INTRODUCTION

Human beings have always been fascinated by flight. Cave people carved, sculpted, and painted winged creatures soaring through the sky. Greek mythology tells of the winged horse Pegasus, ancient Persian myths tell of winged bulls that guarded the royal halls, and a 4000 year old Chinese story, from the Annals of The Bamboo Books, describes how the Emperor Shun escaped from captivity by "donning the work-clothes of a bird." People struggled for centuries to make human flight a reality, and they succeeded. Man worked for decades to bring about the first space flight, and as the 20th century draws to an end, we look to Mars and beyond in hopes of success.

Purpose

Throughout this document you will find that the following three fundamental concepts, when applied in conjunction with one another, have lead to the most dramatic aerospace advances.

1. Public awareness and excitement.
2. International and intranational competition.
3. Motivation to set and attain goals.

Areas of interest

This document will delve into the following areas, in an effort to learn from the successes and failures of our predecessors.

1. The history of flight.
2. The history of the U.S. space program.
3. Current aerospace technologies.

This knowledge will then be used to glimpse into man's future in the Age of Aerospace.

Figure 1: The Egyptian goddess Isis. (1)

THE HISTORY OF FLIGHT

Introduction

Mans' early attempts at flight met with utter disaster. People would climb high cliffs or towers, armed with magic spells, homemade wings, or a combination of the two, and plunge to their deaths as they attempted to fly. Figure 2 illustrates an apparatus designed for such a tower flight. The American Heritage History of Flight credits Roger Bacon as the first man to take a scientific approach to flying. Bacon described a machine that would use man powered artificial wings to beat the air like the wings of a bird. Although Bacon envisioned a flying machine, he made no attempt to create one. The first great scientific pioneer of aviation would not come along until 150 years after Roger Bacon.

Figure 2: A flying apparatus designed by the French locksmith Besnier.
AH PG 28.

Leonardo da Vinci
Leonardo da Vinci was an artist, architect, musician, and mathematician. He detailed his ideas and inventions in a series of manuscripts and drawings, Figure 3, which he left with a friend. These documents did not receive serious consideration until the late 19th century. Although science had overtaken most of his ideas by this time, his towering genius resounded from his works. Da Vinci's manuscripts detailed designs for the following:

1. Parachute
2. Ornithopters (flapping wing devices)
3. Balloons
4. Kites
5. Helicopter

Da Vinci's ideas were followed by years of ludicrous theories of flight. These theories, and the tales of those who attempted to validate them, receive some credit for keeping people interested in flying. Man wouldn't fly until the late 18th century, and it wouldn't be an ornithopter or a helicopter that would take him up, but a balloon.

Figure 3: 3 of Da Vinci's designs, the ornithopter, the parachute, and the helicopter. AH PG 26

Ballooning
The earliest balloons were manufactured in the late 18th century. These early balloons were primitively designed with the following characteristics:

1. Linen or paper construction.
2. Hot air used to create lift.

As with other aerospace technologies, balloons were constantly evolved by their creators. By the beginning of the 19th century, balloons had taken on the following characteristics:

1. Silk or rubber construction.
2. Hydrogen used to create lift.

As balloon flights became more popular, the stories of these flights spread around the world. This sparked great interest in flight and led many scientists and inventors to try their hand at human flight.
Balloons brought in the Aerospace age and they continue to be used today. From the hot air balloons of recreational enthusiasts to the scientific weather balloons of NASA, balloons continually prove to be an integral part of mans' technological aerospace arsenal.

Dirigibles
Balloons were followed by dirigibles, which were large aerodynamically designed balloons with some method of propulsion attached to them. Dirigibles were used as:

1. Transports
2. Machines of war

Their main contribution to aerospace came from the engines that were designed for them. The design and implementation of light and powerful engines would prove to be one of the largest contributing factors in the development of the airplane.

Orville and Wilbur Wright
Orville and Wilbur Wright were brothers from Dayton, Ohio. They originally worked as designers and machinists in a bicycle shop in Dayton, but by the beginning of the twentieth century, both of them had become fascinated with the concept of flight.
During the year 1900, the brothers took several vacations to Kitty Hawk, North Carolina, to build and fly a series of gliders, that they designed. By 1903, the brothers had made over 1000 successful glider flights, and as June of 1903 drew to a close, the brothers decided that a powered glider would be built.
On Thursday, December 17, 1903 the dream of man's first powered flight came true. This first flight only lasted for 12 seconds, and a little over 100 feet, but it opened the door for scientists and inventors from around the world to attach engines to their gliders and attempt to best the Wright brothers. This theme of competition would prove vital to the success and growth of aerospace.

The Prizes of the Day
One of the largest contributing factors to the early growth of aerospace were the privately funded prizes that were offered to successful aviators. These prizes were offered by the thousands, to the first aviator and his aircraft that could comply with a given set of criteria. For example, the Archdeacon prize offered:

* 3,000 francs to the first person to fly 25 meters across French soil.

The criteria and the monetary value of the prizes were increased over time. By 1909 the Daily Mail of London was offering :

* 1,000 pounds to the first person to fly across the English Channel.

These prizes offered the early aviators goals for their flying machines, and the motivation to try and attain them. World War I would bring about a new motivation for increasing the performance of the flying machine, survival.

The Airplane as a War Machine
In the early years of the 20th century, the military potential of the airplane was underrated, although it had not been entirely overlooked. By 1909, the French had decided to purchase war planes, and by 1912 Great Britain's Royal Flying Corps had been established. 1914 sounded the beginning of World War I, and although the airplane was still in its infancy, it had progressed at an amazing rate. By the beginning of the war, airplanes were capable of the following:

1. Speeds in excess of 125 miles per hour.
2. Altitudes of 25,000 feet.
3. Flights of more than 1,000 miles.

War, as is often the case, acted as a spur for technology, and although the airplane was described as a toy in the beginning of the war, it had developed into a powerful weapon by the war's end. Throughout the war, airplanes were used to:

1. Bomb behind enemy lines.
2. Attack enemy airplanes.
3. Scout ahead of ground forces.

The American Heritage History of Flight describes the airplane's significance in war, "Ground Commanders varied in their degree of perceptiveness, but during the furious fighting of September and October that led to Germany's collapse this precept was written in blood and fire for those who had eyes to see: If you hold the air, you cannot be beaten; if you lose the air, you cannot win.

Summary

The importance of the history of flight, does not lie in the names and facts associated with the past, but in the concepts used to improve upon existing technologies to produce new technologies. Three of the concepts that lead to the phenomenal growth of the early aerospace industry are:

1. Public awareness and excitement.
2. International and intranational competition.
3. Motivation to set and attain goals.

Word of mouth and media coverage kept the entire world informed of the latest feats in the field of aviation. This inspired public interest, which lead people to establish grants and prizes for the aviators.
From the outset of the aerospace age, competition has been stiff. International competition as well as intranational competition brought about rapid advances in the aviation industry.
The grants and prizes that were set up, provided the aviators with goals, the means, and the motivation to attain them. Future growth in the aerospace industry will require us to adhere to these fundamental concepts.

THE HISTORY OF THE U.S. SPACE PROGRAM

Introduction

Until the 20th century, man's exploration of the universe was limited to astronomical observations and fictional writings. These observations and writings acted as a catalyst in the minds of American scientists and engineers, of the early 1900's. These scientists and engineers, and those that would follow their lead, would work to establish the U.S. Space Program, the National Aeronautics and Space Administration (NASA), and American dominance in the aerospace industry. It is essential that today's scientists and engineers learn from their predecessors, in order to maintain American dominance in the aerospace industry.

The Father of Modern Rocketry

Robert H. Goddard, known as the father of modern rocketry, registered over 200 patents on various rocket components. Goddard's contributions revolve around the following:

1. Theories on using rockets to explore space.
2. Prototype rocket designs.
3. Empirical data gathered from launches.

Goddard's contributions proved to be crucial to man's exploration of space. Figure 4 shows Goddard with one of his early rockets. Goddard's successes also provided the people of the world with hope that the science-fiction they had been reading for years, might someday become a reality.

Figure 4: Robert H. Goddard with an early rocket. AH PG 284

Rockets and War

As was the case with World War I and the Airplane, World War II forced nations to fund research and development, in the field of rocketry. Throughout the course of World War II, several countries, including the United States, were actively involved in the development of rockets. Germany's V-1 and V-2 rockets, were the most widely used rocket powered weapons, and both represented vast advances in rocketry.
By the end of World War II, rockets had advanced to obtain the following characteristics:

1. Gross weights of over 25,000 pounds.

2. Top speeds of over 3,500 miles per hour.
3. Payloads of more than 2,000 pounds.

The late 1940's and early 1950's brought about few advances in rocketry. It would take one of the greatest rivalries in the history of civilization to propel man, and the aerospace industry, into space.

A National Vision

After World War II, the United States found itself in competition with the Soviet Union. On October 4, 1957, the Soviet Union put the first man made satellite, Sputnik I, in orbit. This sudden display of technological expertise, by the Soviet Union, caught the world by surprise. The United States suddenly found itself scrambling to catch up to the Soviet Union's space program. NASA: A History of the U.S. Civil Space Program describes the importance of the competition between the United States and the Soviet Union, "The history of space and rocketry during the twenty years after World War II was almost entirely propelled by the rivalry between the United States and the Soviet Union, as the two great superpowers engaged in a "cold war" over the ideologies and allegiances of the nonaligned nations of the world."

This theme of competition worked to increase public awareness about the two countries space programs. It also cause the United States government to create NASA and direct funds to research and development in rocketry.

The people of the United States were unified in their national vision of space exploration, by President John F. Kennedy. On May 25, 1961, President Kennedy informed the nation of a national goal to send an American to the moon before 1970. The cold war competition, increased public awareness and support, and vast government funding pulled the nation together in an effort to meet the national goal.

The Apollo Missions

Project Apollo, devised by NASA to obtain President Kennedy's national goal, brought about huge technological advances in the aerospace industry. Apollo catapulted the U.S. space program from its infancy. The following are highlights from the Apollo project:

* The initial missions involved orbiting the earth to test the equipment and procedures in space.
* Apollo 8 successfully orbited the moon.
* Apollo 11 successfully landed on the moon.

The United States had come together as a nation, and re-established themselves as the world leader in space exploration. Now that man had been to the moon, the United States looked towards building a permanent structure in space, and the Skylab project was established.

Skylab

The United States first space station, Skylab, was put into space to prove that people could live and work in space, for extended periods of time. Although a space station would appear to be a large advance in the aerospace industry, Skylab's limited budget forced it to borrow technologies from past projects, instead of creating new technologies.

Skylab was launched on May 14, 1973. The project was plagued by problems from the outset, and although years of astronomy and research were conducted on the station, on July 11, 1979, Skylab plunged into the earth's surface.

Summary

The United States was victorious in the race to the moon, because its space program was funded and supported by both the government and the people. The United State's fierce competition with the Soviet Union provided the world with a vast quantity of

new aerospace technologies. However, U.S. public interest and government funding declined drastically after the Apollo 11 mission. This lead to almost a decade of complacency in the U.S. space program. These trends in the lack of public interest, can be traced throughout time. In order to promote exponential growth in the aerospace industry, the United States must:

1. Constantly set new goals.
2. Continually revise existing goals.
3. Work to maintain public interest.
4. Continue to provide funding for new technologies.

By constantly setting new goals and revising old ones, the United States could avoid losing the public interest, and thus continue to promote exponential growth in the aerospace industry.

CURRENT AEROSPACE TECHNOLOGIES

Introduction

The U.S. aerospace industry has become virtually stagnate. Heavy government spending cuts have taken their toll. The American people, as a whole, have lost interest in the U.S. Space Program. In the early 1980's, a space shuttle launch would attract front page media attention, but today's launches rarely make the news. Never the less, it is important to look at where the industry is today, so that changes can be made for tomorrow.

Satellites

Today, hundreds of man made satellites orbit the earth. A few satellites have made their way to the other side of the galaxy. All of these satellites perform a variety of roles. These roles include:

1. Various types of photography.
2. Data transmission and reflection.
3. Research.

On any given day, the earth is photographed thousands of times by satellites. Weather satellites send pictures of hurricanes, tornadoes, and other weather phenomena to stations on the ground. Spy satellites allow the countries of the world to obtain information on each other, and geographic satellites send information that allow people to pinpoint the location of minerals, as well as to create maps of the earth. Satellite photography has become a necessity in the 20th century, and it will prove to be vital for years to come.

Satellites are also used to transmit data around the world. The earth's spherical shape imposes a problem on world wide communications, Figure 5. Satellites overcome this problem by transmitting and reflecting television, radio, telephone, and even internet signals, Figure 6.

Throughout the last few decades, research satellites have allowed people to learn more about the universe. These satellites have wound their way through the galaxy, orbiting planets, moons, and comets. Throughout their journeys they have transmitted a constant stream of information back to earth. This information will be priceless in future space exploration missions.

Satellites play a huge role in the 20th century aerospace industry. The need to manufacture and launch satellites will continue to grow into the 21st century. Capitalizing on this need will ignite growth in the U.S. aerospace industry.

The Space Shuttle

The space shuttle, Figure 6, was the worlds first reusable spaceship. The rockets of the early U.S. Space Program were all "throwaways." The space shuttle was designed in an effort to make space flight more affordable. Its design specifications included:

* 100 mission life.
* Ability to attain orbits of up to 600 miles.
* Ability to land on existing runways.

All of these design criteria made the space shuttle unique. Never before had a spaceship been launched, remained in orbit for days, and then returned to land on a runway. The reusability of the space shuttle was key to making space travel economically reasonable.

Since its first flight in August of 1977, the space shuttles have logged dozens of missions. From scientific research to satellite placement, the space shuttle system has proven to be both efficient and effective. Although it has been revised over the years, its 20 year old design it becoming outdated. NASA recently signed a contract with Lockheed Martin, for the next generation space shuttle. Allowing the private sector to shoulder the brunt of research and design costs, provides for growth in the industry. The dire effects of government cutbacks can also be avoided by putting the financial responsibility in the hands of the private sector.

Summary

Although the space shuttle system and modern day satellites have performed effectively to this point, it is very important that their replacement systems be designed and tested as soon as possible. The continued success of the U.S. Space Program will depend upon the following:

1. The arousal of national public interest.
2. Research and funding from the private sector.
3. NASA's ability to set and revise goals.

THE FINAL FRONTIER

Introduction

Space flight remains in its infancy. Future generations will witness the International Space Station, manned missions to Mars, and even mining operations in space. Tapping in to the vast secrets and resources of space will guarantee our success as a nation and a species.

U.S. Interests in Space

Throughout the next twenty-five years, the U.S. Space Program will continue to grow. At present, the International Space Station has already been designed. Its implementation will bring the world together in space. This space laboratory will be the bed of many new and exciting ideas, discoveries, and inventions. These ideas, discoveries, and inventions will provide the means to begin space mining operations and to further space exploration efforts.

Summary

Continued growth in the aerospace industry is essential. By discovering the secrets of space and harnessing its resources, humans can insure their success. As a nation, the United States needs to lead the world's international space efforts. This will prove to be profitable for the United States, and for the rest of the world as well.

CONCLUSION

Summary

This report has taken an in depth look at the birth and growth of the aerospace industry. The areas of consideration have included:

1. THE HISTORY OF FLIGHT This section described the people and ideas that brought

about the aerospace industry. The key ideas and concepts that lead to exceptional growth, public interest and awareness, intranational and international competition, and the motivation to set and attain goals were discussed in detail.

2. THE HISTORY OF THE U.S. SPACE PROGRAM This section described the birth of the U.S. Space Program. The need to maintain public interest, to continue to set and revise goals, and to continue to provide funding for space exploration were stressed.

3. CURRENT AEROSPACE TECHNOLOGIES This section briefly described the current uses and issues involved with satellites and the space shuttle system. Emphasis was placed on the design and implementation of replacement systems.

4. THE FINAL FRONTIER This section discussed some of the ideas that may be implemented in the future. More specifically, the International Space Station, the exploration of Mars, and mining in space were discussed briefly. Emphasis was placed on continuing growth and world leadership in the U.S. aerospace industry.

Closing Comments

Growth in the aerospace industry is essential! As this report has detailed, in order to achieve growth in the aerospace industry the United States must:

1. Arouse and maintain public interest.
2. Provide the motivation for the private sector to set and attain goals.
3. Compete with the nations of the world in the aerospace industry.
4. Continue to provide funding for aerospace programs.

The United States' success in the 21st century will be dependent on these ideas. As the finite resources of this planet continue to dwindle, our success as a species will also become dependent on these ideas.