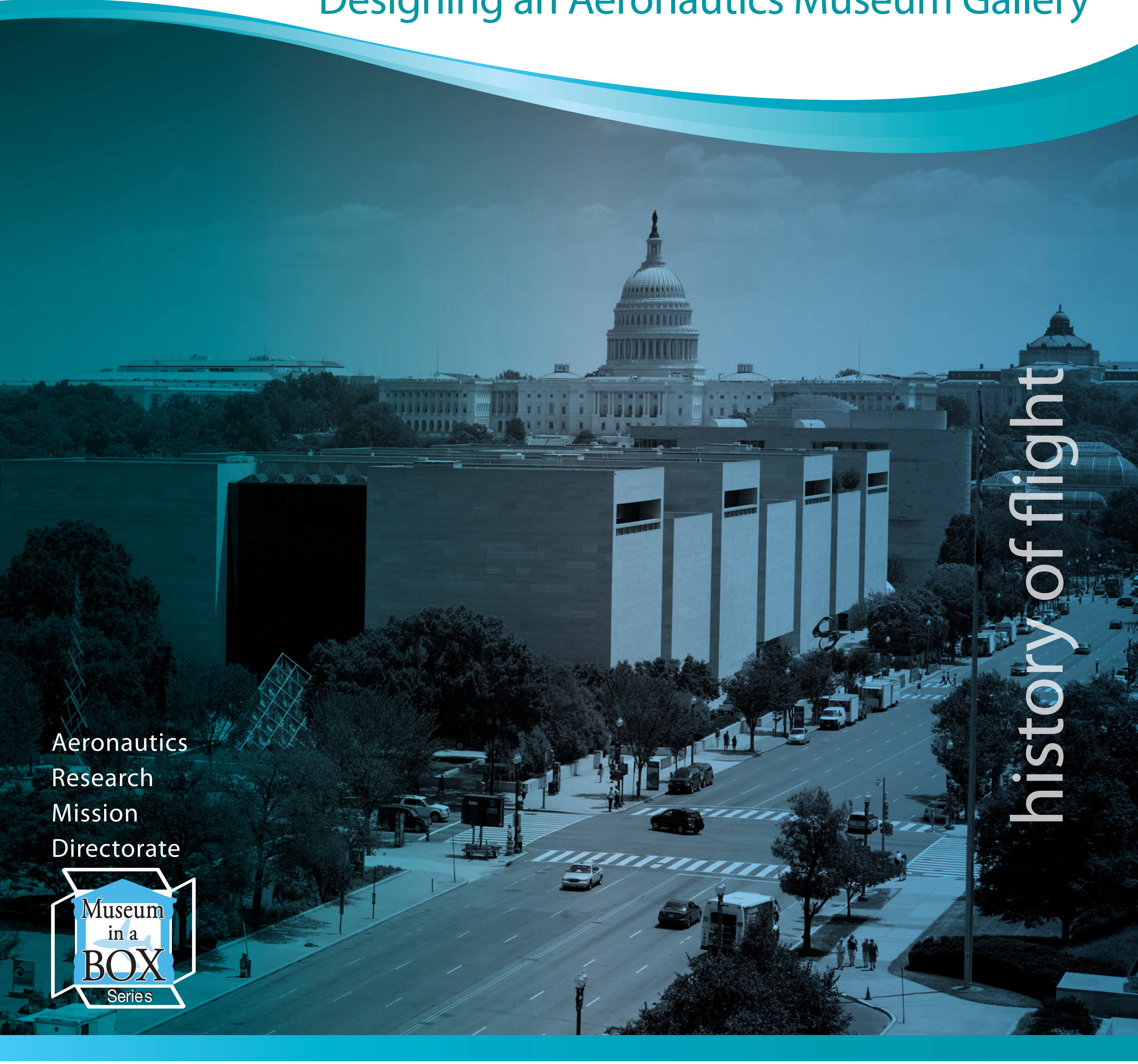
National Aeronautics and Space Administration

GRADES 5-12

Designing an Aeronautics Museum Gallery



history of flight

Aeronautics Research Mission Directorate

Museum in a BOX Series

www.nasa.gov

Designing an Aeronautics Museum Gallery

Lesson Overview

In this lesson, students will learn about science as human endeavor, the importance of aviation museums in telling the story of the history of flight, the history of science, historical perspectives, and the abilities of technological design through the story of the history of flight. In addition, students will gain an understanding of museum careers such as curator, exhibit staff member and museum educator through modeling those roles. Students will work in teams to design a museum gallery with a NASA aeronautics theme. Using graph paper, each team will lay out their gallery to scale with its artifacts and displays. Team members will create a map of their gallery that details the layout of the exhibits. Lastly, the teams will plan programs and activities that will enhance the visitor experience of their aviation gallery.

Objectives

Students will:

1. Comprehend the importance of aviation museums in telling the story of the history of flight.
2. Learn about museum careers.
3. Design an aeronautics museum gallery to scale using NASA's contributions to aeronautics as a theme.
4. Select appropriate artifacts and displays to include in the gallery.
5. Create a map that details the gallery.
6. Plan programs and activities to enhance the visitor experience to the gallery.

Materials:

In the Box

NASA's Contributions to Aviation PowerPoint presentation

Graph paper

Provided by User

Index cards

Scissors

Glue

Pencils/pens

Rulers

GRADES 5-12

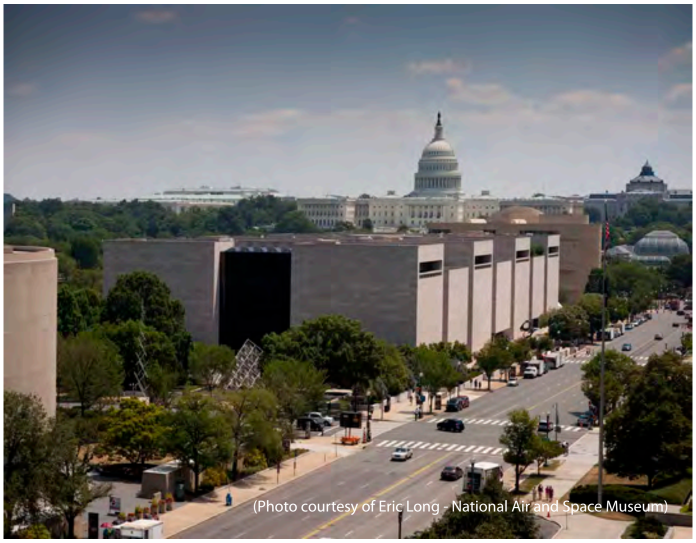
Time Requirements: 8 Hours

Background

Aeronautics Museums

Each year, millions of visitors of all ages visit informal educational institutions which include museums and science centers. Many of the museums have a specialty to showcase, for example, art or natural history. Aviation is no exception. In the United States, there are over 250 museums that focus on aviation. Visitors to these aviation museums can catch a glimpse of aviation history through varied artifacts and displays.

NASA realizes the importance of the informal education community in telling the NASA aeronautics story. Through educational partnerships with numerous informal community institutions, NASA provides artifacts as well as professional development opportunities for its members. The goal is to enhance the informal education community members' capabilities by providing access to NASA staff, research, technology and information.


(Photo courtesy of Eric Long - National Air and Space Museum)

Img. 1 National Air and Space Museum

The two museums in the United States with the largest collection of famous airplanes are 1) the National Air and Space Museum (NASM) in Washington D.C. along with its companion facility the Steven F. Udvar-Hazy Center near Washington Dulles International Airport, and 2) the National Museum of the United States Air Force (NMUSAF) in Dayton, Ohio.

The National Air and Space Museum has almost 9 million visitors each year. NASM's collection includes many of the most significant aircraft and spacecraft in our nation's history. There are over 30,000 aviation objects in the collection. In addition, NASM's archival collection contains numerous photographs, manuscripts, technical drawings, documents, films and oral histories.


(Photo courtesy of the National Museum of the United States Air Force)

Img. 2 National Museum of the United States Air Force

The National Museum of the United States Air Force is the oldest and largest military aviation museum in the world. The museum's collection includes more than 300 aircraft and missiles. Aviation history from the Wright brothers to the present can be seen during a visit. Over 1 million visitors a year visit the NMUSAF.

A museum must be organized in a way that programs and exhibits draw in visitors to educate and tell a compelling story. Museum organization, however, largely depends upon the size of the museum with the larger museums having a greater number of individuals with different roles and responsibilities. The following is a list of several key museum-related job titles that help a museum to operate smoothly. (The list does not include additional personnel whose roles are not unique museum's operations, i.e., the staff for the gift shop, food service, security, maintenance or technicians.)

Museum Jobs Important to the Creation of an Exhibit

Museum Director: The individual responsible for the overall operations of the museum. The director is often the spokesperson to the media and other community organizations. The director generally signs off on new exhibits.

Curator: A subject matter expert in the museum. He or she uses this specialized knowledge to incorporate the artifacts or collections in their museum to create exhibits or displays.

Exhibits Staff: Individuals who design and fabricate large exhibitions. The designers work closely with the curator and education staff at the museum to define and organize the content, develop the narrative, and then build the exhibit.

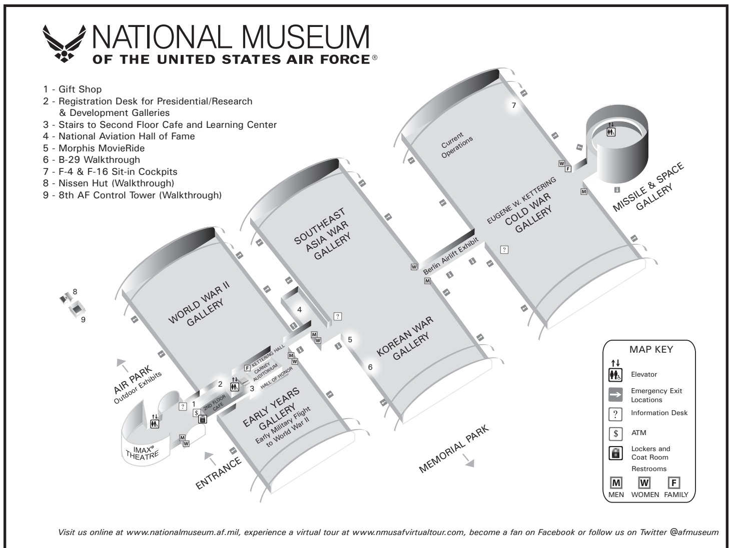
Museum Educator: A trained educator who uses his or her skills to create school programs, classes, tours, lectures, special events, etc. that focus on the exhibits, artifacts and displays in the museum. The museum educator works with the curator and exhibit designers to create visitor friendly exhibits.

Development and Membership Staff: Individuals who often meet with potential donors and write grants to help fund the operations of the museum. They also often oversee membership programs.

Volunteer Coordinator: Individual responsible for the training and recruitment of volunteers to assist the museum staff in various roles such as staffing the information desk or giving tours to students.

Marketing and Public Relations Staff: Individuals responsible for promoting the museum to the community. They serve as media liaisons to publicize museum programs, events and special exhibits. In addition, they are responsible for the museum's membership programs.

The exhibits and displays are included in galleries, which have specific themes. Note in the gallery map for the Museum of the United States Air Force each gallery has a theme. What is included in each gallery is limited by size of the gallery and what is in the collection. On occasion, a museum may borrow an artifact from another museum to use in the exhibit.



(Image courtesy of the National Museum of the United States Air Force)

Img. 3 Gallery Map National Museum of the USAF

Museums often conduct educational and special programs to highlight a gallery or the museum. Educational programs at a museum can include:

Educational Programs

Guided School Group Tours: Guided school group tours allow students to make meaningful connections to the museum's collection by having a specially trained docent, museum teacher; lead them on a guided tour through the museum. During the tour students often have the opportunity to ask questions, participate in discussions, and participate in "hands on" activities.

Self-Guided Tours: On a self-guided tour a visitor is provided a museum map or gallery guide that will enable the visitor to tour without an escort. Sometimes museums have audio tours available where you can listen to a recording at various spots throughout the museum.

Demonstrations: Demonstrations are conducted by museum staff to explain scientific principles or concepts that often relate to a specific gallery in the museum. Note Image4 of the "How Things Fly Exhibit" at the National Air and Space Museum. In this exhibit visitors engage in activities that demonstrate the principles of flight.

(Photo courtesy of Eric Long - National Air and Space Museum)

Img. 4 Photo of How Things Fly Exhibit at the National Air and Space Museum

Discovery Stations: Discovery stations at a museum are sites where visitors can do "hands on" activities on an informal basis with museum artifacts and other appropriate materials that relate to a certain theme.

Story Time: Story Time programs are more likely to be offered to pre-school children as well as students in the first through third grade. After a story, students are involved in "hands on" activities that relate to the story. Sometimes the students get to role play different parts of the story.

Special Programs

Special programs and activities at a museum can include many things. The following are a few examples:

Films: Some museums offer a film series related to the artifacts in the museum.

Presentations: Experts are invited to give presentations at a museum for members as well as guests.

Special Exhibit: A museum has permanent exhibits as well as special exhibits. A special exhibit stays at a museum for a short time. The exhibit might be an aircraft on loan from another museum or an artifact or exhibit from NASA.

Receptions: Receptions at a museum can be formal or informal. Sometimes when there is a special exhibit receptions are hosted for different groups. One group might be for members of the museum, while another might be for potential donors.

Family Days: During Family Days at a museum the entire family is involved all sorts of activities that might include building kites, learning about the physics of a baseball, watching movies, and of course eating.

Summer Camps: Summer camps, usually for 5 days, connect students to science and other subjects through fun-filled activities.

Activity 1

Designing an Aeronautics Museum Gallery

GRADES 5-12

Time Requirements: 8 Hours

Materials:

In the Box

"NASA's Contributions to Aviation" PowerPoint presentation

Graph Paper

Provided by User

Index cards

Scissors

Glue

Pencils/pens

Rulers

Worksheets

Design an Aeronautics Gallery (Worksheet 1)

Gallery Programs (Worksheet 2)

Aeronautics Gallery Guide (Worksheet 3)

Reference Materials

Figure 1

Figure 2

The First Century of Flight: NACA/NASA Contributions to Aeronautics

Objective:

Students will learn about science as a human endeavor, the history of science, and the abilities of technological design as they work in teams to design a gallery for an aviation museum based on the theme of NASA's contributions to aviation.

Activity Overview:

While working in teams, students will experience what it is like to design a museum gallery based on NASA's contributions to aeronautics. In addition, students will learn about different careers associated with working in a museum. Each team will create a scale model of their gallery. Once the teams have completed their scale model, they will prepare a gallery guide of the gallery they have designed. In addition, the teams will plan several educational activities or special programs for their gallery.

Activity:

1. **Introduction**
   a. Have a discussion with the students about what a museum is.
   Ask the students to describe any experiences they have had in visiting a museum. Emphasize that it is a place where artifacts of a historical, scientific, or artistic nature are displayed.
   b. Discuss the organization of a museum by highlighting the different roles of staff at the museum.
   (See list in Reference Materials.)
   c. Ask the students how museum objects are arranged in museums overall.
   They are usually located in different galleries with each gallery having a different theme.
   d. Inform the students that they are to work in teams to create a gallery with a NASA aeronautics theme.
   e. Divide the class into teams of 4-6 students.
   f. Distribute a copy of Figure 1 that depicts 20 of NASA's contributions to general aviation. Also, provide each team with a description of each of the contributions, found in the Reference Materials section.
   Suggestion: Ask each team to write down the name of every contribution they understand, and then circle their favorites. Report out to tell why they are their favorite. Be sure to discuss the ones the teams did not circle.

Key Terms:

Curator

Development and membership staff

Exhibits staff

Marketing and public relations staff

Museum artifact

Museum gallery

Museum director

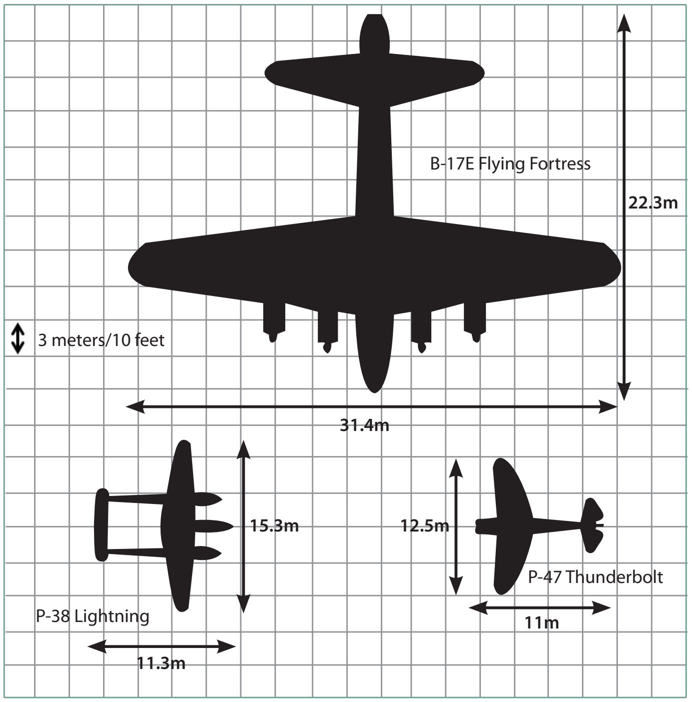
Museum educator

Volunteer coordinator

g. Show the PowerPoint, "NASA's Contributions to Aviation;" it can be downloaded from the MIB website: http://www.aeronautics.nasa.gov/mib.htm

h. If possible, download Richard Hallion's book, "NASA's Contributions to Aeronautics Vol 1 and Vol 2" for the students to use as a resource. *(See list in Reference Materials.)*

2. **Distribute graph paper to each team.** Inform the students that they are to use the graph paper to create a scale drawing of their gallery. The graph paper on Worksheet 3 can be duplicated and distributed for the scale drawing. For this activity the students will not include labeled exhibits. *Show students figure 2 and explain that this is a sample drawing of the beginnings of an aero gallery. This particular gallery is 61 meters (200 feet) by 61 meters (200 feet). It has a WWII theme and three aircraft have been placed in the gallery. The B-17E has a wing space of 31.4 meters (103 feet) and the plane is 22.3 meters (73 feet) long; the P-38 Lightning has a wingspan of 15.3 meters (52 feet) and a length of 11.3 meters (37 feet); the P-47 Thunderbolt has a wing span of 12.5 meters (41 feet) and is 11 meters (36 feet) long. Inform the students that they do not necessarily need to use silhouettes of any aircraft, or other artifacts they might put in their gallery. They can cut out squares, rectangles, triangles, or circles with appropriate dimensions using index cards to put on their graph paper. In the example, the B-17E would be 10.3 spaces wide and 7.3 spaces long. The students can write the name of the artifact or display on the index card.*



(Each square is 3 meters x 3 meters)

Fig. 2 Scale drawing of Aero Gallery

3. **Working as teams, the students are to use the Design an Aeronautics Gallery Worksheet to plan their gallery.** Walk the students through the worksheet highlighting each area. Ask the students if they have any questions.

4. **Using the information on the Design an Aeronautics Gallery Worksheet, the teams are to create a scale drawing of their gallery.** Remind the students they are to use the graph paper to create a scale drawing of their gallery.
Inform the students that besides the artifacts and displays they must consider such things as lighting in the gallery; whether they are going to hang any of the aircraft from the ceiling or have all of the aircraft on the floor. Remind the students that they also should consider in their gallery design if anything needs to be protected either in a display case or behind plexiglass. Lastly, have the students think about the type of floor they will have in their gallery--will your gallery floor support the weight of all of the artifacts and displays in the gallery? What kinds of "hands on" displays will they have for the visitors to interact with.

5. **Next the teams are to use the Gallery Programs Worksheet to plan educational programs or special events for the gallery.** When you get to this section ask the students what kinds of programs they have attended at a museum or science center. Have the class to offer ideas for different kinds of programs. Teams can use this information to plan their gallery programs.

6. **Lastly, each team creates a one-page gallery guide to highlight their gallery.** Use the Aeronautics Guide Worksheet and scale drawing to assist in the design of the team's gallery guide.
Ask the students to think about the kinds of information they would like to know about before visiting a museum gallery and use this information to help them plan their gallery guide. You may want each team to prepare a 2 slide power point that shows their museum guide with slide 1 being the front side of the guide and slide 2 the back side of the guide.

7. **Have an all teams meeting in which each team shares information about their galleries.** After all the teams have shown their gallery guides, ask them to compare and contrast all of the guides.

Discussion Points:

1. **Why are aviation museums a great resource for NASA to use to inform the public about their contributions to aeronautics?**
   Millions of visitors go to aviation museums each year. Museum staffs have a way of taking very technical information and making it understandable by the general public. NASA provides access to scientists and engineers who can provide guidance in the creation of very specific exhibits or displays. NASA also has a traveling exhibits program that institutions and museums can borrow to exhibit.

2. **Compare and contrast the advantages and disadvantages of learning science in a museum verses learning it in the classroom.**
   The advantage or disadvantage is often associated with the amount of time spent learning the subject. Museums often have classes or summer programs where students can participate for longer periods of time to gain a better understanding of science, technology, and/or the universe. Museums have resources that classrooms do not, such as exhibits, demonstrations, programs, and collections.

3. **Why is it important to develop an aeronautics or aviation gallery based on a theme?**
   A theme provides a focus for the gallery. A WWII gallery for example can have many aircraft from WWII on exhibit and have many displays to support the different artifacts.

4. **Why is it important to work as a team in the creation of a gallery?**
   No one person has all of the skills necessary to create a gallery. The curator has the subject matter expertise, while the exhibits staff can create the exhibits or displays to explain the science or technology. The education staff can develop special programs for students or teachers where they can learn the subject first hand.

5. **What was the most difficult task for your team in order to design your gallery?**
   The responses to this question will vary with the students. However, one of the most difficult tasks for the students to do is to decide what to put in the gallery since they are not subject matter experts. Also, students have a tendency to want to put too much in the gallery space.

6. **Why is it important to have educational programs and special activities to compliment the artifacts and displays in an aeronautics gallery?**
   They generate more interest and they help to keep visitors coming back to the museum and galleries.

7. **What were each team's cost estimates to construct and operate their gallery?**
   Answers will vary for each of the teams.

8. **In addition to admissions, what are some of the ways that museums seek additional funding?**
   Some examples that museums use to acquire additional funds is , for example, they seek out private donors, have membership programs, seek grants, host special events, and form partnerships.

9. **Would you like to work in a museum?**
   Responses will vary with students.

NATIONAL SCIENCE STANDARDS 9-12

SCIENCE AS INQUIRY

- Abilities necessary to do scientific inquiry
- Understanding about scientific inquiry

SCIENCE AND TECHNOLOGY

- Abilities of technological design
- Understanding about science and technology

HISTORY AND SCIENCE OF NATURE

- Science as a human endeavor
- Nature of scientific knowledge
- Historical perspectives

NATIONAL MATH STANDARDS 9-12

NUMBERS AND OPERATIONS

- Understand numbers, ways of representing numbers, relationships among numbers, and number systems
- Understand meanings of operations and how they relate to one another
- Compute fluently and make reasonable estimates

MEASUREMENT

- Understand measurable attributes of objects and the units, systems, and processes of measurements
- Apply appropriate techniques, tools, and formulas to determine measurements

PROCESS

- Problem solving
- Communication
- Connections
- Representation

Reference Materials

Glossary

Airbag Systems:
In the 1950s, NASA explored a variety of crew protection systems including airbags. They were later adapted to protect robotic spacecraft during landings. They have now been further tested by NASA and adapted for use as an airbag system on passenger aircraft (as seen on the ATI RT-700, a twin-engine business aircraft).

Airborne Wind Shear Detection:
During the 1980s and 1990s, NASA led a comprehensive research program to identify the characteristics of dangerous wind shear, and validated technologies that can predict its severity while in flight. Today, aircraft are equipped with forward-looking sensors that alert pilots to wind shear hazards.

Area Rule:
In the 1950s, NASA scientist, Richard Whitcomb, discovered several fundamental solutions to key aerodynamics challenges. One of the most revolutionary solutions was the "area rule," a concept that helped aircraft designers avoid the disruption in air flow and resulting drag caused by the attachment of the wings to the fuselage. For decades, aircraft designers have been able to make aircraft fly more efficiently at high speeds by using the area rule.

Artifact:
Pertains to the things in the museum created by humankind whether it be an aircraft or an important document.

Aviation Museum:
This type of museum uses displays and artifacts to highlight the history of aviation.

Composite Structures:
NASA first partnered with industry during the 1970s to conduct research on how to develop high-strength, nonmetallic materials that could replace heavier metals on aircraft. Gradually, composite structures were used to replace metals on parts of aircraft tails, wings, engines, cowlings and parts of the fuselage. Composites reduce overall aircraft weight and improve operational efficiency.

Computational Fluid Dynamics (CFD):
Starting in the 1970s, NASA began developing sophisticated computer codes that accurately could predict the flow of fluids, such as the flow of air over an aircraft's wing or fuel through a space shuttle's main engine. Those ideas and codes became CFD, which today is considered a vital tool for the study of fluid dynamics and the development of new aircraft. CFD greatly reduces the time and cost required for designing and testing nearly any type of aircraft.

Curator:
Museums have subject matter experts also called curators. They use their specialized knowledge to take the artifacts or collections in their museum to create exhibits or displays.

Deicing Systems :
As early as the 1940s through NASA's predecessor, the National Advisory Committee on Aeronautics, or NACA, research on the causes and prevention of icing on the ground or in the air has been a focus. Using icing research tunnels, wind tunnels and flight tests, NASA research has contributed to the development of icing protection systems and operational methods for icing conditions.

Development and Membership staff:
Individual(s) in the museum who often meet with potential donors and write grants to raise funds to help fund the operations of the museum. They also often oversee membership programs.

Digital Fly-By-Wire:
During the 1960s and 1970s, NASA helped develop and flight test a digital "fly-by-wire" (DFBW) system to replace heavier, less reliable hydraulics systems and control linkages with a lighter system using a digital computer and electric wires. The system sends signals from the pilot to the control surfaces of the aircraft, adding redundancy and improving control. DFBW is used today on the Gulfstream G350/G450.

Exhibits staff:
Individuals who design and fabricate large exhibitions. The designers work closely with the curator and education staff at the museum to define and organize the content, develop the narrative, and then build the exhibit.

Glass Cockpit:
During the 1970s and 1980s, NASA created and tested the concept of an advanced cockpit configuration that replaced dial and gauge instruments with flat panel digital displays. The digital displays presented information more efficiently and provided the flight crew with a more integrated, easily understood picture of the vehicle situation. Glass cockpits are in use on general aviation, commercial and military aircraft, and on NASA's space shuttle fleet.

Highway-in-the-Sky (HITS):
During the 1990s, a NASA research program contributed to the development of advanced electronic displays that deliver point-to-point, on-demand communication, navigation and weather data to pilots. The system was commonly referred to as a "highway-in-the-sky".

Lightning Protection Standards:
During the 1970s and 1980s, NASA conducted extensive research and flight tests to identify the conditions that cause lightning strikes and the effects of in-flight strikes on aircraft. NASA's knowledge base was used to improve lightning protection standards for aircraft electrical and avionics systems.

Marketing and Public Relations staff:
Individuals who are responsible for promoting the museum to the community. They work with the media to provide stories for newspapers, television or radio. In addition, they are responsible for the museums membership programs.

Museum Director:
This individual is responsible for the overall operations of the museum. The director interfaces with their museum boards and are often the spokesperson to the media and other community organizations. The museum director generally signs off on new exhibits.

Museum Educator:
This person is a trained educator who uses his or her skills to create school programs, classes, tours, lectures, special events, etc., focusing on the exhibits, artifacts, and displays in the museum. The museum educator works with the curators and exhibit designers to make the exhibits more "visitor" friendly.

Museum Gallery:
A room or area in a museum that exhibits artifacts or displays.

NASA Structural Analysis (NASTRAN):
In the 1960s, NASA partnered with industry to develop a common generic software program that engineers could use to model and analyze different aerospace structures, including any kind of spacecraft or aircraft. Today, NASTRAN is an "industry-standard" tool for computer-aided engineering of all types of structures.

Natural Laminar Flow (NLF) Airfoil:
From the 1970s to the 2000s, NASA researchers have worked to develop airfoil (wing) designs that allow smooth air flow for maximum lift and minimum drag at low and medium cruise speeds. The application of NLF techniques has helped reduce fuel consumption and landing speeds, and increase aircraft speed and range.

Quiet Jets:
During the 1990s and 2000s, tests were conducted in NASA flight research facilities to validate technologies to dramatically reduce the level of noise generated by turbofan engines typically used on small business jets.

Real-Time Graphical Weather:
During the 1990s and 2000s, NASA research drove the development of cockpit displays that provide real-time ground or in-flight weather information to the flight crew. Since not all small aircraft can fly "above the weather," the data is of particular help to pilots in avoiding weather related accidents.

Small Aircraft Transportation System (SATS):
During the first few years of the 21st century, NASA and the FAA partnered on a project targeting technologies that could increase small aircraft travel between small airports. There are many more small airports in the United States than traditional airports, but they can be under-utilized due to lack of control towers or radar. Ultimately, the SATS project enabled the application of beneficial technologies to help overcome that challenge, including Synthetic Vision Systems and Highway-in-the-Sky.

Stall/Spin Research:
From the 1960s through the 1990s, NASA wind tunnels, flight tests, and a special facility constructed to study aircraft stall and spin characteristics were used to identify the causes of small aircraft stalls and spins and ways to recover from them. NASA research led to solutions for general aviation aircraft including spin resistant wings and leading-edge devices for unswept wings.

Supercritical Airfoil :
During the 1960s and 1970s, NASA scientist Richard Whitcomb led a team of researchers to develop and test a series of unique geometric shapes of airfoils or wing sections that could be applied to subsonic transports to improve lift and reduce drag. The resulting "supercritical airfoil" shape, when integrated with the aircraft wing, significantly improves the aircraft's cruise efficiency.

Synthetic Vision Systems (SVS):
From the 1970s to the 2000s, NASA researchers developed and flight tested a class of computer database-derived systems that include head-up displays and other new pictorial format avionics that can aid pilots in low visibility conditions. The most recent design concepts for SVS can create three-dimensional pictures of the world outside the aircraft, day or night, using GPS, terrain models, sensors and a runway incursion warning system.

TURBO-AE Code:

During the 1990s, NASA developed a computer code that generates two-dimensional simulations of potential aeroelastic (AE) problems that can occur in jet engine blades. Such problems include flutter or fatigue that can eventually cause engine fan blades to stall or fail. With TURBO-AE, engineers can more efficiently design thinner, lighter, faster rotating blades for today's jet engines built for higher performance, lower emissions and lower noise.

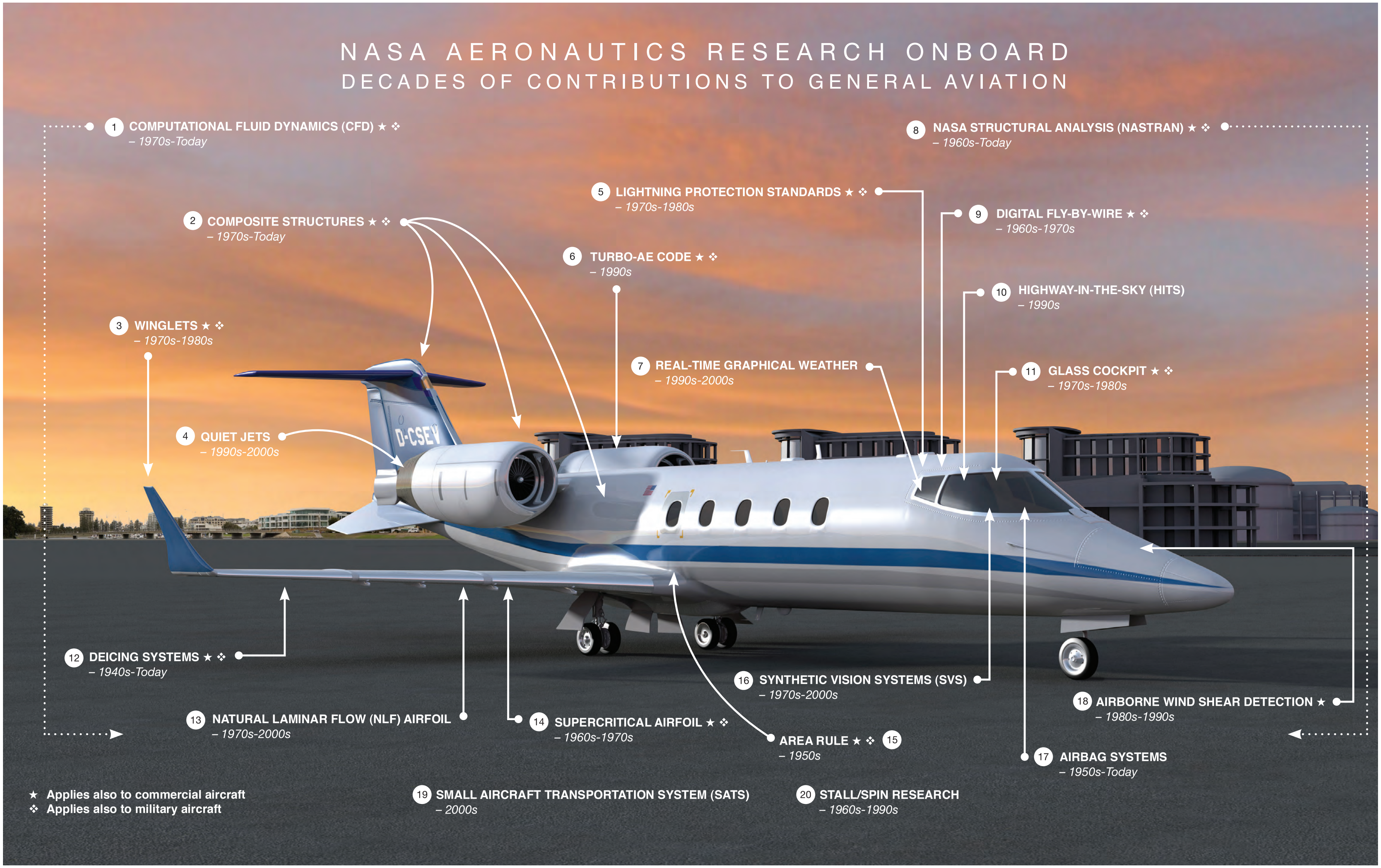
Volunteer Coordinator:

This individual is responsible for the training and recruitment of volunteers to assist the museum staff in various roles such as staffing the information desk or giving tours to students.

Winglets:

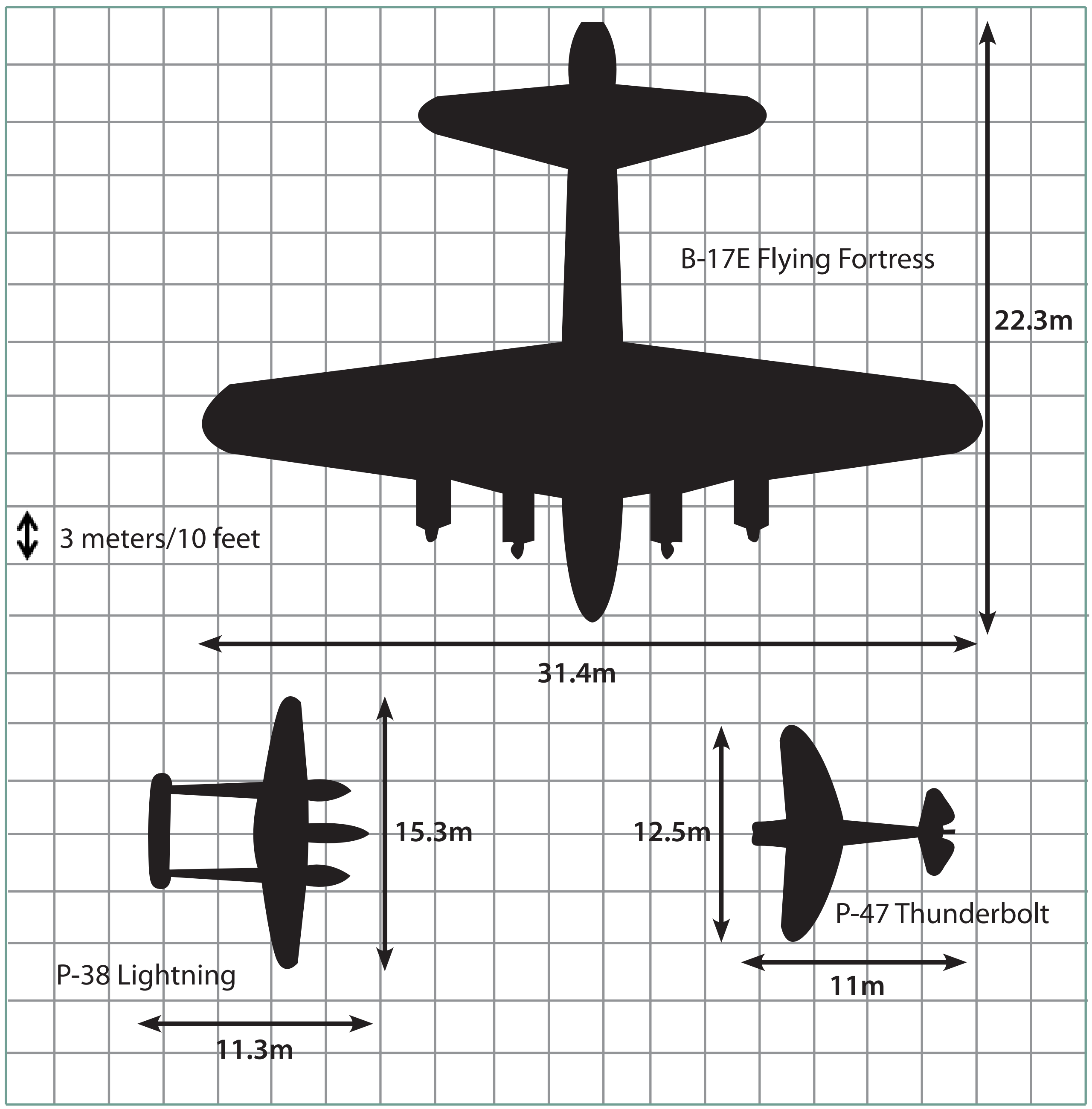
During the 1970s and 1980s, NASA studies led to the development of vertical extensions that can be attached to wing tips in order to reduce aerodynamic drag without having to increase wing span. Winglets help increase an aircraft's range and decrease fuel consumption.

Fig. 1 Decades of Contributions by NASA to General Aviation



(Diagram courtesy of NASA)

Fig. 2 Scale drawing of Aero Gallery



(Each square is 3 meters x 3 meters)

1957

The National Advisory Committee for Aeronautics (NACA), founded in 1915, was soon to become the core of a new federal agency that took NACA's mandate to "direct and conduct research and experimentation in aeronautics, with a view to their practical solution" and expanded it to the realm of space.

October 4, 1957
The Soviet Union launched Sputnik I, the first artificial satellite to orbit Earth.

1958

January 31, 1958
Explorer 1 became the first satellite launched by the United States.

March 17, 1958
The Vanguard I satellite was successfully launched into Earth orbit.

October 1, 1958
The National Aeronautics and Space Administration (NASA) was formed. The 1958 Space Act established NASA as the organization responsible for both aeronautics and astronautics.

November 6, 1958
Last flight of the Bell X-1E, the last of the X-1 series of aircraft. The X-1 was the first aircraft to exceed the speed of sound.

1959

X-15 Program *1959–1969:* ***A revolutionary aircraft, the X-15's 199 test flights uncoverec space program such as high-temperature materials, reaction control systems, and full-pres***

June 8, 1959
First flight of the hypersonic X-15, a planned glide flight to 522 mph piloted by A. Scott Crossfield.

February 17, 1959
The United States launched Vanguard 2, an International Geophysical Year scientific satellite, from Cape Canaveral, FL. Vanguard produced the first photos of Earth from space.

March 3, 1959
The United States sent Pioneer 4 to the moon, successfully making the first U.S. lunar flyby.

1960

March 25, 1960
First NASA X-15 research flight by pilot Joseph A. Walker.

April 1, 1960
The United States launched TIROS 1, the first successful meteorological satellite, for monitoring Earth's weather.

August 12, 1960
NASA successfully orbited Echo 1, a 100-foot inflatable, passive communications satellite.

1961

March 7, 1961
First Mach 4 flight by pilot Robert M. White.

June 23, 1961
First Mach 5 flight by pilot Robert M. White.

November 9, 1961
First Mach 6 flight by pilot Robert M. White.

May 5, 1961
Alan Shepard became the first American to fly in space on the *Freedom 7* suborbital flight from Cape Canaveral, FL.

May 25, 1961
President John F. Kennedy committed the United States and NASA to landing on the moon by the end of the decade.

Panoramic runway photo by: Tom Bozak

	1958	1959	1960	1961
U.S. President	Dwight D. Eisenhower January 20, 1953 – January 19, 1961			John F. Kennedy January 20, 1961 – November 22, 1963
NASA Administrator	Dr. T. Keith Glennan August 19, 1958 – January 20, 1961			James E. Webb February 14, 1961 – October 7, 1968
Price of Gas	$0.30	$0.31	$0.31	$0.31
Collier Trophy	USAF and the industry team of Lockheed and General Electric for development of the F-104	USAF and the Convair Div. of General Dynamics for creation and operation of the Atlas ICBM	Vice Adm. William F Raborn for directing creation of the Polaris fleet ballistic missile system	X-15 test pilots for invaluable technological contributions to the advancement of flight
Sports Illustrated Sportsperson of the Year	Rafer Johnson	Ingemar Johansson	Arnold Palmer	Jerry Lucas
Time Magazine Person of the Year	Charles de Gaulle	Dwight Eisenhower	U.S. Scientists	John F. Kennedy
Academy Award for Best Picture	Gigi	Ben-Hur	The Apartment	West Side Story

NASA AERO

1962	1963	1964	1965	1966

d many "first's" in high-speed, high-altitude research that were also later used in the sure pilot suits.

June 27, 1962
Pilot Joseph A. Walker flew the X-15 to an unofficial world speed record of 4,104 mph.

July 17, 1962
Pilot Robert M. White set a Fédération Aéronautique Internationale world altitude record of 314,750 ft.

August 22, 1963
Highest X-15 flight (unofficial), 354,200 ft (67+ miles) by Joseph A. Walker.

June 25, 1964
First flight of the X-15A-2.

Runway Grooves
1962–1987 (approx.)
NASA developed a process for cutting transverse grooves into runways to help aircraft land safely on wet pavement. The process was adapted to U.S. highways and other types of wet surfaces.

Lifting Body Vehicles Research Program
1963–1976: *The program demonstrated the low speed entry and landing characteristics of vehicles that use body shape, rather than wings, to generate lift.*

March 1, 1963
M2-F1, first flight (ground tow)

August 16, 1963
M2-F1, first air tow

October 21, 1965
M2-F1, last captive flight

July 12, 1966
NASA's Milt Thompson made the first flight of the M2-F2, a heavyweight lifting body vehicle designed to demonstrate the handling characteristics of a spacecraft capable of landing on a runway.

August 16, 1966
M2-F1, last flight (air tow)

December 22, 1966
NASA's Bruce A. Peterson piloted the HL-10 lifting body on its first glide flight.

February 20, 1962
John Glenn became the first American to orbit Earth, making three orbits in his *Friendship 7* Mercury spacecraft.

October 30, 1964
The first flight of the Lunar Landing Research Vehicle, the forerunner of the Lunar Lander that was used to train the astronauts for flying the Lunar Excursion Module, was flown at NASA Dryden by Joe Walker.

June 3, 1965
The second piloted Gemini mission, Gemini IV, stayed aloft for four days, and astronaut Ed White performed the first spacewalk by an American.

December 15, 1965
First rendezvous in space between Gemini 6-A and Gemini 7 for five hours of station-keeping.

Lyndon B. Johnson
November 22, 1963 – January 19, 1969

1962	1963	1964	1965	1966
$0.31	$0.30	$0.30	$0.31	$0.32
The seven Mercury astronauts for pioneering manned American spaceflight	Clarence "Kelly" Johnson for designing and directing development of the Mach 3 Lockheed A-11	Gen. Curtis LeMay for great achievements with respect to air vehicles and national defense	The Gemini Program teams for significantly advancing the human spaceflight experience	James McDonnell for leadership and perseverance in advancing aeronautics and astronautics
Terry Baker	Pete Rozelle	Ken Venturi	Sandy Koufax	Jim Ryun
Pope John XXIII	Martin Luther King, Jr.	Lyndon B. Johnson	William Westmoreland	The Generation Twenty-Five & Under
Lawrence of Arabia	Tom Jones	My Fair Lady	The Sound of Music	A Man for All Seasons

NAUTICS: SOLVING DECADES

1967

October 3, 1967
An unofficial world speed record of Mach 6.7 (4,520 mph) was reached in a modified version of the X-15 by research pilot William "Pete" Knight.

May 10, 1967
M2-F2, last flight

January 27, 1967
During a simulation aboard an Apollo command module on the launch pad at Kennedy Space Center, a flash fire broke out, engulfing the capsule in flames. The three astronauts aboard—Gus Grissom, Ed White, and Roger Chaffee—died of asphyxiation.

1968

October 24, 1968
NASA pilot William H. Dana ended an era by flying the final flight in the X-15 flight research program.

Runway Grooves
1968–1972
NASA teamed with the U.S. Air Force and FAA to conduct the first tests of pavement grooving using an F-4 fighter, a Convair 990 jet transport, and a Beech Queen Air twin-propeller aircraft.

October 23, 1968
First rocket-powered flight of the HL-10, flown by Air Force Major Jerauld R. Gentry.

December 21, 1968
Apollo 8 launched atop the Saturn V booster from Kennedy Space Center with three astronauts aboard–Frank Borman, James A. Lovell, Jr., and William A. Anders. On Christmas Eve, the crew read from the book of Genesis.

1969

Wake Vortex Research
1969-1980
NASA conducted research and test flights on the dangerous wakes of turbulent air that trail behind every aircraft (wing-tip vortices). Resulting data helped the Federal Aviation Administration (FAA) establish safe separation distances between aircraft during takeoffs, landings and cruise flight.

April 17, 1969
First X-24A glide flight, by pilot Jerauld R. Gentry.

May 9, 1969
NASA pilot John A. Manke made the first supersonic flight of a wingless lifting body when he reached a top speed of 744 mph.

July 20, 1969
Apollo 11 became the first mission to land people on the moon. Astronauts Neil Armstrong and Buzz Aldrin walked on its surface while Michael Collins orbited overhead in the Apollo command module.

1970

March 3, 1970
NASA researchers began flight tests of the triplesonic YF-12 aircraft to investigate the effects of sustained high-speed flight.

February 18, 1970
First max speed of 1,228 mph on the HL-10

February 27, 1970
First max altitude of 90,303 ft. on the HL-10

June 2, 1970
First M2-F3 glide flight

July 17, 1970
HL-10, last flight

November 25, 1970
First M2-F3 powered flight

April 11-17, 1970
Fifty-six hours into the flight of Apollo 13, the oxygen tank in the service module ruptured and damaged several of the power, electrical, and life support systems. All crew members returned safely to Earth.

1971

March 9, 1971
NASA research pilot Thomas McMurtry completed the first flight of an F-8A modified with a new wing called the supercritical airfoil. Work on the airfoil design concept began in the 1960s under NASA chief scientist Richard Whitcomb.

June 4, 1971
X-24A, last flight

August 25, 1971
First M2-F3 supersonic flight

July 26, 1971
Apollo 15 made the first use of a Lunar Roving Vehicle on the moon.

Richard M. Nixon
January 20, 1969 – August 9, 1974

Dr. Thomas O. Paine
March 21, 1969 – September 15, 1970

Dr. James C. Fletcher
April 27, 1971 – May 1, 1977

1967	1968	1969	1970	1971
$0.33	$0.34	$0.35	$0.36	$0.36
Hughes Aircraft Surveyor Program team and the Jet Propulsion Lab for aiding lunar exploration	The Apollo 8 crew for flawless execution of the first manned lunar orbit	Neil Armstrong, Edwin "Buzz" Aldrin and Michael Collins for the epic flight of Apollo 11	Boeing, Pratt & Whitney and Pan American Airways for pioneering the Boeing 747	The Apollo 15 crew and NASA's Robert Gilruth for most ambitious science lunar mission
Carl Yastrzemski	Bill Russell	Tom Seaver	Bobby Orr	Lee Trevino
Lyndon B. Johnson	The Apollo 8 Astronauts	The Middle Americans	Willy Brandt	Richard Nixon
In the Heat of the Night	Oliver!	Midnight Cowboy	Patton	The French Connection

1972	1973	1974	1975	1976

April 1972
NASA published fundamental papers introducing the concept of 4-dimensional trajectories (three spatial dimensions plus time), which today are a basis for air traffic guidance in the NextGen.

Advanced Turboprop Proj

The Aircraft Energy Effici

Advanced Supersonic Technology (AST)/Supersonic Cruise Research (SCR) Project *1972–1982:* ***This research effort tackled the technical and environmental challenges of making a viable, advanced commercial supersonic transport. The program resulted in technology of value to the subsonic transport industry such as new aerodynamic design modeling tools.***

Quiet Short-Haul Research Aircraft (QSRA) Project *1974-1981:* ***Developed and demonstrated technologies necessary to support short-takeoff and landing and high-lift cargo aircraft. These technologies were employed on the C-17 Globemaster III.***

November 1, 1973
First flight of supercritical wing on F-III variable sweep wing aircraft.

May 25, 1972
NASA research pilot Gary Krier flew an F-8C modified with an all-electric, digital fly-by-wire (DFBW) control system, a prototype of the flight control system used today on some aircraft and on the space shuttle.

June 7, 1974
First flight of the NASA Boeing 737 Transport Systems Research Vehicle, which conducted thousands of flight hours of research for more than 20 different projects from wind shear detection to noise studies to runway friction.

Energy Efficient Engines
aircraft engines in service at

XV-15 Tilt Rotor

October 22, 1976
After decades of research and wind tunnel testing into technologies to make vertical takeoff and landing (VTOL) possible, NASA and Bell Aircraft rolled out the experimental XV-15 tilt rotor aircraft. Successful flights of the XV-15 led to Department of Defense approval in 1986 to produce the V-22 Osprey.

December 20, 1972
M2-F3, last flight

August 1, 1973
First X-24B glide flight

November 15, 1973
First X-24B powered flight

March 5, 1974
First X-24B supersonic flight

October 25, 1974
Fastest lifting body flight (Mach 1.76, 1164 mph) in an X-24B

November 26, 1975
X-24B, last flight for the Lifting Body Vehicles Research Program

December 7-19, 1972
Apollo 17 was the last of the six Apollo missions to the moon. The astronaut crew included Eugene A. Cernan, Ronald A. Evans and Dr. Harrison H. Jack Schmitt, a geologist.

May 14, 1973
Skylab, an orbital space platform, was launched. Skylab became home to three crews during 1973–74 for periods of 28, 59 and 84 days.

July 15–24, 1975
At the height of the Cold War, the Apollo-Soyuz Test Project became the first joint international human space flight effort.

August 20, 1975
Viking 1 was launched from Kennedy Space Center toward Mars. It landed on the red planet on July 20, 1976.

Gerald R. Ford
August 9, 1974 – January 19, 1977

$0.36	$0.39	$0.53	$0.57	$0.61
The personnel of the 7th and 8th Air Forces and Task Force 77 during Operation Linebacker II	NASA's Skylab Program, with recognition to director William Schneider and its three astronaut crews	John Clark (NASA) and Daniel Fink for the Earth Resources Technology Satellite Program (LANDSAT)	General Dynamics and the USAF F-16 team for advancements leading to effective fighter aircraft	USAF, the B-1 Industry Team and Rockwell Intl. Corp. for B-1 bomber design and development
Billie Jean King / John Wooden	Jackie Stewart	Muhammad Ali	Pete Rose	Chris Evert
Henry Kissinger / Richard Nixon	John Sirica	King Faisal	American Women	Jimmy Carter
The Godfather	The Sting	The Godfather Part II	One Flew Over the Cuckoo's Nest	Rocky

1977	1978	1979	1980	1981

…ect 1976-1987: *After the energy crisis of the early '70s, NASA initiated research into a unique "swirled" design for propellers used on propeller-powered …*

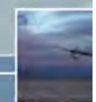
…iency (ACEE) Program 1975–1986: *This program stimulated wide application of lighter and more durable composite materials to secondary and primar…*

Storm Hazards Program *1978–1986: This program conducted extensive research and flight tests to identify conditions … Results informed new design guidelines used in aircraft and flight operations to protect critical digital systems.*

(STOL),

July 6, 1978
First flight of QSRA at Boeing Field, Seattle, WA.

July 10, 1980
QSRA began sea carrier trials on the USS Kitty Hawk without catapult launch or landing arresting gear.



Forward Swept Wing Res… *forward swept wing technolo… controls, and canard effects.*

Project 1976–1984: *Managed at NASA's Glenn Research Center, this project proved that a 15 percent reduction in fuel consumption could be made rela… the time. Research enabled industry's development of the more fuel-efficient high-bypass GE90 turbofan jet engine, which powers the intercontinental Boe…*

Highly Maneuverable Aircraft Technology (HIMAT) 1979–1983: *HiMAT was installe… vehicle to validate use on future fighter aircraft. HiMAT's extensive use of composites, wing…*

July 27, 1979
The HiMAT remotely piloted vehicle completed its first flight.

May 3, 1977
First hover and low-speed flight of the XV-15.

July 24, 1979
First full in-flight conversion from helicopter-to-airplane mode with the XV-15.

Oblique Wing Program 1979–1982: *The wing of this unique research aircraft could be… the fuselage to decrease drag and increase speed and range. The AD-1 was flown 79 times… concept and collect data on handling qualities.*

December 21, 1979
First flight of the AD-1

August 12, 1977
First free flight of Enterprise

September 28, 1978
Last NASA YF-12 research flight before returning aircraft to U.S. Air Force.

July 24, 1979
Research pilot Thomas McMurty flew a KC-135A Stratotanker jet outfitted with winglets, proving that the vertical tips on the ends of the wings reduced drag and improved the aircraft's range.

June 12, 1981
First operational flight of the Lockheed ER-2 high-altitude aircraft used for atmospheric research, observation and mapping missions.

April 12, 1981
Astronauts John W. Young and Robert L. Crippen flew Space Shuttle *Columbia* on the first flight of the Space Transportation System (STS-1).

Jimmy Carter
January 20, 1977 – January 19,1981

Ronald Reagan
January 20, 1981 – January 19, 1989

Dr. Robert A. Frosch
June 21, 1977 – January 20, 1981

James M. Begg…
July 10, 1981 –

1977	1978	1979	1980	1981
$0.67	$0.63	$0.90	$1.25	$1.38
Gen. Robert Dixon and the USAF TAC for developing and implementing flight-training programs	Williams Research Corp. for concept and development of a turbofan to power cruise missiles	Paul MacCready and pilot Bryan Allen for design, construction and flight of the Gossamer Condor	NASA's Voyager Mission team for a spectacular fly-by of and return from Saturn	NASA, Rockwell, Martin Marietta, Thiokol and the Space Shuttle *Columbia* crew
Steve Cauthen	Jack Nicklaus	Terry Bradshaw / Willie Stargell	U.S. Olympic Hockey Team	Sugar Ray Leonard
Anwar Sadat	Deng Xiaoping	Ayatollah Khomeini	Ronald Reagan	Lech Walesa
Annie Hall	The Deer Hunter	Kramer vs. Kramer	Ordinary People	Chariots of Fire

1982	1983	1984	1985	1986

aircraft to reduce noise and increase fuel efficiency.

Advanced Turboprop Project ***1976-1987***

y structures on civil aircraft.

The Aircraft Energy Efficiency Program ***1975–1986***

that cause lightning strikes.

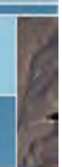
Storm Hazards Program ***1978–1986***

Center/TRACON Automa
1986-1990: *NASA foundati*
optimization led to developm
tools to improve traffic flow a

earch 1981-1990: *The X-29 test vehicle demonstrated*
gy and provided data on aeroelastic tailoring, active

December 14, 1984
The X-29 took its first test flight.

Forward Swept Wing Research ***1981-1990***



tive to the best commercial
ing 777.

Airborne Wind Shear Det
onboard sensor system that c

d for the first time on an unpiloted subscale flight test
lets and canards was adapted for other aircraft.

May 11, 1982
First supersonic flight of HiMAT, Aircraft Number 1.

January 11, 1983
Last of 26 flights made of the HiMat test vehicle.

December 6, 1983
Ribbon-cutting ceremonies were held for the new National Transonic Facility (NTF), the first NASA wind tunnel equipped for scale model testing in actual flight conditions.

1984
Riblets, or small V-shaped grooves, were discovered to reduce aerodynamic drag. This technology has been used on many aircraft and sailing vessels.

Mission Adaptive Wing (MAW) ***1985–1989:*** *The MAW,*
could be adjusted in-flight using an internal mechanism to a
sonic speeds. It was tested by NASA and the U.S. Air Force t

October 18, 1985
The MAW was first tested on an F-111.

pivoted up to 60 degrees to
to evaluate the pivot-wing

August 7, 1982
AD-1, last flight

Laminar Flow Control Pro

X-30 National AeroSpace

April 4-9, 1983
On STS-6, F. Story Musgrave and Donald H. Peterson conducted the first shuttle spacewalk to test new spacesuits and work in the cargo bay.

June 18-24, 1983
Sally K. Ride became the first American woman to fly in space when STS-7 lifted off on June 18, 1983, another early milestone of the shuttle program.

December 1, 1984
NASA and the FAA conducted the Controlled Impact Demonstration using a remotely-controlled Boeing 720 aircraft to test an anti-misting fuel for suppressing post-crash fire.

January 28, 1986
During the 25th launch of the space shuttle, an explosion occurred 73 seconds into the flight of Space Shuttle *Challenger*. All seven crew members died.

1982	1983	1984	1985	1986
			Ronald Reagan January 20, 1981 – January 19, 1989	
s December 4, 1985			James M. Beggs July 10, 1981– December 4, 1985	Dr. James C. Fletcher May 12, 1986 – April 8, 1
$1.30	$1.24	$1.21	$1.20	$0.93
T. A. Wilson and Boeing Co. for development of the 757 and 767 airliners	The Army and Hughes Helicopters Inc. for development of AH-64A Apache helicopter weapons	NASA and Martin Marietta for development of manned maneuvering units to rescue satellites	Russell Meyer and Cessna Aircraft for the outstanding safety record of the Citation fleet	Jeana Yeager, Richard Rutan, Elbert Rutan, Bruce Evans and associates for the Voyager aircraft
Wayne Gretzky	Mary Decker	Ed Moses / Mary Lou Retton	Kareem Abdul-Jabbar	Joe Paterno
The Computer	Ronald Reagan / Yuri Andropov	Peter Ueberroth	Deng Xiaoping	Corazon Aquino
Gandhi	Terms of Endearment	Amadeus	Out of Africa	Platoon

1987	1988	1989	1990	1991

Propulsion Controlled Aircraft (PCA) 1989-1998
NASA developed a computer-assisted engine control system to allow pilots to land aircraft even after losing primary flight controls. By adjusting the thrust from each engine to go up, down, left or right, engines-only landings were flown on NASA research aircraft and on actual transport aircraft.

High Speed Research (HSR) Program ***1990-1999:*** *Int… on the three key challenges to a High-Speed Civil Transport (…*

…tion System (CTAS) *…onal papers on trajectory …ent of a system of software …nd fuel efficiency.*

July 13, 1988
NASA researchers convinced FAA to approve access to live radar data.

April 1990
"CTAS" became the official name and the system began using live data from FAA air traffic control centers.

December 8, 1988
X-29-1 completed its flight research program with flight number 242.

Advanced Composite Technology Program ***1988–1997:*** *This research program focused on how to use textile comp… for commercial or military aircraft. A key ACT contribution was the validation of braided or stitched composite structures a…*

…ection Program ***1986–1993:*** *This program developed the first …can give pilots advance warning of dangerous wind shear conditions.*

1991-1992
NASA flew 130 flights through dan… forward-looking Doppler radar.

…built by the Boeing Company, had a flexible outer skin that …ttain ideal aerodynamic shapes for subsonic through super- …hrough the Advanced Fighter Technology Integration program.

…ject ***1986–1994:*** *Research on active flow control over all speed regimes was developed to produce laminar flow over 65 percent of the wing of the aircra…*

…Plane (NASP) Program ***1986–1994:*** *Conceived to develop operational space planes, this program never advanced beyond its technology development…*

F-18 High Alpha Research Vehicle (HARV) ***1987-1996:*** *The HARV was developed to validate computer codes and wind tunnel test results relating to high angle of attack aerodynamics, flight controls and airflow phenomena.*

July 15, 1991
Research pilot Edward Schneider flew the F/A-18 High Alpha Research Vehicle (HARV) with thrust vectoring paddles for the first time to demonstrate improved agility.

May 4, 1989
The Magellan mission to Venus was launched. It arrived at Venus in September 1990 and, using radar, mapped 99 percent of the planet's surface.

April 24, 1990
Launch of the Hubble Space Telescope from the Space Shuttle *Columbia* (STS-31).

George H.W. Bush
January 20, 1989 – January 19, 1993

…989

Richard H. Truly
May 14, 1989 – March 31, 1992

1987	1988	1989	1990	1991
$0.95	$0.95	$1.02	$1.16	$1.14
NASA Lewis Research Center for design and development of advanced turboprop propulsion concepts	Rear Adm. Richard Truly for outstanding leadership rejuvenating the U.S. manned space program	Ben Rich and the Lockheed-Air Force team, for production of the F-117A Stealth Nighthawk bomber	Bell-Boeing team for development of the V-22 Osprey tilt-rotor aircraft	USAF, Northrop and the Industry Team for B-2 design, development, production and flight testing
'Eight Athletes Who Care'	Orel Hershiser	Greg LeMond	Joe Montana	Michael Jordan
Mikhail Gorbachev	Endangered Earth	Mikhail Gorbachev	George H. W. Bush	Ted Turner
The Last Emperor	Rain Man	Driving Miss Daisy	Dances with Wolves	The Silence of the Lambs

NASA AERONAUTICS: S

1992	1993	1994	1995	1996

erest in a supersonic transport had been renewed, and Phase I of HSR focused (HSCT): the sonic boom, airport and community noise, and ozone depletion.

1995: Phase II of the HSR program began to assess technologies to Civil Transport, including weight reduction, advanced control systems

The Advanced Control Technology for Integrated Vehicles (ACTIVE) Program
1993–2006: *A joint NASA, U.S. Air Force, McDonnell Douglas Aerospace, and Pratt & Whitney effort to evaluate thrust vectoring engine nozzles for improved high-angle of attack control and maneuverability, and to explore integrated intelligent flight control systems.*

April 24, 1996
The F-15 ACTIVE achieved its supersonic yaw vectoring flight at Dryden Flight Research Center, Edwards, CA.

Low Visibility Landing and Surface Operations Project 1993-2000
Research created early concepts for GPS-based airport map displays now on the Airbus A380 and for head-up guidance cockpit displays to improve safety.

Environmental Research Aircraft and Sensor Technology (ERAST) Project
1994–2003: *Pioneering research on high-altitude, long-endurance unmanned aircraft.*

September 11, 1995
Pathfinder Unmanned Aerial Vehicle (UAV) set a new altitude record of 50,567 feet for a solar-powered aircraft.

osite materials, from design through fabrication, on wing and fuselage primary structures s cost-effective, low-weight, high-durability options.

gerous weather to test the

November 30, 1994
A Continental Airlines Boeing 737-300 was the first commercial flight to use the forward-looking Doppler radar to detect wind shear.

July 1996
The Traffic Management Advisor, a NASA CTAS software tool for controlling arriving air traffic, was deployed at Dallas/Ft. Worth International Airport and later at more FAA en-route facilities.

Automatic Dependent Surveillance-Broadcast (ADS
private partnership to test and deploy new airborne surveilla radar; provides air-to-air, air-to-ground, and ground-to-air fu

Sonic Boom Reduction *1994–2000:* *Improvements in the configuration of aircraft to re*

Advanced Subsonic Technology (AST) Program *1992–1999: Led research into areas most likely to improve U.S. civil transport aircraft, including air productivity of the airport terminal area, propulsion, wing design, use of composite materials and improved flight controls. This work continues to inform a*

t, generating less drag and promoting better fuel efficiency.

period, but produced advanced technologies in materials, propulsion and other fields.

June 27-July 7, 1995
Space Shuttle *Atlantis* docked to the Mir space station. It was the first of nine shuttle-Mir link-ups between 1995 and 1998.

William J. Clinton
January 20, 1993 – January 19, 2001

Daniel S. Goldin
April 1, 1992 – November 17, 2001

$1.13	$1.11	$1.11	$1.15	$1.23
USAF, USNRL, the Aerospace Corp., Rockwell and IBM for Global Positioning System development	Hubble Space Telescope (HST) Repair Team for successful HST orbital recovery and repair	McDonnell Douglas, USAF and the Industry Team, for C-17 Globemaster creation and production	Boeing Commercial Aircraft Co. for design, development and production of the Boeing 777	Cessna Aircraft Co. for design, development and production of the Citation X
Arthur Ashe	Don Shula	Bonnie Blair / John Olav Koss	Cal Ripken, Jr.	Tiger Woods
Bill Clinton	The Peacemakers	Pope John Paul II	Newt Gingrich	David Ho
Unforgiven	Schindler's List	Forrest Gump	Braveheart	The English Patient

SOLVING DECADES OF AVIATI

1997	1998	1999	2000	2001

improve the economic competitiveness of a High-Speed … flight deck instrumentation, and displays.

FutureFlight Central *1999–Ongoing: A full-scale airport operations simulator that can cr… airport staff can plan new runways, test new ground traffic and tower communications pro…*

July 7, 1997
Pathfinder UAV set an unofficial altitude record of 71,500 feet for a solar-powered aircraft.

August 6, 1998
The modified, extended-wing Pathfinder Plus flew to a record altitude for propeller-driven aircraft of 80,201 feet.

August 13, 2001
The Helios uncrewed solar-powered UAV flew to world record altitude of 96,863 feet.

May 17, 1997
The X-36 subscale prototype tailless fighter made the first of 31 test flights, showing a high-speed vehicle without a tail could fly normally.

October 2000
NASA and the FAA tested an early version of the Runway Incursion Prevention System, which alerts pilots and air traffic controllers to planes or other vehicles about to encroach on runways.

RIPS

Ultra-Efficient Engine Technology (UEET) Program ***October 1, 1999–2004:*** *In lig… nitric oxide and carbon dioxide emissions from commercial and military jet engines while m… new computer simulation tools were among the beneficial results from UEET.*

Intelligent Flight Control Systems (IFCS) ***1999–Ongoing:*** *Neural network technolog…*

-B) Technology ***1995–2008:*** *NASA supported a public/… …nce and cockpit avionics technology that complements …nctionality; improves safety and increases airport capacity.*

Capstone Program 1999-2006
This FAA-led program was the proving ground for ADS-B technology and its ability to reduce accidents an… NASA supported installation of Global Positioning System (GPS)-based avionics and data link communica…

…duce sonic boom intensity were formulated in a sonic boom study.

…craft aging, noise reduction, environmental impact, …eronautics research at NASA.

Advanced General Aviation Transport Experiments (AGATE) Program ***1994-2001:*** *Under the AST, AGATE revitalized the general aviation industry through an alliance of government agencies, industry and universities that dramatically updated flight deck and propulsion technologies, certification methods and airspace infrastructure for small aircraft.*

July 4, 1997
The Mars Pathfinder landed on Mars and deployed the Sojourner rover. This mission marked the first return of the U.S. to Mars after nearly twenty years.

October 29, 1998
John Glenn returned to space on the Space Shuttle *Discovery* (STS-95). He was a test subject for specific investigations on the similarities between space flight and aging.

July 22-27, 1999
The Space Shuttle *Columbia's* 26th flight was led by Air Force Col. Eileen Collins, the first woman to command a shuttle mission (STS – 93).

October 31, 2000
Expedition One of the International Space Station launched from Baikonur Cosmodrome in Kazakhstan. Astronaut William M. Shepherd and cosmonauts Yuri Pavolich Gidzenko and Sergi K. Kirkalev became the first residents of the ISS.

George W. Bush
January 20, 2001 –

$1.23	$1.06	$1.17	$1.51	$1.46
Gulfstream Aerospace Corp. for design, development and production of the Gulfstream V	Lockheed Martin, General Electric, NASA, USAF and DIA for U-2S/ER-2 development and operation	Boeing Co. for development of the F/A-18E/F Super Hornet	Northrop Grumman, Rolls-Royce, Raytheon, L-3, USAF and DARPA for Global Hawk creation and operation	The Joint Strike Fighter Program Office and industry partners for the Integrated LiftFan Propulsion System
Dean Smith	Mark McGwire / Sammy Sosa	U.S. Women's Soccer Team	Tiger Woods	Randy Johnson / Curt Schilling
Andy Grove	Bill Clinton / Kenneth Starr	Jeffrey P. Bezos	George W. Bush	Rudolph Giuliani
Titanic	Shakespeare in Love	American Beauty	Gladiator	A Beautiful Mind

ON CHALLENGES

2002	2003	2004	2005	2006

…eate a functionally accurate physical and software replication of a control tower or operations center (current or future). With NASA experts, …cedures, validate air traffic planning simulations, and perform cost-benefit studies for new airport requirements and designs.

February 2006
Test flights of an F-15 proved that a flight control system built on an artificial neural network can help pilots retain control of their aircraft during destabilizing conditions.

June 26, 2003
Helios crashes after malfunction

April 2005
The effects of sonic booms on structures and humans on the ground were measured using microphone arrays to capture sound from aircraft flying at low altitudes.

X-43A Program ***2002–2004: The X-43A airplane used innovative scramjet technology to fly at ten times the speed of sound, setting a world's record for air-breathing aircraft.***

March 27, 2004
X-43A set a new aeronautical speed record of Mach 6.83–nearly 5,000 mph.

November 16, 2004
A second unpiloted flight of the X-43A resulted in a second speed record of Mach 9.68–nearly 7,000 mph.

June 5-7, 2005
The Small Aircraft Transportation System project held a public demonstration to showcase future technologies like "Highway in the Sky" that could help small planes better utilize small airports in all kinds of weather.

August 2006
The Future Air Traffic Management Concepts Evaluation Tool (FACET) won NASA Software of the Year. FACET simulates thousands of aircraft trajectories and assists air traffic control managers plan for efficient travel flow across the country.

…ht of future aviation growth, NASA created UEET to research ways to reduce …aintaining performance and fuel efficiency. Multiple engine demonstrations and

…y for aircraft control was invented to help aircraft recover from loss of control.

…iong the thousands of general aviation pilots in the Alaska region who fly remote routes.
…tions suites in commercial aircraft, along with ground systems, equipment and services.

2005
ADS-B began deployment at air facilities from Florida to New York.

November 15, 2002
The Active Aeroelastic Wing F-18A was first flown to explore how aerodynamically twisting flexible wings could improve maneuverability of high-performance aircraft at transonic and supersonic speeds.

June 2003
NASA's Performance Data Analysis and Reporting System was recognized for helping air traffic control centers improve safety and efficiency through customized reports.

August 27, 2003
The F-5 Shaped Sonic Boom Demonstration research aircraft proved its modified forward section reduced the intensity of sonic booms.

September 2003
NASA's Surface Management System software, which helps manage air traffic from gate to gate, was demonstrated at Memphis International Airport.

February 1, 2003
All crew members died after the Space Shuttle *Columbia* broke up 15 minutes before landing.

January 2004
Twenty-one more test flights of the modified F-5E were conducted under the project now renamed "Shaped Sonic Boom Experiment."

Sept – Nov 2004
NASA flight-tested a version of Synthetic Visions Systems that uses GPS signals and computer-based terrain models to create a 3-D image of objects outside the cockpit, improving flight safety in low visibility.

January 3 and 24, 2004
NASA landed two Mars Exploration Rovers, Spirit and Opportunity, on the surface of Mars.

November 2005
A three-week series of flight tests with the Boeing Company and other partners proved that scalloped or asymmetrical chevrons on jet engine nozzles or casings reduce noise inside and outside the aircraft.

July 26, 2005
The Space Shuttle *Discovery* lifted off into orbit, marking NASA's return to human spaceflight after the Columbia disaster.

August 10, 2006
NASA and Gulfstream Aerospace tested a telescopic "Quiet Spike" sonic boom mitigator on a NASA F-15B aircraft and proved it reduced the intensity of sonic booms caused by supersonic aircraft.

December 2006–April 2007
NASA's 8-Foot High-Temperature tunnel hosted testing of Pratt & Whitney Rocketdyne's X-1 scramjet engine, a major technology step toward making hypersonic flight (> Mach 5.0) a reality.

January 19, 2006
The New Horizons spacecraft lifted off from Cape Canaveral, beginning its nine-year trip toward Pluto and the Kuiper Belt.

2002	2003	2004	2005	2006
Sean O'Keefe December 21, 2001 – February 11, 2005			Dr. Michael Griffin April 14, 2005 –	
$1.36	$ 1.59	$1.88	$2.30	$2.59
Sikorsky and industry team for development and introduction into service of the S-92 helicopter	Gulfstream for setting new safety standards with development of the innovative G550 aircraft	The Rutan SpaceShipOne Team for the first privately financed, built and flown space vehicle	Eclipse Aviation Corp. for development and operation of the very light jet the Eclipse 500	USAF and its industry partners for design, test and operation of the revolutionary F-22 Raptor
Lance Armstrong	Tim Duncan / David Robinson	Boston Red Sox	Tom Brady	Dwyane Wade
The Whistleblowers	The American Soldier	George W. Bush	The Good Samaritans	You
Chicago	The Lord of the Rings: The Return of the King	Million Dollar Baby	Crash	The Departed

2007	2008

April 26, 2007
First test flight of the Stratospheric Observatory for Infrared Astronomy (SOFIA), a Boeing 747 carrying an infrared telescope to capture images and spectra not possible by the largest ground-based telescopes.

February 2008
A broken fan blade was used to test the strength and durability of a jet engine containment case made of lighter, composite material versus metal.

March 2008
A NASA wind tunnel hosted tests of the Smart Material Actuated Rotor Technology (SMART)—new trailing edge control flaps and "smart" material actuators that can reduce helicopter vibrations and noise.

2007
Over 300 aircraft in Alaska received ADS-B to help air traffic separation efforts.

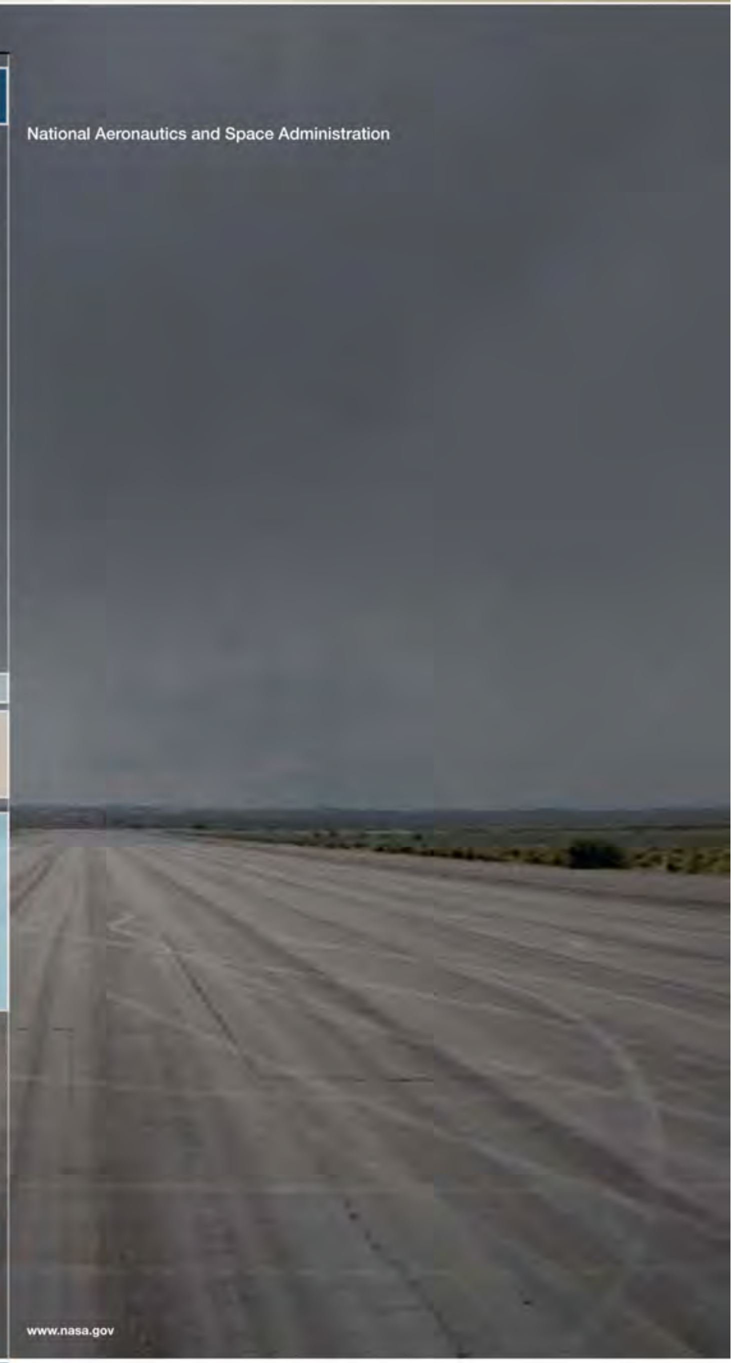
X-48B Flight Tests
2007–Ongoing:

July 20, 2007
The first test flight of the 21-foot wingspan X-48B Blended Wing Body research aircraft took place at NASA's Dryden Flight Research Center.

June 6–7, 2007
NASA's MESSENGER (Mercury, Surface, Space Environment, Geochemistry and Ranging) probe flew by Venus on its way to encountering Mercury in 2008.

May 25, 2008
After deploying a parachute system developed in collaboration with NASA aeronautics, the Phoenix Mars Lander touched down in the northern polar region of Mars to analyze soil and water ice samples.

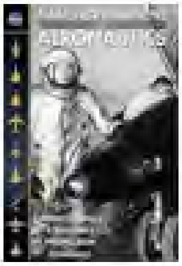
2007	
	U.S. President
	NASA Administrator
$3.03	Price of Gas
The Automatic Dependent Surveillance-Broadcast (ADS-B) team of public and private sector groups	Collier Trophy
Brett Favre	Sports Illustrated Sportsperson of the Year
Vladimir Putin	Time Magazine Person of the Year
No Country for Old Men	Academy Award for Best Picture



NP-2008-08-539-HQ

(Chart courtesy of NASA)

Additional Readings



"NASA's Contributions to Aeronautics, Volume 1"
Edited by Richard P. Hallion
(posted August 2010)
Since its creation, NASA has steadily advanced flight within the atmosphere, repeatedly influencing aviation's evolution by extending the rich legacy of its predecessor, the National Advisory Committee for Aeronautics, or NACA. This first volume in a two-volume set includes case studies and essays on NACA-NASA research for contributions such as high-speed wing design, the area rule, rotary-wing aerodynamics research, sonic boom mitigation, hypersonic design, computational fluid dynamics, electronic flight control and environmentally friendly aircraft technology.

"NASA's Contributions to Aeronautics, Volume 2"
Edited by Richard P. Hallion
(posted September 2010)
The second volume includes case studies and essays on NACA-NASA research for contributions including wind shear and lightning research, flight operations, human factors, wind tunnels, composite structures, general aviation aircraft safety, supersonic cruise aircraf research and atmospheric icing.

Downloads:
+ .mobi | + .prc | + .pdf | + .epub

The NASA Aeronautics: Solving Decades of Aviation Challenges PDF's can be downloaded at the following websites:

http://www.aeronautics.nasa.gov/pdf/timeline_poster_back.pdf

http://www.aeronautics.nasa.gov/pdf/timeline_poster_front.pdf

NASA Aeronautics Research Onboard Lithographs can be downloaded at the following website:

http://www.aeronautics.nasa.gov/onboard_lithos.htm

Lithographs are also available in Spanish.

To learn more about the numerous contributions that NASA has made to aeronautics visit NASA's interactive website:
http://www.nasa.gov/externalflash/aero_onboard/

Do internet searches:

Smithsonian Institution—National Air and Space Museum

National Museum of the United States Air Force

Aviation Museums in the United States

Worksheets

Design an Aeronautics Gallery Worksheet

The following topics were given as several of NASA's major contributions to aeronautics.

Airbag Systems	NASA Structural Analysis (NASTRAN)
Airborne Wind Shear Detection	Natural Laminar Flow (NLF) Airfoil
Area Rule	Real-Time Graphical Weather
Composite Structures	Small Aircraft Transportation System (SATS)
Computational Fluid Dynamics (CFD)	Stall/Spin Research
Deicing Systems	Supercritical Airfoil
Digital Fly-By-Wire	Synthetic Vision Systems (SVS)
Glass Cockpit	TURBO-AE Code
Highway-In-The-Sky (HITS)	Quiet Jets
Lightning Protection Standards	Winglets

Your team is to decide which of these categories you want to include in your gallery. You may decide to build a gallery around only 1 category, 3 or 4 of the categories, or all of the categories.

Follow the steps below to create your gallery.

Step 1. As a team, brainstorm ideas for the theme of your gallery. Have each team member offer an idea. Once everyone has had an opportunity to offer an idea, repeat the process until no additional ideas are offered.

Idea 1	
Idea 2	
Idea 3	
Idea 4	
Idea 5	
Idea 6	
Idea 7	
Idea 8	
Idea 9	
Idea 10	
Idea 11	
Idea 12	

Step 2. Have every team member vote for the three of the ideas they like the best. Then, as a team, discuss the 3 ideas that received the most votes. After the discussion, decide on the final idea for your gallery. Record your theme on the summary page at the end of this worksheet.

Step 3. Decide how large you want your gallery to be. Consider details such as whether there will be any large artifacts in the gallery. Since many museums have an interactive and/or hands-on section, consider this in your team's design as well. Record the gallery dimensions on the summary page at the end of the lesson. Remember that the larger a gallery is, the more costly it is for the museum to operate.

Worksheet 1 (cont.)

Design an Aeronautics Gallery Worksheet

Step 4. Now that you know the theme for the gallery and its size, it is time to decide on the categories to include in the gallery.

As a team, discuss each of the categories and decide which ones to include in the gallery. List the selected categories on the summary page at the end of this worksheet.

Step 5. Have each team member take 1 or 2 of the categories and research them for ideas of things to include in the gallery. For example, if a team member researched the category winglets, he or she might recommend including an aircraft with winglets in the gallery. The team member might also indicate that 1 or 2 displays would also be needed to use with the aircraft to explain certain concepts.

Use the responsibility form below to assign tasks to be completed.

Responsibility Form	
Assignment	Responsible Person

Design an Aeronautics Gallery Worksheet

As each team member conducts their research, he or she must use the Category Exhibit Sheet to record research results. Ideas for displays, artifacts, photos, etc., should be listed. A Category Exhibit Sheet needs to be completed for each category by each person.

Category Exhibit Sheet - Ideas of Things to Include in Gallery		
Aeronautics Category:		
Recommended Artifact or Display	Description	Size of Area (L x W) Required in Gallery

Worksheet 1 (cont.) Design an Aeronautics Gallery Worksheet

Step 6. As a team, come back together and select the final artifacts and displays for your gallery. List the artifact, display, etc., that your team has selected for inclusion on the summary page.

Step 7. For each artifact, display, etc., cut them to scale using an index card and label it with what it is. Then place the index card on the graph paper.

Step 8. Now that the team has selected the items to be included in the gallery, it is time to finalize the layout of your gallery. Think about the visitor flow through the gallery: Is it to be directional? This means that everyone enters the gallery at same place and follows a certain route through the gallery to its exit. Make sure to show the entrances and exits for the gallery. Once everything has been decided upon, create a final scale drawing of your gallery on the graph paper. Decide the scale for each square on the graph paper. Note the dimensions on the graph paper. After completing your scale drawing attach it to the worksheet.

Summary Page

Gallery Theme:____

Gallery Dimensions: Length ___________Meters Width ___________Meters
___________Feet ___________Feet

Design an Aeronautics Gallery Worksheet

NASA Aeronautics Contribution categories to include in gallery to support gallery theme

Name of Artifact / Display	Reason for Selection	Required Space in Square Meters

Worksheet 2 Gallery Programs Worksheet

Assume that you will have to build an addition to the aviation museum for your team's gallery. What will be the cost to construct and operate the gallery?

Note as building costs are given in square feet, the metric system will not be used in this section of the activity.

A factor not considered in your team's gallery design was the costs associated with the construction and operation of your gallery. If a new gallery space was constructed to house your collection, the following description represents some of the costs:

Assume your gallery space is 100 feet by 100 feet. The total area of the gallery would be 10,000 square feet. It costs approximately $200 a square foot for construction costs. For this gallery, the construction costs would be approximately 2 million dollars. To outfit the gallery, the cost would be an additional $150 a square foot or in this case, it would be an additional 1.5 million dollars. Also, the yearly operation costs for lights, heat, and air conditioning approximates $40 a square foot each year. This would add another $400,000 to the total costs. In addition to all of these costs, are the staff salaries, maintenance and security fees.

Museums are dependent on admissions to help fund the expenses of the museum. Calculate the greatest number of visitors that your team's gallery can safely hold at one time. To calculate this, the first thing that needs to be determined is what is called the "load factor." This is the number of square feet required by each visitor in the gallery. Let us assume that it is 5 square feet. Now suppose that the artifacts and displays take up 60 percent of the space. This leaves 40 percent of the space for visitors. In our example, this would be 4,000 square feet, and if each gallery visitor requires 5 square feet, then the maximum number of visitors in the gallery at one time is 800. In our example, assume that a visitor stays in the gallery for one hour.

Now assume that your gallery is open from 9 to 5 each day. Over the course of a few months, it is determined that the occupancy rate for the gallery is 6 percent. The gallery is open 8 hours a day. If there was a 100 percent occupancy rate, this would translate into 6400 visitors a day (8 hours x 800 visitors/hour). Since the occupancy rate is only 6 percent, approximately 384 visitors would visit the gallery each day (6400 X .06).

If the admission to the gallery was $10, the museum would generate $3,840 a day in admissions. If the museum was open 360 days a year, the total income based on admissions of 384 visitors per day is $1,382,400. If the operations expenses are deducted, $982,000 is left to pay for salaries and the operation of the rest of the building. A rule of thumb is that the exhibit space is approximately one-half the space in a museum. Therefore, another $400,000 would have to be deducted for the operations costs for the remaining museum space leaving only $532,000 to fund all the other museum expenses.

For your team's gallery:

1. What is the number of square feet of exhibit space? ______________________________

2. What is the number of square feet required for the artifacts and displays?______________________________

3. What is the amount of space available for visitors?______________________________

4. Assuming the load factor is 5 square feet, what is the greatest number of visitors that can be in the gallery at any one time? ______________________________

5. Based on the information given above in the explanation and a 5 percent visitor occupancy rate what is the expected number of gallery visitors each year?______________________________

6. Decide on an admission rate and then calculate how much money can be generated based on a 5 percent visitor occupancy each year. Does the admissions cover the expenses for the team's gallery?

   ____

Gallery Programs Worksheet

To help increase the number of visitors each year, the museum conducts numerous educational programs, special programs and activities related to the museum or a particular gallery.

1. Describe several educational programs that you would suggest to do pertaining to your team's gallery.

2. Describe several special programs and activities that you would suggest to do pertaining to your team's gallery.

3. Describe several creative ideas for how the museum might raise additional funds to support all of the operations of the museum.

Worksheet 3 Aeronautics Gallery Guide Worksheet

When a visitor goes to a museum, they want to make the most of their time. A map of the museum or a gallery guide can assist them in planning their visit. A gallery guide provides detailed information about the artifacts in the gallery. In some cases, the guide shows the path the visitor needs to follow to gain a better understanding of the gallery's theme.

Your team is to design a guide for your team's gallery. On the front side, you need to include a detailed map of the gallery, drawn to scale, identifying the various artifacts and displays. On the reverse side of the guide, your team must highlight the story of the gallery including important artifacts or displays, and any special programs or activities associated with the gallery.

Specifications for the guide:
The guide must be 8 inches by 10 inches. The guide should be black and white. The font is to be no smaller than 10 points. A scale drawing of the map is to be on the front side of the guide. The reverse side of the guide is to have the text in 3 columns. Use the Gallery Guide Design sheets to assist in the planning of the layout of your gallery guide.

Gallery Guide Design

Story	Displays	Programs

Images

Img. 1 National Air and Space Museum

(Photo courtsey of Eric Long - National Air and Space Museum)

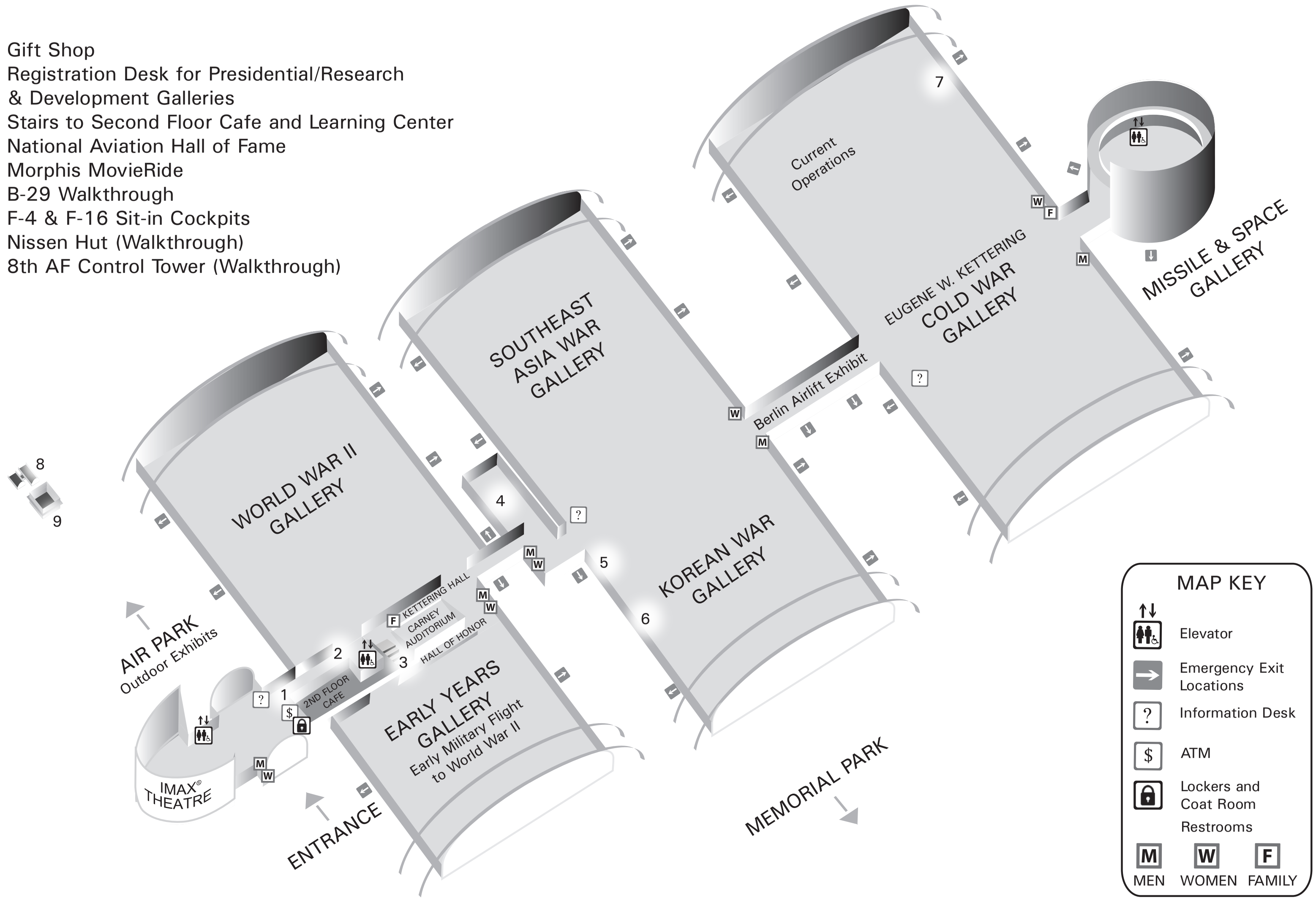
Img. 2 National Museum of the United States Air Force

(Photo courtesy of the National Museum of the United States Air Force)

Img. 3 Gallery Map of the National Museum of the United States Air Force

NATIONAL MUSEUM OF THE UNITED STATES AIR FORCE®

1 - Gift Shop
2 - Registration Desk for Presidential/Research & Development Galleries
3 - Stairs to Second Floor Cafe and Learning Center
4 - National Aviation Hall of Fame
5 - Morphis MovieRide
6 - B-29 Walkthrough
7 - F-4 & F-16 Sit-in Cockpits
8 - Nissen Hut (Walkthrough)
9 - 8th AF Control Tower (Walkthrough)



Visit us online at www.nationalmuseum.af.mil, experience a virtual tour at www.nmusafvirtualtour.com, become a fan on Facebook or follow us on Twitter @afmuseum

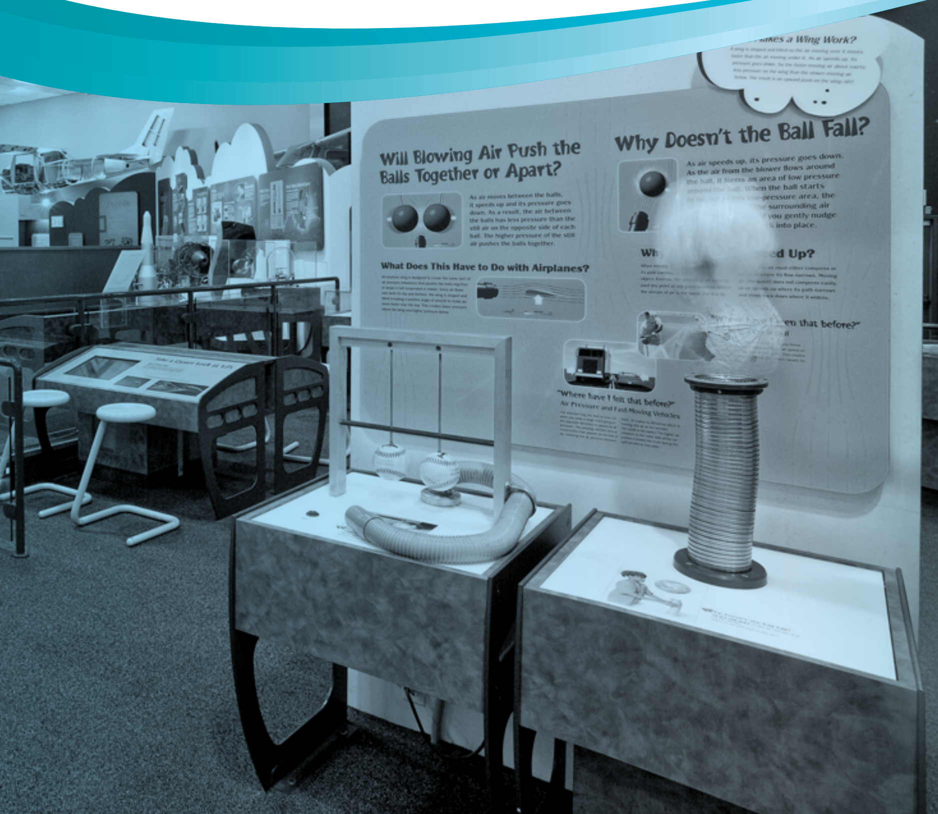
(Courtesy of U S Air Force, National Museum of USAF http://www.nationalmuseum.af.mil/shared/media/document/AFD-110620-020.pdf)

Img. 4 Photo of How Things Fly Exhibit at the National Air and Space Museum

(Photo courtesy of Eric Long - National Air and Space Museum)

Aeronautics
Research
Mission
Directorate

Museum in a BOX Series



history of flight

EP-2010-12-462-HQ