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The Aerospace Industry: Its History and How it Affects the U.S. Economy

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I. INTRODUCTION/RATIONALE

The Aerospace Industry is one of the most powerful industries in the United States. It encompasses a worldwide complex of manufacturers who produce airplanes, helicopters, military aircraft, missiles, rockets, spacecraft and satellites. These manufacturers employ a vast number of supplier firms that make a variety of products ranging from avionics and hydraulic systems to rubber gaskets and adhesives. It is most interesting to study the effects of such a powerful industry on the U.S. Economy.

I want to begin by looking into the history of the Aerospace Industry from its inception to the present. The history of man's efforts to fly show us how his thinking developed through the ages.

The Aerospace Industry as it stands today supplies five basic markets: military aircraft, missiles, space, commercial airliners, and general aviation. I want to explore these markets individually as to how they developed, what each one entails, and how each affects our economy. Included in this will be a discussion of the deregulation of the airline industry.

There are great fluctuations from half a million to nearly one million workers in this industry. Thus, it is important to study the kinds of jobs that are included in the Aerospace Industry and how these fluctuations affect these workers. I will also review the forecasts for the 1990's in Aerospace.

The Aerospace Industry Association has predicted a moderate decline in sales in the 1990's, because of cuts in United States military spending as East-West tensions ease. The trade group said in a year-end report in 1989 that civilian and military aerospace sales were expected to grow in 1990 by 5% to $120.6 billion, but that industry profits would fall by 13% to $4.3 billion. They do not minimize the impact on the industry of the defense spending cuts they know are coming and they are braced for "heavy weather."

It appears as if in the 1990's, sales will rise to $137, but there will be a decline in military spending in the next decade that will be only partly offset by increasing civilian sales. The Association does not expect an impact of catastrophic dimension but rather a moderate decline in real inflation adjusted sales volume, with gains in non-defense business off-setting to a considerable degree the indicated reductions in defense business.

How does this Aerospace Industry affect our U.S. Economy? How does the U.S. Economy affect the Aerospace Industry? Is an aerospace career a good choice for the young people? What are aerospace careers? How can the Aerospace Industry affect the economy of a city or state? These and other questions are going to be explored in this unit on the Aerospace Industry and the U.S. Economy.

II. LEARNING GOALS

Upon completion of this unit, the student will:

1. Know how the idea of flying evolved through the centuries into the streamlined aircraft of today.
2. Know about all the different aspects of the Aerospace Industry.
3. Know about all of the careers in the Aerospace Industry—what they entail; training necessary;

average salaries
4. Know about the prospects for the Aerospace Industry of tomorrow.
5. Know how Defense Spending Affects the U.S. Aerospace Industry
6. Know about the U.S. Airline industry—its current status and future prospects
7. Know how the Aerospace Industry affects the U.S. Economy
8. Know how foreign countries have been getting into the Aerospace Industry and how this will affect the U.S. Economy
9. Know how the Aerospace Industry affects our State Economy

III. SUGGESTED TEACHING STRATEGIES

1. Discussion of history of Aerospace after
    A. Visit to museum with historic materials
    B. Lecture
    C. Research
2. Discussion of Aerospace Careers after
    A. Library Research
    8. Speakers
    C. Company visits
    D. Video presentation on Aerospace Careers
3. Discussion of the Aerospace industry of today and tomorrow
    after
    A. Lecture
    B. Speakers
    C. Research
4. Discussion of how Defense Spending and the U.S. Airlines affect the Aerospace industry after
    A. Lecture
    B. Speakers
    C. Research
5. Discussion of how the Aerospace Industry affects the U.S. Economy and State Economies after

A. Lecture
B. Speakers
C. Research

6. Discussion of how foreign Countries are taking a larger part of the Aerospace Industry after

A. Lecture
B. Speakers
C. Research

IV. HISTORY Of AEROSPACE BEFORE 1900

In 1256, Roger Bacon published his *Mirror of Alchemy* . His scientific insights and predictions, like scattered seeds, grew and multiplied. Bacon suggested that the surface of the atmosphere must be a kind of “liquid fire” or “Ethereal air.” If “ethereal air” were obtainable, it could be enclosed in these copper spheres, making it possible to carry a man aloft as a cork rises in water. Or else, it might be worthwhile for man to invent a flying instrument that could be made to flap wings, to reach in this way, the treasure of “liquid fire.”

The first important work on the problems of flight came some four or five hundred years ago, when science first began to make significant progress. One of the first serious thinkers about flight was Leonardo da Vinci, who lived from 1452 to 1519. Most famous as an artist, daVinci was also a musician, architect, mathematician—and perhaps, the first aeronautical engineer. He designed a parachute and a model helicopter, which may have actually flown. In his thinking about manner flight, da Vinci was influenced by his interest in birds and spent a great deal of time working on flapping-wing machines. Leonardo did not realize that the motions of a bird’s wing are much more complicated than he could reproduce with his mechanism. Neither did he realize that the power which a man can produce is very small compared to his weight. It was not until a hundred and fifty years after da Vinci’s time that a biologist named G.A. Borelli came to the conclusion that man’s great weight and small power output would make it possible for him to fly by using his own muscles. If Leonardo da Vinci had worked on the design of fixed-wing gliders instead of bird-like machines, he might have moved aviation—at least the science of gliding—ahead by hundreds of years.

But, it was not a flapping machine or an airplane of any kind that first lifted man into air. It was a balloon.

In 1782, Joseph Montgolfier in France wondered what it was that made smoke and sparks rise above a fire. If he could capture the “gas,” or whatever it was in a bag, would it have lifting power? He tried it with a small bag made of silk. Much to his surprise, the bag filled with smoke from the fire soared to the ceiling of the room. Joseph and his brother, Etienne built several larger bags, which they called “aerostatic machines,” and filled them with mysterious “gas.” In 1783, one of the larger balloons built by the Montgolfier brothers soared more than a mile in the air.

Balloonists soon found that they couldn’t fly where they wanted to—they could only go where the wind happened to take them.

While the balloonists and dirigible drivers were trying to make practical use of their clumsy craft, other men believed that man would some day fly in heavier-than-air gliders, and model airplanes. Later, they began to build gliders large enough to carry a man.

During the first half of the nineteenth century, a man named George Cayley, an Englishman, built a whirling-arm device with which he could measure the force on a lifting surface that was moving through the air at various angles. He built and flew model gliders and developed many new ideas about heaver-than-air flights. Cayley, who was called “the father of aerial aviation,” fixed a car to the wings with straights and diagonal bracing. It was the first time diagonal bracing was used to insure the sturdiness of the wings so that they could carry a heavier load. The verdict of history is that aviation would have advanced fifty years if Cayley’s writings had reached a wide enough audience. But, they did not.

Then, Professor Samuel P. Langley, who taught physics at the University of Pittsburgh, began to re-examine the heavier-than-air machine from a new angle. He wondered about the physical forces that allowed Penaud’s flying toy to maintain its equilibrium during a flight of 200 feet. On May 6, 1896, in the presence of Alexander Graham Bell and several other friends, Langley catapulted this flying machine model into the air and it flew 30 miles per hour. Although the propeller stopped, the flying machine came down slowly and settled on the Potomac. It seemed that man was on the verge of successful mechanical flight.

Of the many other experimenters who worked on the problems of flight in the last half of the nineteenth century, only a few can be mentioned here. One was Sir Hiram Maxim, an American inventor who moved to England.

He built a huge machine, weighing several tons and powered by a 360-horsepower steam engine. Its wing area totaled more than 4,000 square feet—more than the wing area of a small transport airplane. On the trial run, the machine lifted off the track. The guard rail failed to hold it and Maxim had to shut off the steam in order to keep from losing control of his machine. It was damaged when it settled back on earth.

A German inventor and engineer named Otto Lilienthal had large bird-like wings and a fixed rear stabilizer or tail. He made more than two thousand flights, experimenting with the method of control, which was accomplished by shifting the weight of the pilot. Lilienthal was the first to demonstrate clearly that controlled heavier-than-air flight was possible for man. In a flight on a gusty day in 1896, Lilienthal crashed and was fatally injured.

Some say that a helicopter powered by a rubber band inspired the invention of the airplane. Wilbur and Orville Wright were indeed fascinated by this toy which their father had given them. In truth, their development of the first airplane was probably the product of their inquisitive, pioneering spirit and their deep interest in all kinds of mechanical things. In 1892, they established the Wright Cycle Company. Building, repairing and selling bicycles became their daily work. They thought of flying when they read about the gliding experiments of Otto Lilienthal in Germany.

In 1899, when Orville and Wilbur were thirty-three and thirty-seven years old, respectively, they began serious work on problems of flight. The Wrights found that Lilienthal and other glider pilots had met disaster because they could not control their machines in the air. Thus, the Wright Brothers singled out the most important problem, which had not yet been solved: how to balance and control the flying machine in the air.

The Wright Brothers searched for some method of making one wing lift more than the other. They hit upon the idea of building two wings held apart by struts so that the whole structure could be twisted like a box with top, bottom, and ends, but no front or back. By thus twisting or warping the wings, the pilot could increase the lift on one wing and decrease it on the other in order to hold the wing level or to bank the airplane for a turn.

The models and gliders built by the Wrights illustrated another ability that helped carry them to success—their mechanical skill.

The Wrights had to build several gliders before they proved very efficient. This achieved, Wilbur and Orville began to think of building a new machine with an engine. The gasoline engine had already been invented.

V. HISTORY AfTER 1900

The Wrights used a motor. Then, they designed some propellers. Slowly, the new machine began to take shape, and in November 1903, it was shipped to Kitty Hawk for assembly at the test site.

On December 17, Orville was at the controls of their machine. The machine rose from the track and covered 120 feet in about 12 seconds. Several other flights were made. Then, a gust of wind upset the machine and it was damaged severely. Not much press was given their efforts.

The Wrights made or attempted 105 flights during 1903, the largest of which was 5 minutes and included more than 3 complete circles of the field. It was not until 1906, nearly three years after the first Kitty Hawk flights, that important articles began to appear telling of the Wright's achievements.

When the Wrights attempted in 1905 to offer their invention to the United States government, the response they received was almost unbelievable. They wrote to their congressmen, describing their flights thus far, and asked whether the government was interested either in purchasing flying machines or in acquiring the information they had accumulated. Their letter was sent to the War Department, which evidently didn't believe their story.

Several times, the Wright Brothers wrote to the U.S. government, and they continually failed. Then, President Theodore Roosevelt set the machinery in motion to change this indifference. His administration took steps to invite the Wrights to make a proposal for supplying an airplane to the government. The first demonstration flight of the first military airplane in history took place at Fort Myers, Virginia, on September 5, 1908. Orville Wright flew for just over a minute.

As the need for more engine power grew, larger radial engines were designed with a double tow of cylinders. Engines of this type were used on American World War II bombers such as the B-17, B-24, and B-29. Large commercial transports by these engines carried airline passengers all over the world, before being replaced by jet powered airliners.

In 1922, a a new idea called jet propulsion had appeared in a report published by the United States Bureau of Standards. Because it was predicted that this engine would use four times as much fuel as a good engine-propeller system at 250 miles per hour, no one was very interested in jet propulsion at that time.

The steady progress in aeronautics has given us not only faster airplanes, but a great variety of airplanes that can do very special things. The job of the earliest airplanes was simply to get off the ground and fly, somehow.

The helicopter is able to land anywhere. The jet transport carries passengers for a great distance at high speed. The supersonic fighter is designed to travel at faster than the speed of sound. Small private airplanes are designed to be easy to fly, operate economically, land at big or small airports and to provide comfortable transportation.

On May 15, 1918, the U.S. Army Air Service began mail flights. A young pilot named Charles Lindbergh wanted to win a prize of $25,000 for flying from New York to Paris. He succeeded at this and became a symbol of the pioneer who pointed the way to mass air transportation

The air war, prophesied by H. G. Wells in 1908, began its growth and by the 1930's, advance in aviation had become so rapid that there were 150 aircraft manufacturers, each with a different model plane. In July 1936, the Douglas DC-3 made its first flight from Chicago to New York. After the airplane had reached a safe level of inherent stability, the constant goal was speed.

Hitler, who had several thousand combat planes, miscalculated the aircraft production capacity of his enemies, which reached 300,000 in the United States alone.

In spite of the devastation wrought by airplanes, their engineers could truly claim a proud record. No machine in the history of civilization to that time had ever made so many advances so quickly. During the war, the entire world of technology had concentrated on the flying machine without regard to cost.

Toward the end of the war, the U.S. had the fastest propeller plane, one that accelerated to just beyond 500 miles per hour. Then, the Germans sprang a surprise with an airplane that had no propeller. It took air at the front, mixed it with fuel, and ejected it in the rear in a roaring blast. The jet age had opened up for modern man.

The jet engine was invented by Frank Whittle. In 1930, he applied for his first patent on his gas turbine. After further study in the mechanical sciences at Cambridge University and serving as test pilot for the Marine Aircraft Experimental Establishment at Felixstowe, Whittle joined Power Jets, Ltd. to continue his experiments, and a jet propulsion turbine was built to his design. In May 1941, the first flight using the Whittle jet engine was successfully made. While an officer of the Royal Air Force, he refused to claim any remuneration for his work or inventions; however, in 1948, he was awarded a sum of money and recognition for his achievements.

Jet and rocket engines had an almost parallel development. Both gave a forward push to the front end of a tube as the hot gases exit from the rear. An American Professor of Physics, Robert H. Goddard, transformed mathematical equations into engineering hardware. He was granted two patents on rocketry in 1914.

By 1956, the supersonic speed of bombers and fighters made them practically indistinguishable, each with about the same weight and the same operational ceiling. Both bombers and fighters could breeze along at 2,000 miles per hour.

DeHavilland was the first of the modern giants of aviation to foresee that a pressurized cabin far above the weather zone could provide a pleasant ride for everyone. In 1949, he decided to gamble his fortune on a jet passenger liner. In May 1952, one was available with 48 passengers going 490 miles per hour and flying 42,000 feet.

Today, almost every country has airliners and most countries fly jets. In few places of the world is the huge shape of the jet liner unfamiliar, so interwoven has air travel become in the daily life of man.

Aviation is one of the fastest growing industries in the U.S. It has increased yearly at the rate of at least fourteen percent.

VI. AEROSPACE INDUSTRY TODAY

"One small step for man, one giant leap for mankind." When the Apollo 11 crewmen set foot on the surface of the moon, the world's attention was drawn to one of America's largest and most rapidly developing industries. But, exploration in space is only a small part of this field. The Aerospace Industry is concerned mainly with the planning and manufacturing of new and better spacecraft for exploration of the universe, aircraft for civilian transport and the military services, and missiles for national defense. But, the industry has also improved other things, too. For instance, it pushes for constant improvement in ways we can predict the weather. It certainly has increased our knowledge of our world, and certainly the capacities of our bodies in relations to flying and to space.

About 1,703,000 men and women work in the Aerospace Industry and perhaps, no other field employs such diverse talents. Because of the great emphasis on research and development, about 25% of those who work in aerospace are engineers, scientists and technicians—a higher percentage than in most other industries.

VII. CAREERS IN AEROSPACE

Engineers are concerned with everything from initial planning and design to final assembly and testing. More than 30 types of engineers are employed in the industry: electronic, electrical, industrial, chemical, nuclear, mechanical and aerospace engineers are among the large classifications.

Aerospace engineers usually specialize in a particular area of work such as structural design, navigational guidance and control instrumentation and communications, simulation, propulsion testing or production methods, or in a particular type of transport such as private planes, passenger planes, jet-powered military aircraft, rockets, satellites, or manned space capsules.

Aerospace scientists work with engineers in the pre-production stages. Other scientists working in the industry include physicists, mathematicians, chemists, metallurgists, and astronomers.

A college degree in the appropriate specialty is the minimum requirement to become an engineer or scientist.

Assisting the scientists and engineers in developing aerospace vehicles with greater reliability, speed, range, and carrying capacity are the technicians. Technicians fill such important jobs as laboratory aides, drafters, electronic aides, mathematics aides, production planners, computer programmers, and flight simulators. For the most part, technicians are educated in technical institutes or junior colleges, although some workers may qualify as technicians after several years of diversified experience or military on-the-job training. Some technicians may become engineers with years of appropriate work experience and some college training, usually at night.

After the scientists, engineers, and technicians have completed the initial planning and design, model builders make a scale model of the aerospace craft, which is thoroughly tested under simulated conditions. A full-sized prototype is then constructed. This is tried out on the ground, and then it is time for a test pilot to combine the knowledge of a student of aeronautics with the coordination of a Grand Prix racing driver.

More than half of all aerospace production is for the Department of Defense and the National Aeronautics and

Space Administration. Thousands of federal employees are responsible for initiating the design of many aircraft and involved in the testing of all aircraft. Every model must meet strict federal specifications. If test results prove satisfactory, production can begin, usually under the direction of a prime contractor who may employ thousands of workers.

Many of the individual parts and sub-assemblies are made by sub-contractors. About half of all aerospace employees work in plant jobs. Because of the uniqueness of its products, the industry is very dependent on highly trained workers who are flexible enough to move from one custom job to another.

There are skilled workers who shape complicated parts from sheets of thin metal using hand tools or several machines. Less skilled sheet metal workers may use a single machine to fabricate parts required in large quantities.

Most skilled machinists lay out the work and set up and operate several types of machine tools. Other machine tool operators may do more repetitive work on one machine. Because many aerospace plants make their own machine tools, skilled workers such as jug and fixture builders and tool and die makers are needed.

After all the parts and components are ready, they are put together by assemblers. These workers may fit together major sub-assemblies, for instance, joining the wing or the tail to the fuselage, or they may install components such as fuel systems or flight controls. They are involved with riveting, drilling, bolting, and welding. A large proportion of assemblers are semi-skilled and do repetitive work, but some skilled mechanics and installers perform diversified work on experimental prototype or special aircraft.

Although some assembly may be noisy or carried out in cramped quarters, working conditions are good for most plant employees. Factories are usually new, brightly lit, and well-ventilated, and the number of on-the-job accidents is low.

Because products are extremely complex and accuracy is critical, parts are inspected and tested at all stages of manufacturing. Inspectors are highly skilled and may operate sophisticated testing equipment. Some specialize in a particular component or phase of production; others may work in a team under the direction of a chief mechanic. Skilled inspectors generally have several years of machine shop experience. Other inspectors may be trained to conduct simpler tests.

Mechanics who do the final check-out of an aerospace craft before its first flight may gain experience working in earlier stages of production or receive all their training in check-cut work.

Training for other plant work varies from a few days on the job for the less skilled assembly operations to several years of apprenticeship for such workers as machinists, tool and die makers, and electricians. Most aerospace plants support some kind of formal training either by holding their own classes or covering tuition for outside courses so that workers can keep up with changing technology and advance to higher positions.

Percentage-wise, the number of unskilled workers in the industry is low and continuing to decrease, although plants do employ many material handlers, maintenance workers, and custodial employees.

As in all industries, managerial, administrative, clerical, and other office personnel are also needed. In aerospace, however, many managerial positions require a background in science or engineering.

The industry also has special needs for medical personnel in a variety of jobs. Researchers study the effects on man of high speeds and space travel, physiological planners make sure that space capsules and aircraft are designed with human requirements in mind, and practicing doctors and nurses work at the larger aerospace plants.

Another important group of workers are the technical writers and illustrators who produce manuals and other literature describing the operation and maintenance of the aerospace products and their many components.

For the most part, salaries are very good in the industry. Many workers are represented by unions, and most employees receive a full quota of benefits that range from paid vacations to hospitalization coverage to pension.

Job demands, however, can fluctuate quickly because production levels and employment rates depend largely on funding by the federal government. For example, in one five-year period, aerospace employment decreased by one-half. Many workers, including scientists, engineers, and technicians, have been laid off during production cutbacks. The employment rate is expected to increase slightly in the near future, and there will continue to be plenty of opportunities in a variety of jobs for people with a wide range of talents and interests.

If any of the jobs in the aerospace industry were appealing to a young person, on the most part, it would be very rewarding to enter such a field.

Overall, the Aerospace Industry is most concerned about a shortage of engineers during the next decade. Cornell University predicts a shortage of 560,000 engineering graduates by the year 2010.

This shortfall will be exacerbated because a large percentage of those graduating in the next decade will be immigrants whose clearance to work on defense projects will be difficult. Moreover, non-U.S. citizens overwhelmingly dominate the pool of graduates with advanced degrees in science and engineering. Because of those shortages, engineering salaries will be very competitive in the 1990's.

Aerospace leaders, leaders in government, industry and the military recognize that in the fact of demographic trends as much as 85% of America's new workers will be women, minorities and immigrants. Thus, the industry will have to draw its technology professionals from this supply. To this end, the industry has taken the lead in implementing multi-cultural management.

Aerospace employers are going to have to find new ways to recruit, manage, and retain this diverse group. Perhaps, more importantly, the industry must start to ensure the progression of women, and minorities to the middle and upper-management ranks.

The shrinking number of young people entering the work-force coupled with the rising technical skills required by the Aerospace Industry make the task of utilizing minority workers particularly critical between now and the start of the 21st Century.

The U.S. Commercial jet transport manufacturers took just half of 1989 to smash all-time records for orders met in 1988. Forecasters see a free world market for as many as 13,000 new large transports through the year 2000.

The commercial aircraft boom will fuel demands for more pilots, mechanics, flight controllers and other aviation professionals. The airlines will hire more than 60,700 pilots by the end of the 1990's. Another strain on pilot availability in the U.S. is the commercial aviation boom sweeping the Pacific Rim nations.

Pacific Rim air traffic may quadruple in the next 10 years, as the Asia-Pacific region accounts for 40% of worldwide traffic. Japan Air Lines have already tapped the U.S. market to fill its voracious pilot needs. As of late 1989, almost 70% of the pilots hired by the airlines were military-trained.

Engineers and scientists will continue to find rewarding careers in the military's civilian programs over the coming decade, besides healthy compensation packages and the chance to work in attractive locations from coast to coast.

California, Washington, and Texas are states with large aerospace manufacturers.

VIII. THE AEROSPACE INDUSTRY TOMORROW

Defense Department expenditures for military aircraft, missiles and other aerospace systems are not expected in the civilian sector. Much of the present fleet of airliners will be replaced with quieter and more fuel-efficient aircraft and there will be increased demand for spacecraft, helicopters and business aircraft.

IX. AEROSPACE INDUSTRY AND DEFENSE SPENDING

In looking at the markets of the Aerospace Industry, we see that military aircraft, missiles and space are dependent upon defense spending. Transformation of Eastern Europe's political structure has left American Defense leaders in "future shock"—but still cautious about pronouncing radical shifts in Western military strategy.

One of the architects of the post-war super power era, former Secretary of State Henry Kissinger, has said that the deployment plans for allied nuclear and conventional weapons will need to be reconsidered. Yet, General John R. Glavin, Commander-In-Chief of U.S. and allied forces in Europe, has stressed the need for modernization of both nuclear and conventional aircraft and weapon systems. At this point, therefore, we do not know how this will be affecting the Aerospace Industry.

We do know, however, that commercial air service should be an early beneficiary of the thaw in Eastern Europe's political climate.

Throughout the 20th Century, U.S. science and technology has been the envy of the world and a major factor in maintaining the U.S. as a global economic force.

However, a reorganization of the world order is under way that already has begun to change the balance of economic and technological power around the globe. Unfortunately, the policies and procedures guiding U.S. science and technology have not kept pace with this rapidly changing environment.

This makes it imperative that the White House and Congress revitalize the process by which government and industry select, fund and use major new U.S. science and technology efforts.

The success or failure of this revitalization could significantly influence the U.S. position in the world in the coming decades. While Western Europe is moving to consolidate its technological clout under the "Europe

1992" banner and Japan is executing a broad technology strategy, the U.S. lacks an advanced technology policy to carry the nation into the 21st century.

Compounding the problem is the prospect of significantly reduced U.S. defense spending. One out of three U.S. scientists and engineers is employed by the Defense Industry. Measures must be taken to ensure that Defense cutbacks do not dilute U.S. science and technological capacities.

Reductions in the Defense budget should be viewed as an opportunity to increase the funding for civilian science and technology and to reform the way the government handles such research.

Although Defense research provides employment for those involved, it does comparatively little to benefit the U.S.'s standing in the world scientifically, technically or economically. A disproportionate share of federal science and technology funding has been going toward Defense.

Japan and West Germany spend a higher percentage of their gross national product on civilian science and technology compared with the U.S.

What has been lacking is the strong integration of U.S. economic policy and national technology policy.

Japan already integrates its economic and technological planning and uses that policy to its advantage in the world market. Western European countries are looking to similar strategies as they transform their economic systems starting in 1992.

The space program has, to many Americans, symbolized the highest level of U.S. science and technology.

In reality, however, there are now literally dozens of areas of U.S. science and technology equally deserving of federal funding support, all with significant potential to benefit the nation's science and technology base. Some reporters have characterized the situation as "the dilemma of the golden age," where so many worthy projects must vie for such constrained funding.

Transferring more federal science and technology funding to the civil sector could help prime the nation's technological pump. It also would bring the U.S. more in line with nations like Japan and West Germany, where research and development growth rates have been rising faster than in the U.S., enabling these countries to match U.S. development spending as a percentage of their gross national products.

The massive downsizing of long-range defense spending plans will also force the Pentagon to make difficult choices between moving ahead with new, high-technology weapon programs or upgrading existing systems.

One of the bigger factors in choosing between existing or new systems is the extent to which new systems are needed to meet national security goals. "This requires an assessment of the enemy threat and U.S. needs that aren't currently available," according to the Defense Industry.

Defense cutbacks have affected NASA, also. The White House is currently in a search for new ways to advance the nation's manned space program. It feels that the agency's high cost of estimates for space ventures is forcing them to search for competitive alternatives.

So, we see that Defense cutbacks can affect the Aerospace Industry in the next decade. We also see that it is hoped that the U.S. will turn to research and development during this time.

X. AEROSPACE INDUSTRY AND U.S. AIRLINE INDUSTRY

On the other side, we find that the U.S. Airline Industry is poised for the beginning of a long-term upward cycle as the market emerges from a reorganization characterized by more consolidation at several major hubs and routes and by declines in excess capacity.

For the near term, most of the fundamental problems affecting the major airlines appear to have bottomed out. Fuel prices have returned to manageable levels, and the effects of future price hikes will be mitigated by the influx of newer, more efficient aircraft. Although absolute expenditures will probably rise, fuel costs per available seat mile also will be held in check by the increases in long-haul flights.

The decade ahead for airlines will be recognized as the time of huge fleet expansion. Deliveries of all types of jet transports are expected to range such year between 600 and 700 aircraft to the year 2000. These new aircraft will replace less efficient aging and noisy transports and are earmarked as growth aircraft to meet the projection of rising traffic demand.

The rush to buy new aircraft has created for manufacturers the longest backlog in history. A buyer must wait until the mid-1990's for delivery of most models.

Such a hardware expansion has implications for airline personnel and training, maintenance and facilities. Airlines are preparing for this growth and changing times in their own ways.

The bigger airlines are attempting to get bigger, to form with other carriers to develop traffic feed, and cover as broad an area of the globe as possible. This kind of growth has become possible in the electronic age, when computers aid in offering the mix of discount and full-fare tickets, and computer reservations systems facilitate ticket distribution.

Growth of the world airline business may have been inherent in spite of rigid economic regulation by governments. But, the deregulation movement, which began in 1978 in the U.S., certainly put the spur to cargo and passenger traffic here, and it is having similar responses elsewhere.

Competition is intensified when regulations are removed from an industry reasonably equipped with aircraft capacity. With competition comes reduced fares. In the post-deregulation period through 1988, average fare and rate levels on a world scale declined by 7.5% a year. In strict economic terms, the fares dropped because unit costs, or aircraft costs, were reduced with efficiency improvements. At the same time, more people were flying, causing an increase in the load factor.

XI. AEROSPACE INDUSTRY AND THE U. S. ECONOMY

So, we see that the Defense industry has a strong impact on the Aerospace Industry. When a great deal of money is being put into the Defense Industry, it has all kinds of needs produced by the Aerospace Industry. Millions of Aerospace workers have jobs, and they are contributing to the growth of our U.S. Economy by purchasing many things. However, when Defense spending is cut, then, there isn't a need for as many Aerospace employees, and they are laid off. When these employees are laid off, they are not able to buy anything. Thus, others in the U.S. Economy begin to be laid off, too, since there isn't as much need for goods and services. Since the Aerospace industry is so large, it has a powerful impact on the U.S. Economy.

When there is any kind of war, the Defense spending grows and the Aerospace Industry grows. But, in peace time, Defense spending is cut and so is the Aerospace Industry.

Many people are encouraging better use of our skilled scientist and engineers during these cutbacks. It is hoped that more research and development will take place during these periods. And what does the future seem to hold for the Aerospace Industry?

It seems as if Western Europe will have the greatest impact on the U.S. Aerospace and Defense Industries in the coming decade, and it is the changes now taking place there that are both the most fundamental and least understood in the U.S.

Eastern Europe is going to command the headlines for a long time as it undergoes further unprecedented changes. But, it is going to be even longer before it becomes an economic power, or even an economic entity. The Pacific Rim, with Japan as its economic centerpiece, also will be highly visible as the economic balance of power swings in that direction.

The changes under way in Western Europe will be every bit as fundamental as those in Eastern Europe, and they will have both more drastic short and long-term effects on the U.S. than will the changes in Eastern Europe or the developments in Asia.

The predominant event of the 1990's in Western Europe will be the development of the existing European Community into, first, an economic union and, more importantly but less understood, into a political union. As this union develops, it is going to focus the economic muscle of Western Europe into a new competitive force, quite capable of taking on the U.S. or Japan on even terms, if only the will and direction are forthcoming.

XII. FOREIGN COUNTRIES IN AEROSPACE

And, when Europe is unified, its Aerospace Industry is going to gain new impetus. Part of this will come from the gradual trend away from nationalistic rivalries toward a more perceptive and aggressive leadership. France has been advocating this sort of approach for many years, but could not implement it in the multi-national world that has been Western Europe.

Leadership of the new and economically more powerful pan-European Aerospace Industry is almost certainly going to devolve onto French shoulders. Britain, West Germany, and Italy will all play key roles in the fields of technology, finance and marketing, but France alone among the major European powers has displayed the necessary combination of imagination, planning capacity and foresight to provide effective leadership in the world market.

The French have been instrumental in establishing a proto-European Aerospace Industry—The Airbus Industry Consortium—that has demonstrated it can compete technologically with the U.S. The French also showed early on that they had the courage of their convictions in pulling out of NATO to avoid what they considered a too-great and too-long dependence on U.S. technology.

The Chinese are also getting more into the Aerospace Industry. The People's Liberation Army Air Force of

China is pursuing aircraft update projects and the phased development of two new designs in a forced modernization program that is structured to fit government-imposed austerity constraints. The Ministry of Aerospace Industry in China is coordinating a fundamental shift from military to commercial and export-oriented production in its factories throughout China as part of a plan to modernize the China industrial base with Western assistance.

Ten years of political “openness” in China have created a strong environment for Aerospace manufacturing. Chinese factories build more than 20 types of bombers, fighters, trainers, and helicopters. This is a very strong base for the design and production of future aircraft for world markets.

To increase efficiency, safety and aircraft comfort, Chinese design bureaus, factories and sub-system manufacturers are beginning to compete for projects. Joint ventures with foreign companies have helped introduce Western manufacturing equipment, technology and procurement philosophy in China.

Japan is equally becoming strong in the Aerospace market. Japan is set to launch its first spacecraft to the Moon, a mission indicative of both Japan’s interest in future lunar exploration and the maturing of space program capacities in the Pacific Basin. Large Japanese engineering companies have begun to spend millions of dollars of their own funds to develop technology that could be used for a manned lunar base.

The Japanese companies hope these technology efforts will enable them to participate with the U.S. in the development of a manned lunar base early in the 21st Century.

Soviet Ministry of Aviation executives, visiting the U.S. for a university-sponsored management education program, said they are interested in pursuing joint ventures with U.S. Aerospace firms.

It appears that any joint venture between Soviet and U.S. jet engine firms would have to begin on a small scale with cooperative research on a technical problem such as noise reduction. Only after this type of effort would it be possible to consider larger ventures. But, this is a beginning.

Thus, it is becoming perfectly clear that the U.S. cannot just sit back and hold the Aerospace market. The U.S. is going to have to become more competitive itself if it wants to keep the Aerospace Industry as one of its largest, most important industries.

XIII. AEROSPACE INDUSTRY AND CONNECTICUT ECONOMY

And, how does this Aerospace Industry affect cur State of Connecticut and our local economies? We see headlines like “100 jobs cut by Sikorsky,” which tell us that since Defense cuts, Sikorsky Aircraft in Stratford has had to lay off workers. Senator Christopher J. Dodd, D-Conn. says, “Around here, you can never be sure if cuts were made, because someone didn’t work hard enough to protect their programs. We have to be ready to put up a fight.” He continues, “You’re going to have jet engines coming up; you are going to have Seawolf coming up; you’re going to have Tridents coming up; you’re going to have tank engines coming up. At least when you consider our larger programs, we build the kinds of basic systems that are not under attack. There will be a debate about how many jets to build, but there will be jets. It’s ‘How many submarines do we need?’ Not, ‘Let’s stop building submarines.”’

If the success of Connecticut’s Defense Industry is based on luck, the state has been extremely lucky for a very long time. It is consistently among the largest recipients of Pentagon work to prime contractors, last year receiving more than $6 billion.

Its principal prime contractors include Pratt & Whitney based in East Hartford, which builds jet engines for the Air Force and Sikorsky Aircraft of Stratford, which builds helicopters for all the services. Also, Electric Boat in Groton builds Los Angeles, Seawolf and Trident submarines for Navy and Textron-Lycoming builds turbine engines for the Army.

The state also got another $6 billion in Defense sub-contracts last year. The industry’s prime contractors and larger sub-contractors employ about 134,000—about one worker in 12. Its indirect influence is vast, though harder to measure. The industry funnels work to hundreds of shops, vendors and service providers statewide.

XIV. SAMPLE LESSON PLANS

Sample Lesson #1—History of Aerospace

OBJECTIVE: THE STUDENTS WILL BE ABLE TO:

1. Identify the leaders of the Aerospace Revolution
2. Identify the contributions of the Wright Brothers
3. Identify the progress during World War II
4. Identify all developments up to the present
5. Project future accomplishments

MATERIALS NEEDED: Reading Materials Regarding the History of Aerospace

VOCABULARY: vertical descent; heavier-than-air machine; square parachute; aeronautical; hot-air balloon; propeller; horsepower; glider; monoplanes; DC-3; rocket; Turbo-jet engine; helicopter; whirling-arm device; radial engines; B-29; B-17; B-24;

BRAINSTORMING QUESTIONS:

1. How did the idea of flying originate?
2. Who were the most important men involved in the development of flying?
3. What were the contributions of the Wright Brothers?
4. How much progress was made during World War II?

PROCEDURE:

1. Trip to New England Air Museum
2. Review vocabulary and meanings

RELATED ACTIVITY: Students go to the library and do a report on one of the major contributors to the discovery of today's airplanes Students present their reports to class

Sample Lesson #2—Careers in Aerospace

OBJECTIVE: THE STUDENT WILL BE ABLE TO:

1. Identify the different careers in the Aerospace Industry
2. Be able to discuss the different careers in regard to their own interests

MATERIALS NEEDED: Reading materials on the different careers in Aerospace

VOCABULARY: Engineers: electronic, electrical industrial, chemical, nuclear, mechanical, aerospace; structural design, control instrumentation, simulation, propulsion testing, drafters, flight simulators, fabricating, riveting, welding, inspectors technical writers

BRAINSTORMING QUESTIONS:

1. Do you know what the Aerospace Industry does?
2. What kinds of jobs do you think are included in the Aerospace Industry?
3. What kind of training do you think that you would need for these jobs?

PROCEDURES:

1. Read books on careers on Aerospace
2. Review vocabulary and meanings
3. Speakers from Aerospace Industry will discuss various careers
4. Students will visit Sikorsky Aircraft (Stratford)

RELATED ACTIVITIES: Students will go to the library and do research on several Aerospace Careers; students will present their reports to the class

Sample Lesson #3—Aerospace Industry of Today and Tomorrow

OBJECTIVE: THE STUDENT WILL BE ABLE TO:

1. Identify the different parts of the Aerospace Industry
2. Discuss the importance of each sector to the entire industry

MATERIALS NEEDED: Reading materials regarding the Aerospace Industry

VOCABULARY: As given before

BRAINSTORMING QUESTIONS:

1. What is included in the Aerospace Industry?
2. How strong is the Aerospace Industry?
3. What do you think are the projections for the 1990's in the Aerospace Industry?

PROCEDURE:

1. Give lecture on Aerospace Industry
2. Review vocabulary and meanings
3. Speakers from Aerospace Industry

RELATED ACTIVITY: Students will choose an article about the Aerospace Industry and write a report Students will present the report to class

Sample Lesson #4—Defense Spending, U.S. Airlines and How They Affect the Aerospace Industry

OBJECTIVE: THE STUDENT WILL BE ABLE TO:

1. Identify the parts of the Defense Industry
2. Explain the effects of Defense Spending on the Aerospace Industry
3. Explain the effects U.S. Airlines have on the Aerospace Industry

MATERIALS: Reading materials regarding Defense Spending and
U.S. Airlines

VOCABULARY: nuclear aircraft, weapon systems, deregulation

BRAINSTORMING QUESTIONS:

1. What is the Defense Industry?
2. What effect do you think Defense Spending has on the Aerospace Industry?
3. How successful is the U.S. Airline Industry?

PROCEDURE:

1. Give lecture on Defense Spending and U.S. Airlines
2. Review vocabulary and meanings
3. Speakers regarding Defense Spending
4. Speakers from Airlines

RELATED ACTIVITY: Students will read articles on Defense Spending and Airlines and write a report on each; students will present reports to class

Sample Lesson #5—How the Aerospace Industry Affects the U.S. and State Economies

OBJECTIVE: THE STUDENT WILL BE ABLE TO:

1. Explain how the Aerospace Industry affects the U.S. Economy
2. Explain how the Aerospace Industry affects the State Economy

MATERIALS: Reading Materials on how Aerospace affects the U.S. and State Economies

VOCABULARY: Pacific Rim, Western Europe

BRAINSTORMING QUESTIONS:

1. How do you think the Aerospace Industry affects the U.S. Economy
2. How do you think the Aerospace Industry affects the State Economy

PROCEDURES:

1. Give lecture on the effects of the Aerospace Industry to the U.S. and State Economies
2. Review vocabulary and meanings
3. Speakers regarding Aerospace and the U.S. and State Economies

RELATED ACTIVITY: Students will read articles on the Aerospace Industry and its effects on the U.S. and State Economies and write a report on each Students will present reports to class

Sample Lesson #6—How are Foreign Countries taking a larger part in Aerospace Industries?

OBJECTIVES: THE STUDENTS WILL BE ABLE TO:

1. Identify the countries that are getting involved in the Aerospace Industry
2. Identify the part that each country will play in the future
3. Discuss how this will affect the U.S. Aerospace Industry

MATERIALS: Reading materials on Foreign countries getting

involved in Aerospace Industries

VOCABULARY: Airbus Industrie Consortium

BRAINSTORMING QUESTIONS:

1. What countries do you think are getting involved in Aerospace Industries?
2. Which ones do you think will be the leading competition to the U.S?
3. How do you think this competition will affect the U.S. Aerospace Industry?

PROCEDURE:

1. Give lecture on Foreign countries getting involved in Aerospace Industries?
2. Go over vocabulary and meanings
3. Speakers regarding Foreign competition in Aerospace Industry

RELATED ACTIVITY: Students will read articles on Foreign competition in the Aerospace Industry and write a report; students will present reports to class

XV. TEACHER BIBLIOGRAPHY

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Aviation Week and Space Technology, Jan. 15, '90 "NASA losing 30 yr. monopoly in planning for Moon and Mars."

XVI. SPEAKERS

HISTORY: New England Air Museum
Near Bradley Airport

I-91, Exit 40 to Route

75; (203) 623-3305 75 aircraft; tour guides; movies; special exhibits

CAREERS: Personnel Representative (Sikorsky Aircraft)

AEROSPACE INDUSTRY: Lizabeth Morearty Schmitz; 15 Happy Acres Rd;
Clinton, CT 06413

DEFENSE SPENDING: Representative (Chris Dodd's Office) 1-800-334-5341

AIRLINES: Caroline A. Salmans; 27 Rolling Brook Lane;
Huntington, CT 06484

U.S. & STATE ECONOMIES: Representative (Bruce Morrison's Office)
773-2325

FOREIGN COMPETITION: Timothy T. Kao, Prof. Economics
(South Central Community College)

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All *Aviation Week and Space Technology* magazines for articles will be relevant

XVIII. CLASSROOM MATERIALS NEEDED: All available in library

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