Designing an Aeronautics Museum Gallery
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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

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.

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.

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.
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 Image 4 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.

**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

Time Requirements: 8 Hours

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.
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.*

![Fig. 2 Scale drawing of Aero Gallery](image-url)
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 versus 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 museum’s 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 airflow 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 to General Aviation

NASA Aeronautics Research onboard

Figures courtesy of NASA
Fig. 2 Scale drawing of Aero Gallery

(B-17E Flying Fortress)

(P-38 Lightning)

(P-47 Thunderbolt)

(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.

### 1958
- October 4, 1957
  - The Soviet Union launched Sputnik 1, the first artificial satellite to orbit Earth.

- 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.

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

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

### 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.

### 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

- James E. Webb
  - February 14, 1961 – October 7, 1968

### Price of Gas
- $0.30
- $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 Sportsman of the Year
- Rufe 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
<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>June 27, 1962</td>
<td>Pilot Joseph A. Walker flew the X-15 to an unofficial world speed record of 4,104 mph.</td>
</tr>
<tr>
<td>August 22, 1963</td>
<td>Highest X-15 flight (unofficial), 384,500 ft (74.8 miles) by Joseph A. Walker.</td>
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</tbody>
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**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 1963-1975**
The program demonstrated the low speed entry and landing characteristics of vehicles that use body shape, rather than wings, to generate lift.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
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<tbody>
<tr>
<td>March 1, 1963</td>
<td>M2-F1, first flight (ground tow)</td>
</tr>
<tr>
<td>August 16, 1963</td>
<td>M2-F1, first air tow</td>
</tr>
<tr>
<td>October 30, 1964</td>
<td>The first flight 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.</td>
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<td>October 21, 1965</td>
<td>M2-F1, last captive flight</td>
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<tr>
<td>July 12, 1966</td>
<td>NASA's MR 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.</td>
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<tr>
<td>August 16, 1966</td>
<td>M2-F1, last flight (air tow)</td>
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<tr>
<td>December 22, 1966</td>
<td>NASA's Bruce A. Peterson piloted the HL-10 lifting body on its first glide flight.</td>
</tr>
<tr>
<td>June 3, 1965</td>
<td>The second piloted Gemini mission, Gemini IV, stayed aloft for four days, and astronaut Ed White performed the first spacewalk by an American.</td>
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<tr>
<td>December 15, 1965</td>
<td>First rendezvous in space between Gemini 6-A and Gemini 7 for five hours of station-keeping.</td>
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**Lyndon B. Johnson**
November 22, 1963 – January 19, 1969

<table>
<thead>
<tr>
<th>Name</th>
<th>Role</th>
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<tbody>
<tr>
<td>$0.31</td>
<td>The seven Mercury astronauts for pioneering manned American spacecraft</td>
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<tr>
<td>$0.20</td>
<td>Clarence &quot;Kelly&quot; Johnson for designing and directing development of the Mach 3 X-15A-11</td>
</tr>
<tr>
<td>$0.30</td>
<td>Gen. Curtis LeMay for great achievements with respect to air vehicles and national defense</td>
</tr>
<tr>
<td>$0.31</td>
<td>The Gemini Program teams for significantly advancing the human spaceflight experience</td>
</tr>
<tr>
<td>$0.32</td>
<td>James McDonnell for leadership and perseverance in advancing aeronautics and astronautics</td>
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<tr>
<td>Terry Bulger</td>
<td>Pasha Roselle</td>
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<tr>
<td>Ken Venturi</td>
<td>Sandy Koufax</td>
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<td>Jim Ryan</td>
<td>The Generation Twenty-Five Under</td>
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<td>Pope John XIX</td>
<td>Martin Luther King, Jr.</td>
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<tr>
<td>Lyndon B. Johnson</td>
<td>William Westmoreland</td>
</tr>
<tr>
<td>Lawrence of Arabia</td>
<td>Tom Jones</td>
</tr>
<tr>
<td>My Fair Lady</td>
<td>The Sound of Music</td>
</tr>
<tr>
<td>A Man for All Seasons</td>
<td></td>
</tr>
</tbody>
</table>
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.

**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 890 jet transport, and a Beech Queen Air twin-propeller aircraft.

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

**March 9, 1971**
NASA research pilot Thomas McMurtry completed the first flight of an F-16 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.

**May 10, 1967**
M2-F2, last flight

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

**April 17, 1969**
First X-24A glide flight, by pilot Gerald R. Gonty.

**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.

**February 18, 1970**
First supersonic flight 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-F2 pilot flight

**July 17, 1970**
HL-10, last flight

**November 25, 1970**
First M2-F3 powered 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.

**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.

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

**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.

**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, 1968 – September 15, 1970

**$0.33**
Hughes Aircraft Surveyor Program team and the Jet Propulsion Lab for aiding lunar exploration

**Dr. James C. Fletcher**
April 27, 1971 – May 1, 1972

**$0.34**
The Apollo 8 crew for flawless execution of the first manned lunar orbit

---

**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**
<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972</td>
<td>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.</td>
</tr>
<tr>
<td>1973</td>
<td>The Godfather was released.</td>
</tr>
<tr>
<td>1974</td>
<td>Quiet Short-Haul Research Aircraft (QSRA) Project 1974-1981:</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
<tr>
<td>1975</td>
<td>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.</td>
</tr>
<tr>
<td>1976</td>
<td>XV-15 Tilt Rotor</td>
</tr>
<tr>
<td></td>
<td>October 22, 1976:</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
</tbody>
</table>

**May 25, 1972**
NASA research pilot Gary Krier flew an F-106 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.

**August 1, 1973**
First X-24B glide flight

**November 15, 1973**
First X-24B powered flight

**March 5, 1974**
First X-24B supersonic flight

**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 Harrison H. Jack Schmitt, a geologist.

**December 20, 1972**
M2-F3, last flight

**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.

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

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<table>
<thead>
<tr>
<th>Name</th>
<th>Role/Title</th>
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<tbody>
<tr>
<td>0.36</td>
<td>$0.39</td>
</tr>
<tr>
<td>The personnel of the 7th and 8th Air Forces and Task Force 77 during Operation Linebacker II</td>
<td>NASA’s Skylab Program, with recognition to director William Schneider and its three astronaut crews</td>
</tr>
<tr>
<td>0.53</td>
<td>$0.57</td>
</tr>
<tr>
<td>John Clark (NASA) and Daniel Fink for the Earth Resources Technology Satellite Program (LANDSAT)</td>
<td>General Dynamics and the USAF F-16 team for advancements leading to effective fighter aircraft</td>
</tr>
<tr>
<td>0.57</td>
<td>$0.61</td>
</tr>
<tr>
<td>USAF, the B-1 Industry Team and Rockwell Int. Corp. for B-1 bomber design and development</td>
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**1972**
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**1973**
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**1976**
- 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.
Project 1976-1987: After the energy crisis of the early '70s, NASA initiated research into a unique "swirled" design for propellers used on propeller-powered aircraft. This effort was part of the Aircraft Efficiency (ACEE) Program 1975-1986: This program stimulated wide application of lighter and more durable composite materials to secondary and primary structures of aircraft.

Storm Hazards Program 1978-1986: This program conducted extensive research and flight tests to identify conditions that result in violent weather situations. 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 Research
Forward swept wing technology, 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 relative to the time. Research enabled industry's development of the more fuel-efficient high-bypass GE90 turbofan jet engine, which powers the intercontinental Boeing 777.

Highly Maneuverable Aircraft Technology (HIMAT) 1979-1983: HIMAT was installed in a vehicle to validate use on future fighter aircraft. HIMAT's extensive use of composites, wing sweep, and advanced propulsion allowed for high maneuverability.

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

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 adjusted to decrease drag and increase speed and range. The AD-1 was flown 79 times for the concept and collect data on handling qualities.

December 21, 1979
First flight of the AD-1.

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).

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

August 12, 1977
First free flight of Enterprise.

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

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

Jimmy Carter

Ronald Reagan

Dr. Robert A. Frosch

James M. Begg
July 10, 1981 –

$0.07
$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 turboprop for 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 flyby and return from Saturn
NASA, Rockwell, Martin Marietta, TRW, and the Space Shuttle Columbia crew

Steve Gauthier
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
**Advanced Composite Technology Program 1986-1997:** This research program focused on how to use textile composite materials for commercial or military aircraft. A key ACT contribution was the validation of braided or stitched composite structures at full-scale levels.

**Project 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 aircraft.

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1987</td>
<td>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.</td>
</tr>
<tr>
<td>1988</td>
<td>July 13, 1988 NASA researchers convinced FAA to approve access to live radar data.</td>
</tr>
<tr>
<td>1989</td>
<td>December 8, 1988 X-29-1 completed its flight research program with flight number 242.</td>
</tr>
<tr>
<td>1990</td>
<td>April 1990 “CTAS” became the official name and the system began using live data from FAA air traffic control centers.</td>
</tr>
</tbody>
</table>

**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.

<table>
<thead>
<tr>
<th>Event</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 4, 1989</td>
<td>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.</td>
</tr>
</tbody>
</table>

**1993:**

<table>
<thead>
<tr>
<th>Top Achievements of 1993:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richard H. Truly</td>
</tr>
<tr>
<td>May 14, 1989 – March 31, 1992</td>
</tr>
<tr>
<td>NASA Lewis Research Center for design and development of advanced turboprop propulsion concepts</td>
</tr>
<tr>
<td>Rear Adm. Richard Truly for outstanding leadership and as executor of the U.S. manned space program</td>
</tr>
<tr>
<td>Ben Rich and the Lockheed-Air Force team for production of the F-117A Stealth Nighthawk bomber</td>
</tr>
<tr>
<td>Ball-Boeing team for development of the Y-22 Osprey tilt-rotor aircraft</td>
</tr>
<tr>
<td>USAF, Northrop and the Industry Team for B-2 design, development, production and flight testing</td>
</tr>
<tr>
<td>“Eight Athletes Who Care”</td>
</tr>
<tr>
<td>Orel Hershey</td>
</tr>
<tr>
<td>Greg LeMond</td>
</tr>
<tr>
<td>Joe Montana</td>
</tr>
<tr>
<td>Michael Jordan</td>
</tr>
<tr>
<td>Mikhail Gorbachev</td>
</tr>
<tr>
<td>Endangered Earth</td>
</tr>
<tr>
<td>Mikhail Gorbachev</td>
</tr>
<tr>
<td>George H. W. Bush</td>
</tr>
<tr>
<td>Ted Turner</td>
</tr>
</tbody>
</table>

**Top Films of 1993:**

<table>
<thead>
<tr>
<th>1993 Films</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Last Emperor</td>
</tr>
<tr>
<td>Rain Man</td>
</tr>
<tr>
<td>Driving Miss Daisy</td>
</tr>
<tr>
<td>Dances with Wolves</td>
</tr>
<tr>
<td>The Silence of the Lambs</td>
</tr>
</tbody>
</table>

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

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


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

Research created early concepts for GPS-based airport map displays now on the Airbus A300 and for head-up guidance cockpit displays to improve safety.


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

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 CTRAS software tool for controlling arriving traffic, was deployed at Dallas/Ft. Worth International Airport and later at more FAA en-route facilities.

Automatic Dependent Surveillance-Broadcast (ADS-B) private partnership to test and deploy new airborne surveillance radar; provides air-to-air, air-to-ground, and ground-to-air functionality.

Advanced Subsonic Technology (AST) Program 1992-1996: Led research into areas most likely to improve U.S. civil transport aircraft, including air traffic control, productivity of the airport terminal area, propulsion, wing design, use of composite materials and improved flight controls. This work continues to inform the future, generating less drag and promoting better fuel efficiency.

Sonic Boom Reduction 1994-2000: Improvements in the configuration of aircraft to reduce sonic boom.

1996: A panel of experts presented a study on the problems of the 747-400 and the 777.

Erosion of the boom of the 747-400 was determined to be caused by the ground effect. The study recommended a redesign of the aircraft's fuselage to reduce the boom.

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 linkups between 1995 and 1998.

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

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

<table>
<thead>
<tr>
<th>$1.13</th>
<th>$1.11</th>
<th>$1.15</th>
<th>$1.23</th>
</tr>
</thead>
<tbody>
<tr>
<td>USAF, USNR, the Aerospace Corp., Rockwell and IBM for Global Positioning System development</td>
<td>Hublie Space Telescope (HST) Repair Team for successful HST orbital recovery and repair</td>
<td>McDonnell Douglas, USAF and the Industry Team, for C-17 Globemaster creation and production</td>
<td>Boeing Commercial Aircraft Co. for design, development and production of the Boeing 777</td>
</tr>
</tbody>
</table>

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 AVIATION

1997

- 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 train airport staff to plan new runways, test new ground traffic and tower communications protocols.

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 a propeller-driven aircraft of 80,201 feet.

May 17, 1997

The X-32 subsonic prototype tailless fighter made the first of 31 test flights, showing a high-speed vehicle without a tail could fly normally.

August 13, 2001

The Helios unmanned solar-powered UAV flew to world record altitude of 96,833 feet.

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.

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

Intelligent Flight Control Systems (IFCS) 1999-ongoing: Neural network technology reduce sonic boom intensity were formulated in a sonic boom study.

J7) Technology 1995-2008: NASA supported a public/private and cockpit avionics technology that complements air traffic controllers' situational awareness 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 and delays. NASA supported installation of Global Positioning System (GPS)-based avionics and data link communications.

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.

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 22-27, 1999

The Space Shuttle Columbia’s 26th flight was led by Air Force Gen. Eileen CID. 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 comanauts Yuri Pavlovich Gidzenko and Sergei K. Krikalev became the first residents of the ISS.

$1.23

Gulfstream Aerospace Corp., for design, development and production of the Gulfstream V

$1.06

Lockheed Martin, General Electric, NASA, USAF and DHI for the V/STOL development and operation

$1.17

Boeing Co. for development of the FA-18EF Super Hornet

$1.51

Northrop Grumman, Rolls-Royce, Raytheon, L-3, USAF and DARPA for Global Hawk creation and operation

$1.46

The Joint Strike Fighter Program Office and industry partners for the Integrated Lift Fan Propulsion System

Dean Smith

Mark McQuire / 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

- 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.

2003

- The 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.

2004


2005

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

2006

- Flight of future aviation growth, NASA created UEET to research ways to reduce maintaining performance and fuel efficiency. Multiple engine demonstrations and

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

- The 80-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.

- NASA and Gulfstream Aerospace tested a conceptual “Quiet Spike” sonic boom mitigator on a NASA F-15B aircraft and proved it reduced the intensity of sonic booms caused by supersonic aircraft.

2005

- 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.

2006

- The Space Shuttle Discovery lifted off into orbit, making NASA’s return to humans spaceflight after the Columbia disaster.

2007

- Dr. Michael Griffin

Sean O’Keefe

December 21, 2001 – February 11, 2005

$1.36

Leidos and industry team for development and introduction into service of the S-92 helicopter

Silkysky and industry team for development and introduction into service of the S-92 helicopter

Guillemot for setting new safety standards with development of the Innovative G500 aircraft

The Futon 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

The American Soldier

Boston Red Sox

Tom Brady

Dwayne Wade

The Whistleblowers

The Lord of the Rings: The Return of the King

Million Dollar Baby

Crash

The Departed

The Good Samaritans

You

Chicago

$1.59

$1.88

$2.30

$2.59
<table>
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<tr>
<th>Year</th>
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</tr>
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<tbody>
<tr>
<td>2007</td>
<td>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.</td>
</tr>
<tr>
<td>2008</td>
<td>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.</td>
</tr>
<tr>
<td>2008</td>
<td>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.</td>
</tr>
</tbody>
</table>

**U.S. President**

<table>
<thead>
<tr>
<th>Award</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>NASA Administrator</td>
<td>Price of Gas</td>
</tr>
<tr>
<td>Collier Trophy</td>
<td>Brett Favre</td>
</tr>
<tr>
<td>Sports Illustrated Sportsperson of the Year</td>
<td>Vladimir Putin</td>
</tr>
<tr>
<td>Time Magazine Person of the Year</td>
<td>Academy Award for Best Picture</td>
</tr>
</tbody>
</table>

(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, supersonic 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 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 aircraft research and atmospheric icing.

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_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
Worksheet 1

Design an Aeronautics Gallery Worksheet

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

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

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.

|--------|--------|--------|--------|--------|--------|--------|--------|--------|---------|---------|---------|

**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.
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.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Responsible Person</th>
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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.

### Aeronautics Category:

<table>
<thead>
<tr>
<th>Recommended Artifact or Display</th>
<th>Description</th>
<th>Size of Area (L x W) Required in Gallery</th>
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</table>
**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
Worksheet 1 (cont.)

Design an Aeronautics Gallery Worksheet

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

<table>
<thead>
<tr>
<th>Name of Artifact / Display</th>
<th>Reason for Selection</th>
<th>Required Space in Square Meters</th>
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</table>
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?
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.
<table>
<thead>
<tr>
<th>Story</th>
<th>Displays</th>
<th>Programs</th>
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National Air and Space Museum

(Photograph courtesy of Eric Long - National Air and Space Museum)
MUSEUM IN A BOX

National Museum of the United States Air Force

Photo courtesy 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

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)
history of flight