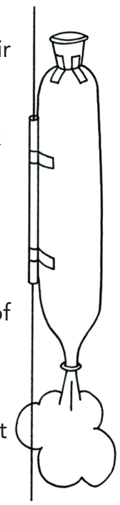
- **Payload**—cargo carried on any vehicle launched into space, such as on the space shuttle.

Part 1. In the space below, add descriptions of payloads carried on several other space shuttle missions. Be sure to include at least one more student experiment.

Additional Space Shuttle Missions/Payloads

- ______________________________
- ______________________________
- ______________________________
- ______________________________

Part 2. Large rockets that carry large spacecraft present some major engineering challenges due to their weight. Weight was such a concern that, following the first two shuttle missions where the massive external fuel tank was painted white, NASA eliminated the latex paint, saving 600 pounds.



The solution to the problem of propelling larger and heavier rockets into space involves something called *staging*: Smaller rockets are attached to the top of big rockets, and when the big rockets use up their supply of fuel, they fall away and the smaller ones take over.

Follow your teacher's instructions as your team conducts your own mini-experiment with balloon rocket payloads. First launch your rocket with no cargo in your payload bay. Record how far your rocket traveled below on line 1. For each additional launch, record the payload weight, any design changes you made, and how far the rocket flew. Use additional paper if you need it.

	Wt. Lifted	Results/Changes
1.	0	
2.		
3.		
4.		

Which rocket design carried the heaviest payload the greatest distance? Share your team's ideas with the class about why you think that design was the most effective.

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To learn more about space shuttle payloads, go to **www.nasa.gov/mission_pages/shuttle/shuttlemissions/index.html**

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The Space Shuttle: A Living Legacy

Goal: To help students appreciate the technological innovations generated as a result of the U.S. space program

Introduction: Many important advances in technology in many areas—including health and medicine, transportation, public safety, consumer goods, environmental and agricultural resources, computer technology, and industrial productivity—have resulted from what NASA scientists and engineers have learned as a result of the space program, including the space shuttle program. They include the innovations shown below.

- Teflon-coated fiberglass developed in the 1970s as a new fabric for astronaut spacesuits has been used as a permanent roofing material for buildings and stadiums worldwide.
- The real-time **GPS** data streaming from NASA's GPS Network provides pilots with accurate knowledge of their positions, and GPS navigation systems have become very popular with drivers.
- Materials from the space shuttle thermal protection system are used on NASCAR racing cars to protect drivers from the extreme heat generated by the engines.
- The foam insulation used to protect the shuttle's external tank has replaced the heavy, fragile plaster previously used to produce master molds for prosthetics. The new material is light, virtually indestructible, and easy to ship and store.
- A seven-step process for monitoring and testing food production was developed by NASA to ensure that astronauts on the way to the moon would not get food poisoning. This was adopted for the general population by the Food and Drug Administration and the Department of Agriculture, resulting in a significant drop in the number of cases of salmonella.

In this activity, you will do research independently and with your team to identify more of the exciting innovations that are a legacy of the U.S. space program. Then you will craft a vision statement that reflects what your team thinks the future of space exploration will bring—where we might go and what we might learn—in the next decade.

Instructions: First develop and list your team's Top 10 innovations below. Use the back of this sheet to make notes about the reasons behind your team's choices; you will need these when presenting your recommendations to the class. Then, with the class as a whole, develop a Top 10 list drawn from all the team recommendations before voting on the one innovation the class thinks has had the greatest impact.

Part 1. List the innovations you find in the order in which you think they should be ranked, from most to least significant. Next to each one, list the engineering disciplines that you think would have been involved in developing them.

Innovations	Disciplines
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

The #1 innovation as voted on by the class: ____________

____

Part 2. Now consider what you have learned about the history of the U.S. space program and the technological innovations that have resulted from it. With your team, craft a one- or two-sentence vision statement that conveys your team's ideas about where space endeavors will take humans in the next 10 years: Where will we have gone? What will we have learned? What new innovations will result from that new knowledge? Write your statement in the space below.

____

____

____

Key Term

- **GPS**—or Global Positioning System, is a group of satellites orbiting the Earth and transmitting precise signals that allow GPS receivers to manipulate the data and display accurate location, speed, and time information.

To learn more about technological advances generated by the space program, go to **www.sti.nasa.gov/tto/pdf/Shuttle_spinoffs.pdf**

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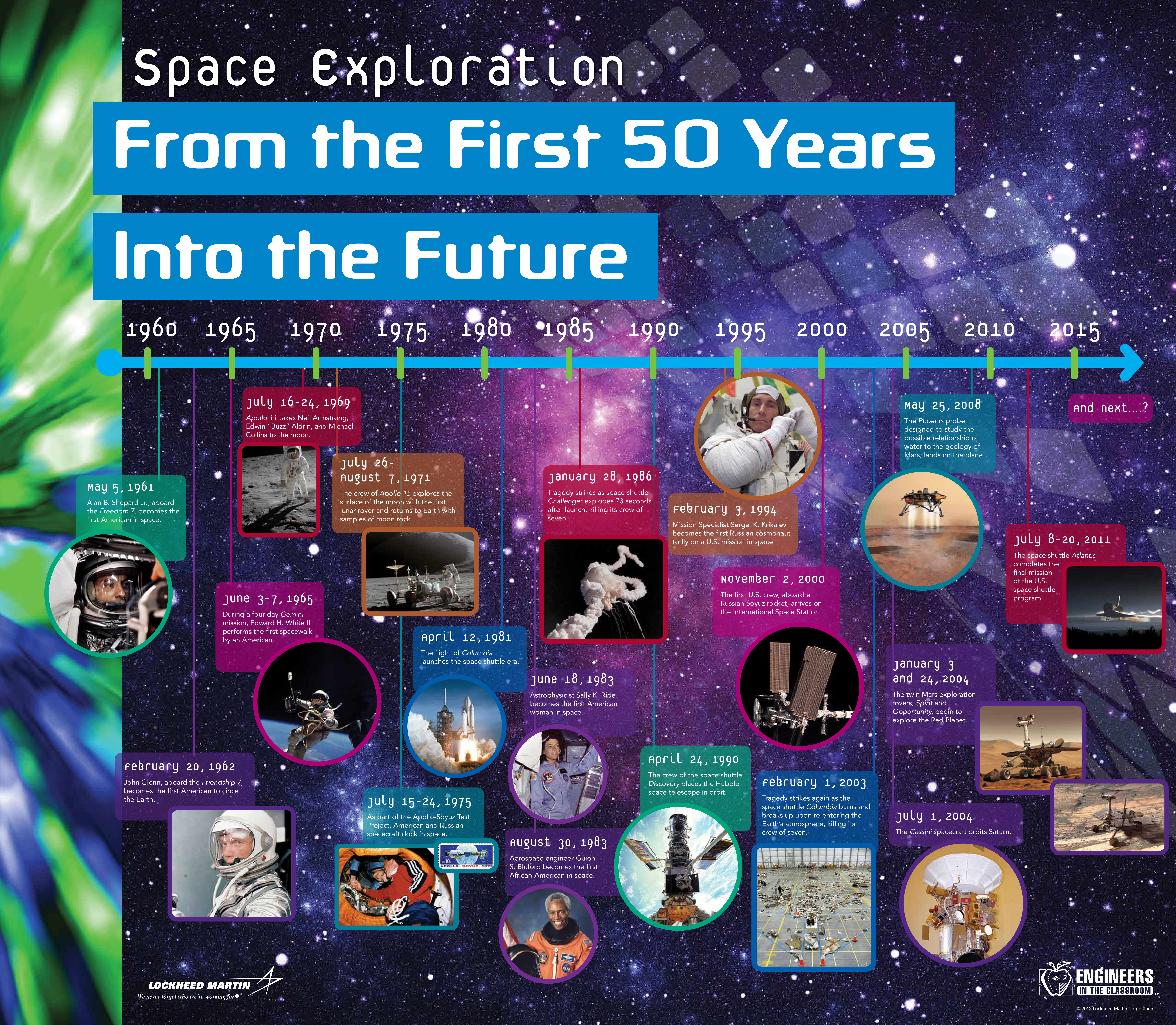
Space Exploration
From the First 50 Years
Into the Future
1960
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
2015
May 5, 1961
Alan B. Shepard Jr., aboard the Freedom 7, becomes the first American in space.
February 20, 1962
John Glenn, aboard the Friendship 7, becomes the first American to circle the Earth.
June 3-7, 1965
During a four-day Gemini mission, Edward H. White II performs the first spacewalk by an American.
July 16-24, 1969
Apollo 11 takes Neil Armstrong, Edwin "Buzz" Aldrin, and Michael Collins to the moon.
July 26-August 7, 1971
The crew of Apollo 15 explores the surface of the moon with the first lunar rover and returns to Earth with samples of moon rock.
July 15-24, 1975
As part of the Apollo-Soyuz Test Project, American and Russian spacecraft dock in space.
APOLLO SOYUZ 1975
April 12, 1981
The flight of Columbia launches the space shuttle era.
June 18, 1983
Astrophysicist Sally K. Ride becomes the first American woman in space.
August 30, 1983
Aerospace engineer Guion S. Bluford becomes the first African-American in space.
January 28, 1986
Tragedy strikes as space shuttle Challenger explodes 73 seconds after launch, killing its crew of seven.
April 24, 1990
The crew of the space shuttle Discovery places the Hubble space telescope in orbit.
February 3, 1994
Mission Specialist Sergei K. Krikalev becomes the first Russian cosmonaut to fly on a U.S. mission in space.
November 2, 2000
The first U.S. crew, aboard a Russian Soyuz rocket, arrives on the International Space Station.
February 1, 2003
Tragedy strikes again as the space shuttle Columbia burns and breaks up upon re-entering the Earth's atmosphere, killing its crew of seven.
January 3 and 24, 2004
The twin Mars exploration rovers, Spirit and Opportunity, begin to explore the Red Planet.
July 1, 2004
The Cassini spacecraft orbits Saturn.
May 25, 2008
The Phoenix probe, designed to study the possible relationship of water to the geology of Mars, lands on the planet.
July 8-20, 2011
The space shuttle Atlantis completes the final mission of the U.S. space shuttle program.
And next....?
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